Mobility and distance decay at the aggregated and individual level

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Abstract

Most crimes are committed near to where the offender lives; this has been observed both at the aggregate and at the offender level. At the aggregate level, as the distance increases there is a decline in the number of offences committed, and initially this decline is quite slow. This pattern has been described by a number of researchers, and results in a distance decay curve. Near-home offending has also been observed at the level of the individual offender, although it has been debated whether distance decay actually exists at the level of the individual offender. We therefore believe it is important to distinguish near-home offending from decay, i.e. the gradual decline in offences as distances increase. This paper studies mobility patterns and decay curves on serious property crimes in Belgium. First, aggregated patterns are discussed and categorised. Second, individual offenders are analysed. It becomes clear through studying offender patterns that offender mobility and decay are not intertwined at the individual level to the same extent as they are at the aggregate level. This suggests that it is important, particularly when studying individual offenders, to clarify whether (average) distances or decay are being considered.

1   Introduction

Criminology research can start from a variety of positions, including those identified in the literature (Patricia Brantingham & Brantingham, 1981; Cohen & Felson, 1979) – legislation; the criminal; the victim or target of the crime; and place – the scene of the crime, where offenders and targets meet. As such, place can be called the fourth dimension of crime. The study of place and crime has increased in popularity, primarily because place is six times more predictive for future crime than offender identity (Sherman, 1995, pp. 36-37). Studying place therefore offers criminologists a number of opportunities. Several studies on crime and place have identified a 'distance decay pattern' in which most crimes are committed near the offender's home, and the number of crimes declines as distances increase (see for example Phillips, 1980; Turner, 1969; White, 1932). This concept has two subdivisions, although these are rarely mentioned explicitly. First, most crimes are committed near home (i.e. offenders tend not to

travel very far). Second, the distance curve shows decay, with the result that the number of crimes committed gradually reduces as distances increase.

Although distance decay is usually considered in relation to short distances, decline may also occur over long distances – decay refers to a distribution and is independent of absolute distance calculations. The primary concern of this paper is, therefore, whether the number of offences reduces over longer distances on both the aggregate and the individual offender level. As such, this paper contributes to a discussion about the application of the distance decay pattern (Rengert, Piquero, & Jones, 1999; Smith, Bond, & Townsley, 2009; Van Koppen & De Keijser, 1997) and to a better understanding of the distance decay pattern. It does so by splitting distance decay in its two components:

1. near-home offending: do offenders primarily operate within the vicinity of their homes, as many studies have found? (for a literature review, see Canter & Youngs, 2008a, pp. 4-6)
2. gradual decline: is there an even or an uneven distribution? Does the proportion of crimes wane with distance? (Canter & Youngs, 2008a, pp. 7-8)

Using mobility features from criminological literature, we compared mobility in terms of average distance travelled, with the mobility shown by specific types of offender at the aggregate level. We expected more emphasis to be put on crimes further from home for these offenders, compared with the general pattern.

However, the average distance travelled to commit a crime is only a central measure and does not reveal any information on the actual shape of the distance decay curve. To flesh out the picture, therefore, we first explored whether high mobility actually results in different mobility patterns. In other words, does the distance decay curve of offences/offenders that are related to high mobility also show a deviating distance decay pattern, or is there straightforward decay, with the curve only slightly 'stretched' over the longer distance?

Second, we bring distance decay down to the level of the individual offender. Distance decay curves are often explored at the aggregated level (which often includes both near-home offending and decay), or central measures are used to calculate offender travelling behaviour, resulting in a loss of some interesting information (Paul Brantingham & Brantingham, 1984, pp. 222, 227). This is often done because listing a number of individual decay curves hampers a clear overall view of the data. In this paper, instead of focusing on central measures, we measure decay itself – i.e. the distribution of distances travelled, independent of the offenders' mean distances travelled.

2   Distance decay

The principle behind the distance decay pattern is that criminals tend to commit most of their crimes close to home, and commit fewer crimes as distance increases. The greater the distance, the fewer the crimes committed. A distance decay curve can be created by counting and combining the individual distances

between an offender's residence and the places where they carried out their crimes (Turner, 1969; Phillips, 1980). Figure 1 illustrates a distance decay curve, as presented by Van Koppen and De Keijser (1997, p. 510). This curve is of a fairly standard shape. Nevertheless, the average distances vary in relation to the nature of the crime.

Figure 1: Example of a distance decay curve (Van Koppen & De Keijser, 1997)
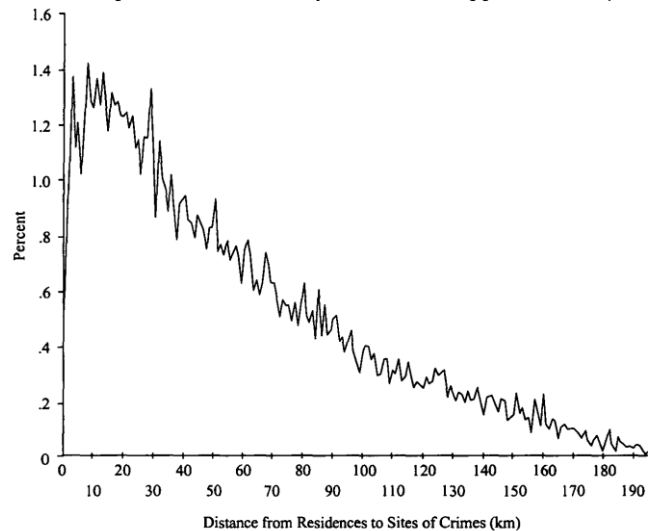
White (1932) observed in his sample an average distance of 2.7km[1] for all types of criminality. He made the observation that crimes against people are committed very close to home (1.3km), while crimes against properties occur further away (2.8km). Other researchers have drawn similar conclusions. Phillips (1980, p. 175) found a mean average distance of 2.3km, ranging from 1.1km for assault to 1.7km for burglary, and 4km for petty larceny. Reppetto (1974) observed an average distance for burglary of only 0.8km. Capone and Nichols (1976, p. 209) concluded that average distances differ not only by type of crime, which in their study was robbery, but also in relation to type of target premises. The distances travelled to rob loan companies, for example, averaged 13.4km, while the average distance travelled to rob parking lots was only 3.5km. More recently, Wiles and Costello (2000) found a mean average distance of 3.1km, and in their study on serial arsonists Edwards and Grace (2006, pp. 223-224) found the mean distance travelled from the home base to the crime site was 6.6km. The distance decay curve actually has its origins in other sciences, such as biology, medicine and geography (see for example Mizutani & Jewell, 1998; Snow, 2008; Tobler, 1970), rather than in criminology.

The limited mobility of most offenders can be explained from a variety of perspectives. First, the rational choice perspective would indicate that costs and

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[1] Many of these studies are US studies and use mile instead of km. For uniform representations, we converted 1 mile into 1,6km.

gains will be weighed against each other (Cornish & Clarke, 1986). The actions that require least effort and result in maximum gains will be taken (see also Zipf, 1949). Travelling further takes more time, effort and cost (Pettiway, 1982, p. 257); for example, travelling longer distances means vehicles need to be used for longer periods of time, increasing the chances of arrest by routine police controls. There are few reasons to choose to travel longer distances if the benefits do not increase accordingly. This could explain why criminal mobility correlates with higher criminal achievements (Morselli & Royer, 2008; Snook, 2004, p. 62).

Second, everyday life influences offender mobility. Criminals will commit their crimes in areas where they also carry out other, non-criminal, activities. Brantingham and Brantingham (1981) highlighted this pattern, and called it 'awareness space'. This is the total space an offender knows. Offenders are likely to perceive criminal opportunities when they are travelling about for other reasons. Most criminals will rarely decide to commit crimes in an area they have never been before, as without any form of reconnaissance they do not know the precise location of opportunities for crime, and have no knowledge of particular risks. Work and recreation are typical examples of non-criminal activities that help criminals to shape their awareness space and identify possible crime sites. Rengert and Wasilchick (1985, pp. 68-71) described these in their study on burglary. Offenders do not tend to commit their crimes when they are actually travelling for non-criminal purposes; instead, they notice opportunities when travelling, and feel safer when they are familiar with an area – which includes getting to know possible escape routes and dead-ends, and developing their risk perception. The authors narrow the concept of 'awareness space' down further using the term 'search space', as not every part of the awareness space contains criminal opportunities (Rengert & Wasilchick, 1985, p. 55). Criminals first identify a suitable area that may provide an opportunity for crime, and then narrow their exploration down to potential targets (see also Bernasco & Nieuwbeerta, 2005). The more the space is narrowed, the more concrete criminal planning and operations become. After the principle of least effort, which is part of the rational choice perspective, Goodwill and Alison (2006, p. 408) consider anchoring and familiarity – what we called the influences of everyday life – as the most important issues in explaining criminal mobility.

A third influence is the existence of barriers. Elffers (2004) suggested that physical barriers, such as rivers, seas or forests limit travel options. Other authors have found that social (De Poot, Luykx, Elffers, & Dudink, 2005; Reynald, Averdijk, Elffers, & Bernasco, 2008) and even ethnic (Bernasco & Block, 2009; Gabor & Gottheil, 1984) barriers restrict offender mobility too.

The concept of limited offender mobility, and thus distance decay, is particularly useful in two fields. First, police authorities use it for geographical profiling, where a criminal's anchor point region is deduced from the location of several crimes (Besson, 2004, p. 145; Rossmo, 1995, 2000; Rossmo, Thurman, Jamieson, & Egan, 2008; Van der Kemp & Van Koppen, 2007). Specific computer software has been developed for this purpose, although the actual value of this software and its various functions has been the subject of considerable debate (Alison, Smith, & Morgan, 2003; Canter & Hammond, 2006, 2007; Paulsen, 2006; Snook, Canter, & Bennell, 2002; Snook, Taylor, & Bennell, 2004; Snook, Zito, Bennell, & Taylor,

2005; Van der Kemp & Van Koppen, 2007). Moreover, some offenders act as criminal 'commuters' (Canter & Larkin, 1993). They operate around another anchor point than their residence, making it difficult to create a geographical profile.

Distance decay theory also proves useful in the field of theoretical criminological research. Different offence, offender and target types may influence the distance decay pattern (Bernasco, 2006; Bernasco & Block, 2009; Kocsis, Cooksey, Irwin, & Allen, 2002; Kocsis & Harvey, 1997; Pettiway, 1982; Santtila, Laukkanen, Zappala, & Bosco, 2008). However, the principle behind the distance decay pattern has also been the subject of debate. One discussion relates to the method used. As most papers in this field have been based on official police statistics, it may well be possible that people who commit crimes near home are more likely to be arrested, and thus the role of distance decay would be overestimated (Eck & Weisburd, 1995, p. 16; Laukkanen, Santtila, Jern, & Sandnabba, 2008, p. 233). In other words, criminals who are more mobile may also be more successful and evasive, and are therefore less likely to be arrested (McIver, 1981, p. 43). In addition, not all criminals start their crime trip from home (Wiles & Costello, 2000, p. 40); however, most researchers assume they do, and therefore crime trip calculations may be biased.

A second issue relates to a discrepancy between the individual and the aggregate level. Van Koppen and De Keijser (1997) argued that the assumption of an individual distance decay function is an ecological fallacy. They modelled a number of offenders showing no individual distance decay pattern, resulting in a distance decay pattern on the aggregate level. They were criticised by Rengert, Piquero and Jones (1999) for their interpretation of the ecological fallacy, for neglecting the role of surface calculations over distances, for the interpretation of geographic work on profiling and for the assumption of random target selection. Nevertheless, this did not end the discussion over the role of the distance decay function. By using qualitative offender interviews, Polisenska (2008) put the near-home hypothesis in question, as she found that a number of burglars would travel considerable distances to commit their crimes. Smith, Bond and Townsley (2009, p. 217) also found that the aggregate distance decay function neglects the variation that exists between individual offenders' crime trip distributions.

In the present paper, this second issue is tackled. The aim is to further improve the interpretation of the distance decay pattern. Two main hypotheses are formulated:

1. General distance decay neglects the differing patterns over distinguished groups. As such, larger average mobility may result in different decay patterns as well. Testing this hypothesis, we calculated such patterns for certain sections of offenders. Group divisions were based on a number of basic features and follow a suggestion made by Rengert et al., namely that *"[...] the next step is to identify how distance-decay parameters vary between groups of offenders (i.e., ethnicity, gender, region) and what that says about their offending behavior."* (1999, p. 442)

2. Distance decay is mostly observed at the aggregate level. Assuming the presence of a similar pattern on the level of the individual offender is incorrect. In order to test this hypothesis, we measured individual decay using a method proposed by Smith et al. (2009, pp. 230-232).

3   Method

This study used data on serious property crimes in Belgium drawn from the General National Database, the main nationwide database of the federal police forces, covering the period 2002–2006. We included in our analysis all serious property offences for which the offender was known and was resident in Belgium.

Serious property offences were identified as those with aggravating circumstances. The result of this selection process was data for 72,726 offender–offence combinations. Using police data may potentially bias the result because, as has been said, it is quite possible that offenders who do not travel very far are more likely to get caught (Bruinsma, 2007, p. 485; Canter & Youngs, 2008b, p. 12; Eck & Weisburd, 1995, pp. 15-16; Rhodes & Conly, 1981, p. 177). In this regard, this study suffers from the same flaws as previous analyses of police data.

Because we wanted to calculate the distances between offence location and offender residence we obviously needed to know where offenders lived. As we did not have addresses for offenders who lived abroad, and because it was unlikely that all foreign residences were the starting points for crime trips in Belgium, we only considered those offenders with a known residence in Belgium. Thus, 67,981 cases were included.

Due to the large size of the sample and difficulties encountered with automated detailed geo-coding (see also Wiles & Costello, 2000, pp. 7-8), a simplified way of coding the locations was used. The surface area of Belgium measures approximately 31,000km², and is divided into 589 municipalities. This research focused particularly on nationwide offender mobility, as we have observed a considerable proportion of offences being committed outside the home area. Therefore, the Lambert coordinates of the centre of each municipality are used to localise residences and crime places. This means that for every offender starting in a particular municipality or every crime being committed in that area, the same coordinate is used. We admit that this level of detail is quite rough in absolute figures and that small environmental units are preferable (Oberwittler & Wikström, 2009). Yet, this approach fits best in the general framework of this paper, which examines offender mobility and mobile offenders. However, we believe this approach is acceptable, taking into account the fact that other researchers have worked at city level using around 100 geographic subdivisions (see for example Bernasco & Luykx, 2002 for a Western European study; and White, 1932 for one of the pioneer studies in this field), compared with nearly 600 for this paper. Moreover, our aim was to observe general patterns of criminal activity, which can be done at many different units of geography (Swartz, 1999, p. 43). Using these coordinates, Euclidian ('as the crow flies') distances between the home base and crime site were then calculated. In cases

where the place of offence and offender residence were located in the same municipality, the distance was estimated by using the formula:

$$d = \frac{\sqrt{S}}{2}$$

in which S measures the surface of the area. This approach has also been used by Bernasco (2006, p. 147). In order to be able to draw easily comparable distance decay curves, we divided the recorded distances into bands of 10km each.

We then used a two-pronged approach. First, a number of aggregated distance decay curves were drawn. In this we were following Rengert et al.'s (1999, p. 442) suggestion that it is important to identify how distance-decay parameters vary between certain groups of offenders. The divisions were related to characteristics that literature suggests influence travel patterns:

- Multiple offending. Experienced offenders are found to travel further than other offenders (Barker, 2000; Beauregard, Proulx, & Rossmo, 2005, p. 587; Gabor & Gottheil, 1984). As our data set contained no information on prior convictions or arrests, we considered those offenders most experienced when they had committed 10 or more crimes in the period under consideration. This notion has been used before (Elffers, 2003; Ferwerda, Kleemans, Korf, & Van der Laan, 2003; Ferwerda, Versteegh, & Beke, 1995; Smith, et al., 2009, p. 224; Snook, et al., 2005). Although this approach is suitable when taking a general perspective, the possible impact of the law of small numbers forced us to only use these offenders in the second stage of analysis. Thus, this criterion merely provides information on the possible bias it generates when calculating individual decay patterns.
- Co-offending. Co-offenders are found to be more mobile than other offenders. They are likely to commit their offences near the residence of one offender, causing the other(s) who live elsewhere to travel longer distances (Bernasco, 2006, p. 147). Co-offending may increase the offenders' awareness space and enable them to travel further (Patricia Brantingham & Brantingham, 1981; Gabor & Gottheil, 1984; Tremblay, 2004, p. 22).
- Eastern European offenders. Previous research has shown that Eastern European offenders tend to be more mobile compared with other offenders, particularly when they commit offences in Western Europe (Ponsaers, 2004; Van Daele, 2008; Van Daele, Vander Beken, & De Ruyver, 2008), although in Eastern European countries offenders generally appear to travel further to commit crimes (Polisenska, 2008).
- Older offenders. Young offenders tend to commit more impulsive, opportunistic offences, and therefore travel shorter distances (Deakin, Smithson, Spencer, & Medina-Ariza, 2007, p. 54; Gabor & Gottheil, 1984, p. 270). Their choices are also affected by their reduced transport options (for example not having a driving licence). In this paper we

considered offenders older when they were aged 30 or over at the time of offence.

- Attractive targets. Mobile offenders often travel to attractive targets and richer neighbourhoods (Deakin, et al., 2007, p. 65). Normally, targets in deprived areas are more at risk than those in affluent areas (Johnson & Bowers, 2004, p. 238). However, mobile criminals are more likely to travel to attractive targets further afield (Bernasco & Block, 2009, p. 98; Johnson & Bowers, 2004, p. 243; Maguire, 1982, pp. 19-20). Mawby described this as 'rich pickings' (2001, p. 72). These offenders typically use arterial roads and major highways to reach affluent areas (Paul Brantingham & Brantingham, 1984, p. 357; Fink, 1969; Hakim, Rengert, & Shachmurove, 2000, p. 12; Kleemans, 1996, p. 192; Laukkanen, et al., 2008, p. 232; Maguire, 1982, pp. 41-42; Rossmo, 2000, p. 214). In order to measure the attractiveness of target areas, we used an affluence index designed by the Belgian National Institute for Statistics, in which every area with a wealth index above a mean of 100 is considered to be attractive.

First we analysed whether our data confirms that offenders with these features showed increased mobility. We also considered whether this results in different travel patterns. To do this we analysed the aggregated distance decay curves of criminal actions containing these features, to see whether they deviate from the distance decay curve.

After comparing these aggregated distance decay curves, we took things further. On the individual level, most studies use mean distances to describe offending patterns. However, the distance decay curve would be more useful for this type of analysis (Smith, et al., 2009, p. 220). One problem is how to measure decay patterns. Decay is often represented as a curve, which provides a whole range of information but leaves no room for further calculation; we therefore used a quantification of decay. This approach follows a method proposed by Smith, Bond and Townsley (2009, pp. 230-232), and uses the skewness scores of each individual decay curve. Skewness measures asymmetry, which is exactly what we are looking for in this approach. If skewness has a positive value, the right tail of a distribution is longer than the left. As distance decay illustrates most offences being committed near home (i.e. on the left side of the distribution), we expected most cases to be located on the left, and thus we expected distance decay to correspond with significant high skewness scores. In order to judge the significance of the individual decay curves, we worked with the Z-scores of this skewness, which are calculated through dividing the skewness by its standard error. Only if this value differs more than 2 standard deviations from zero (greater than 1.96 or lower than –1.96) is the skewness significant.

Using one measure means that further calculations can be carried out and comparisons can be made. However, it is also likely to result in a loss of information, as patterns contain richer information than just single values (Paul Brantingham & Brantingham, 1984, p. 222; Rossmo, 2000, p. 101). Because this paper attempts to compare the individual decay patterns of people from

different groups that have been distinguished on the aggregate level, this loss of information may be regrettable but it does not hamper the outcome.

Skewness and their corresponding z score measure relative decay. They only consider the shape of the distance decay curve, not the distances that are observed within the curve. Thus, offender A who commits 8 offences at 2km and 2 at 10km from home will have a skewness z-score of 2.59, the same score as offender B who commits 8 offences at 4km and 2 offences at 20km from home.

The skewness score cannot be calculated for all offenders. In order to rule out small-number coincidences, only offenders who have committed 10 or more offences were taken into account. The first 5 offences are indicative for the range in which offenders operate (Barker, 2000, pp. 64-65), so it was imperative that this criterion is maintained. In order to outweigh overgeneralization, we only included offenders who had committed at least 10 offences from this stage on. This avoided a possible bias that could be generated by the law of small numbers. Given the similar curve that multiple offending generated in the first stage of the analysis (see below), we did not expect to see differences by implementing this condition.

Second, skewness estimates could not be calculated for those offenders who committed all their crimes in the same area. Those who commit crimes in the area where they live have been labelled 'marauders'; if it is another area they are 'commuters' (see Canter & Larkin, 1993). The nature of our dataset and the rough geographic variable allowed for no further specification within the boundaries of a particular municipality.

As with the first stage, we compared the individual decay results between our chosen groups with the general results for Belgium. This enabled us to compare aggregated and individual decay, and addressed the question of whether mobility and decay are intertwined or relatively independent from each other.

4   Results

We first considered the mean distances travelled at the aggregate level, observing whether our chosen features result in higher mobility on the aggregate level. In general we noticed a mean distance travelled of 19.1km. This is substantively higher than the results found in literature. However, as most other studies have been executed on city level, not country level, these studies exclude travelling across city borders. Calculating the median distance, we found an average of 7.2km, indicating that our first calculation was certainly influenced by a number of extreme values (we observed a number of crime trips over 250km, which is more or less the maximum distance that can be travelled in Belgium). We then calculated the mean and median distance travelled for each chosen feature. (see Table 1).

Table 1: Distances travelled and 'mobility features'

Mobility characteristics	N	Mean distance (km)	Median distance (km)

Multiple offenders	18,755	24.4	11.1
Co-offenders	41,590	20.1	7.2
Eastern European offenders	7,078	34.7	22.1
Offenders age 30+	16,496	22.1	8.9
Attractive targets	31,569	20.1	8.6
All	*67,981*	*19.1*	*7.2*

Although correlations between travelled distance and these features were negligible, absolute figures indicated a slightly higher mobility for all features except one. This first step showed that these features did result in higher offender mobility than the average for Belgium, though the difference was only slight for some features. A next step, however, was whether these higher central values of mobility (mean and median) were also accompanied by different distance decay curves.

In order to keep the curves comparable, we divided the distances travelled into bands of 10km. The first band contained all crimes committed at less than 10km from an offender's residence, the second included the crimes committed from 10 to 19km, and so on. As very few offences were committed over 100km from an offender's residence, we only included distances of less than 100km. Because the used branches are not detailed, we overcame some of the interpretation problems that may be caused by working only with municipality coordinates. Moreover, because even such rough distinction shows a lot of variation and corresponding distance decay curves, the measure – despite its roughness – is adequate for the framework of this paper.

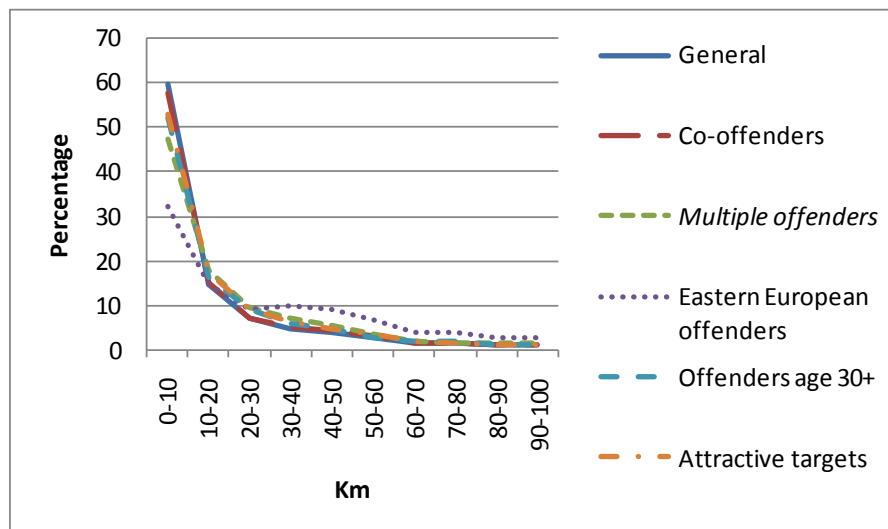Figure 2: Aggregated distance-decay patterns

Figure 2 illustrates that the pattern of most offender groups followed a distance decay pattern, regardless of their higher mobility. One pattern deviated from this – Eastern European offenders tended to be less likely to offend within the

10km range from home (32%, compared with percentages of at least 47%, but mostly over 50%, for the other groups). They also committed many more offences over 20km from their residence. Thus, the distance decay pattern for Eastern European offenders appears to be less straightforward than it is for other offenders.

This exercise shows that particular groups of offenders are indeed more mobile, as indicated by previous research, but that higher mobility rarely implies different decay curves. Apart from Eastern European offenders, most offence patterns showed a quite steep level of decay, even with their higher level of mobility. Eastern European offenders show an existing but modest decay pattern, with fewer offences committed within 10km and more at distances over 20km from the residence.

This approach uses offender–offence combinations as the unit of analysis. Although it has also been used by other authors (see for example Hodgson & Costello, 2006; Kleemans, 1996), we admit it is a slightly unusual approach. Most studies use either the offence or the offender as the unit of analysis. If the offender alone is analysed, features that are linked to the offence are excluded, and vice versa. Working with offender–offence combinations allows characteristics of both the offender and the offence to be included in the analysis.

Although the presence of a distance decay pattern is widely accepted within criminological research, it is often observed at the aggregate level and there is an ongoing discussion about whether it can also be observed at the offender level (Rengert, et al., 1999; Smith, et al., 2009; Van Koppen & De Keijser, 1997). Taking into account the observed variations on the aggregated level, we compared these results with an individual measure of decay. It is important to bear in mind that this only measures decay and does not test the near-home hypothesis. Thus, offenders can be quite mobile, still following a decay pattern, or can commit most offences in a limited area but without any particular decay. We could calculate mean skewness, but this again eliminates individual variations.

Co-offending and the choice of attractive targets refer to offence characteristics and not offender features. We therefore defined offenders as co-offenders when they committed more than half of their crimes with other offenders. When the mean attractiveness score of a target area is higher than the overall mean – higher than 100 – we considered offenders to be heading for attractive targets.

Table 2: Individual decay

	Valid	Missing	Mean	Skewness Z			
				> 1.96	> 0 and < 1.96	< 0 and > −1.96	< −1.96
All multiple offenders	765	116	2.10	49.4	24.7	14.1	11.8
Co-offenders	485	70	2.04	48.5	26.6	15.5	9.5
Eastern European offenders	122	6	1.67	38.5	31.1	19.7	10.7
Offenders age 30+	155	10	1.84	45.8	25.8	18.1	10.3

Attractive targets	365	53	1.94	46.0	25.5	16.2	12.3

On the individual level, only a minority of offenders show straightforward distance decay, meaning they have a skewness z-score above 1.96. Depending on which offenders are considered, only 38.5–49.4% show distance decay in the strict sense. For about 25%, we found decay, but could not determine whether this was significant. For another 14–20% we found a distance increase, but again could not determine its significance. Nevertheless, we found that 10% of the offenders showed a significant negative skewness, meaning that they follow a distance increase instead of a distance decay pattern.

For 15.2% of the offenders the skewness could not be determined, because they committed all offences within the same area. For the respective subtypes of offenders, this ranged from 4.9% for Eastern European offenders to 14.5% for offenders heading for attractive targets. This also implies that Eastern European offenders and offenders aged 30 or older have a wider spread of target areas than co-offenders and offenders heading for attractive targets.

5   Discussion

At the aggregate level, we noticed quite a large variation in mean distance travelled, ranging from 19.1km in general to 34.7km for Eastern European offenders. This resulted in differences in distance decay patterns. However, apart from Eastern European offenders, where distance decay deviated slightly more (fewer offences were committed at distances of less than 10km), decay variations appear to be more or less in line with the general distance decay pattern. Thus, at the group level, near-home offending and decay are intertwined to a large extent, as higher mobility leads to slightly less decay. In other words, longer distances travelled result in a distance decay pattern that is slightly stretched to the right. At least, this is what we observed at the aggregate level.

At the individual level, the pattern appears to be less straightforward. By using the skewness z-scores of offenders' decay curves, we calculated the individual level of decay. The result is a relative measure, only focusing on the distribution of decay itself: skewness is independent from mean distance travelled and, therefore, from near-home offending.

Although most offenders tend to commit their crimes near home, this does not always translate into a decay curve at the individual level. About half of the offenders showed a pattern of distance decay at the individual level. Moreover, for every 5 offenders following a clear distance decay pattern, 1 follows a significant distance increase pattern. For Eastern European offenders and offenders systematically heading for attractive targets, this odds ratio becomes 4 to 1.

As z-scores significance is subject to the standard error, we wondered whether individual distance decay variations are partially due to the skewness standard error. The standard error for z > 0 is similar to that for z < 0 (respective means of

0.56 and 0.57; assumed equality p<0.05). For significant and insignificant z-scores (z falling outside or inside the –1.96 to 1.96 span), however, we observe significant differences (respective means of 0.55 and 0.58; p<0.01). This shows that z-score significance may indeed be biased by the standard error of the individual distributions.

As the standard error is strongly correlated with the number of crimes committed (r=0.797, p<0.01), we also controlled for additional bias by taking into account the number of crimes individual offenders committed. We found that offenders with significant distance decay committed more crimes on average than those who followed significant distance increase patterns (respective means of 23.5 and 21.0). Yet these differences were not significant (p=0.22). Neither standard error differences nor differences in the average number of committed crimes could falsify our finding that for every 5 offenders showing a distance decay pattern, there is at least 1 who shows a distance increase pattern.

Within our subgroups, co-offenders tend to be most likely to follow distance decay. This is rather unexpected. After all, offending perpetrated in a group setting often cannot be explained by simply the sum of individual rationality (Tillyer & Kennedy, 2008, p. 81). Co-offenders are likely to commit their crimes near the residence of one offender (Bernasco, 2006, p. 147). This would mean that for crimes that are committed near the residence of offender A, we would not expect straightforward decay for offender B. If all co-offended crimes were committed by two offenders, this would mean that at least half of the offenders are likely to show no decay pattern, and as some crimes are committed by more than two offenders, this percentage should be even higher. Before any hasty conclusions are drawn, however, consider the following three points.

First, skewness estimates could not be calculated for 14.4% of the co-offenders. Together with those offenders heading for attractive targets, this is substantially higher than it is for Eastern European offenders (4.9%) and offenders aged over 30 (6.5%). Thus, co-offenders who commit all offences in the same area, which could well be the resident area of one of the co-offenders, are excluded from the analysis.

Second, co-offenders may live near each other, making their decay patterns resemble each other, particularly at our level of analysis. For 53% of the crimes that were committed by two or more offenders, at least two offenders lived in the same area. Thus, for over half of the co-offended crimes, the anchor point of one offender was the same as for at least one other offender. In these cases, the fact that co-offenders would tend to commit their crimes near the anchor point of one participant does not influence the individual decay pattern.

Third, co-offending networks are by no means fixed and not all co-offenders are multiple offenders. In fact, only 23.6% of co-offended crimes were committed by criminals who were classed as multiple offenders. Individual decay patterns were only calculated for multiple offenders. As these offenders are more experienced than others, they may have more discretionary power in the choice of target area, and therefore may choose to offend near their own residence. This behavioural model could apply for 76.4% of the co-offended crimes.

Taking into account these three points, we believe the relatively large proportion of individual decay among co-offenders is not contradictory to previous findings.

Because of their relativity, skewness z-scores by no means contradict the fact that the majority of crimes are committed near home. On the contrary, their main value lies in cutting decay loose from near-home offending. Also, like mean distance, this is only one value. It reveals some of the information that is lost when discussing mean distance, but does not provide as much information as a distance decay curve. Unfortunately, this appears to be the price to be paid for working with comparable and quantifiable values. In addition, it only takes into account information on the crimes, and neglects the environmental backcloth (see Patricia Brantingham & Brantingham, 2004). Intervening opportunities (Elffers, Reynald, Averdijk, Bernasco, & Block, 2008; Stouffer, 1960), awareness (Patricia Brantingham & Brantingham, 1981), search space (Rengert & Wasilchick, 1985) and incorrect anchor point perception (Wiles & Costello, 2000) are not considered. Yet this is also the case for most journey-to-crime research using mean distance travelled.

In this paper we used Belgian municipalities as a unit of analysis. This related to the nationwide data used, the emphasis on mobile offenders within the broader framework this paper is situated in, and the importance of municipalities from theoretical, methodological and policy perspectives (Hardyns & Pauwels, 2009, pp. 169-171). However, this also implies a loss of information at smaller levels of offender mobility. For a number of offenders, skewness estimates and skewness z-scores could not be computed, because they have committed all offences in the same area. 73.3% of them committed the offences in their home area. A further division of geographic locations could clarify the decay patterns of these offenders as well. Future research could therefore work with exact address locations in order to calculate distances more precisely. This could rule out any possible bias due to the level of analysis.

This paper considered variations in individual decay patterns. It is important, particularly from a theoretical perspective, that we have established that these differences do exist. By providing evidence that supports the conclusion of Smith et al. (2009) that individual differences in distance decay are often lost if analysed only at the aggregate level, we hope to stimulate the discussion about whether distance decay can be applied at the level of the individual offender.

Future steps could contribute to the journey-to-crime research from both a theoretical and a policy perspective. From a theoretical perspective, it is important to explore whether an increase in the distance travelled to commit a crime is accompanied by a directional bias. This would enable the principles of geographic profiling to be either questioned or supported. If decay variations are combined with directional bias, establishing a geographical profile would become difficult for this type of offender. If, however, distance increase curves show limited directional bias, this would mean that even for these offenders, offence locations are mainly spread around the anchor point. In that case, such offenders could be geographically profiled in the traditional way.

From a policy perspective, added value could be found in investigating why offenders decide to travel further, even if they know of and have experience of

targets nearby. Is this the result of successful preventive measures close to the residence, forcing offenders to travel further, or is it merely influenced by locations further afield being more attractive or less risky? A next step could therefore be to explore whether decay is a function of target features, offender characteristics and the environmental backcloth.

6   Conclusion

This paper explored two main issues. We were interested in mobile offending and wanted to establish whether high mobility is accompanied by different mobility patterns. We therefore selected some features of mobile offending from literature and found that these did result in higher average distances travelled in our sample. Yet higher mobility does not necessarily lead to different distance decay distributions: slightly fewer offences appear to be committed within 10km of home, but nevertheless a clear distance decay pattern was observed. Only in the case of Eastern European offenders did this turn out not to be the case: the percentage of offences committed by Eastern European offenders near to their homes was found to be considerably lower than for other offenders, and they committed more crimes at distances of 20–40km from their residence than did other offenders. Although some decay was still observed, it was less straightforward for this subgroup.

Establishing distance decay patterns reveals two main issues. On the one hand, it turns out that higher mobility does not always lead to notably different distance decay patterns. Thus, high mobility does not necessarily equal different mobility. On the other hand, even some basic group divisions, such as nationality, can result in deviating distance decay patterns. Even at the aggregate level, taking the universality of the distance decay pattern for granted is questionable, which is confirmed by the skewness z-scores for the 'Eastern European' and the 'aged above 30' subgroups. Variations do indeed exist, and can reveal interesting information if group divisions are well chosen in respect of the crime being studied.

Additionally, we attempted to translate aggregated distance decay patterns into individual distance decay patterns, by calculating individual skewness z-scores. The results were given for each offender type and revealed that fewer than half of the offenders followed a significant distance decay pattern. At the other end of the spectrum we found a distance increase pattern among over 10% of offenders.

Although distance decay can clearly be seen at the aggregated level, at the level of the individual offender it is less apparent. Eastern European offenders differed most from the general pattern in the first analysis. At the offender level, they are less likely to show significant decay, but tend to compensate this with non-significant decay patterns.

The results appear to confirm those of Smith et al. (2009), namely that substantial variation is hidden when only aggregated distance decay patterns are considered. At the aggregated level, the pattern of decay turns out to be a consequence of near-home offending. But at the offender level, this is no longer

the case. Skewness z-scores indicate that decay is not the simple result of offender mobility. Skewness may therefore function as a measure to estimate the travel patterns of an individual offender. It is important to clarify whether one is measuring distances travelled (i.e. investigating near-home offending), or decay patterns, and to keep them both separated, as the connection they show on the aggregated level cannot easily be seen on the level of the individual offender.

7   References

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