MEASURING SEGREGATION AT THE MICRO LEVEL: AN APPLICATION OF THE M MEASURE TO MULTI-ETHNIC RESIDENTIAL NEIGHBOURHOODS IN AMSTERDAM

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ABSTRACT

A wide variety of segregation measures are used in scientific research. However, the usual measures are not suitable for use at micro-geographical scale level, for example, to evaluate the magnitude of spatial attraction or separation between pairs of ethnic groups within multi-ethnic residential neighbourhoods in Amsterdam. In this paper we examine the social importance of possessing such knowledge for these areas, we discuss the deficiencies of the usual segregation measures as regards this level of analysis, and we draw attention to a recently developed spatial segregation measure, the so-called M measure, which does happen to be suitable for this goal. We apply the M measure to some of these residential neighbourhoods which existed in Amsterdam on 1 January 2003. The conclusion is that although neighbourhoods can have a very similar ethnic mix, the spatial attraction or avoidance between certain pairs of groups may be quite different between these neighbourhoods.

Key words: Segregation, micro level, postcodes, M measure, census analysis, Amsterdam

INTRODUCTION

In a number of small areas of Amsterdam, the vast majority of the population consists of mixed (non-western) immigrants. Figure 1 shows the areas in which, on 1 January 2003, the percentage of immigrants, in this paper confined to non-western foreigners, was greater than 80 per cent. We refer to these areas as ethnic clusters. On average they are 300 to 600 metres in size and are inhabited primarily by people from Surinam, Morocco and Turkey. We discuss research methods used to analyse the detailed ethnic-geographical structure of those ethnic clusters. The usual segregation measures cannot be used at this level of analysis because they have undesirable side effects. However, a recently developed spatial segregation measure, the so-called M measure, can be used to good effect, for it has the desired properties for this level of analysis. By way of an illustration, we elaborate the M measure for two ethnic clusters shown in Figure 1.

The motive behind the presented research is the question of whether, within a multi-ethnic cluster, the different ethnic groups – including native Dutch people – live randomly among each other or are segregated, meaning that some groups keep a certain distance from other groups. If the places of residence in an ethnic cluster of the various ethnic population groups are not randomly mixed, that could be an

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Figure 1. *Amsterdam, districts, residential area and ethnic clusters of (non-western) immigrants as of 1 January 2003.*

indication of possible tensions within that ethnic cluster. After all, if different groups live mixed together in a particular area, this creates a solid basis, from the spatial point of view, for mutual contact and the stimulation of culture transference between those groups. However, if this is not the case, this could indicate a situation in which hard-line attitudes are adopted and confrontations occur between the groups, with the isolation of a population group being imminent.

THE IMPORTANCE OF THE MICRO LEVEL FOR INTEGRATION AND SEGREGATION

The focus of this paper is the measuring of segregation at the micro level. In terms of content we apply ourselves to small areas in Amsterdam, ranging in surface area from five to 30 hectares, where on 1 January 2003 more than 80 per cent of the population was of non-Western origin and where at least half a per cent (1,327 people) of Amsterdam's non-Western immigrants lived together (see Figure 1). In Amsterdam they form the core, the top, of the so-called ethnic clusters. In international literature such areas are often referred to as concentration districts. The desire to carry out a segregation analysis at that scale level stems from the important role earmarked to these concentration districts in the integration process.

Theories of segregation – For a long time, the residential neighbourhood is considered to play an important role in the integration of immigrants, and the spatial distribution of the places where ethnic groups are living is used to determine their level of social integration (Park *et al.* 1925; Clark 1965; Massey 1985; White 1987; Massey & Denton 1993).

The oldest theory in this respect is that of assimilation, starting in the early twentieth century with the work of the Chicago school (Park *et al.* 1925; Park 1926). At that time large numbers of immigrants moved to North American cities, settling in ethnically-concentrated neighbourhoods. Because of their poor social, educational and financial situation they started living in the less attractive parts of the cities, leading to a high level of spatial segregation. This segregation had a negative connotation associated with the low level of integration in the new community. But, as time goes by, the assimilation theory states that the economic situation of these immigrants will improve, and that they will move to other parts of the city. And at the end, they will be living in the ethnically neutral suburbs, and segregation will have disappeared. So, all's well that ends well. The theory of assimilation has had great influence on the study of ethnic residential segregation for a long time, up to and including the present. Due to this theory, maps of the spatial distribution of ethnic groups are used to calculate measures of segregation, indicating the level of assimilation of the ethnic group (Drever & Clark forthcoming).

Assimilation theory has been confronted with a lot of criticism. Research (Dunn 1998; Burnley 1999; Logan *et al.* 2002) indicates that a lot of immigrants will not leave the immigrant enclaves at all. This is in accordance with the conclusion of other research (Fairbairn & Khatun 1989; Ray 1994, 1999; Gober 2000) showing that segregation can also become stronger instead of weaker. Segregation could even lead to the developing of ghettos; the opposite result of what is expected by assimilation theory. Research on ghettos started at the beginning of the twentieth century. Initially the focus was on how residential segregation hampered the access to good housing and facilities (Myrdal 1944; Clark 1965). Nowadays the concern is more with the relationship between increasing ghettoisation and decreasing contact with white people and the loss of social capital (Massey & Denton 1993; Kozol 2005). In summary, there is a wide variety of theories of segregation, ranging from the raising of ghettos of underprivileged groups on one side to assimilation or acculturation in the receiving community on the other. According to Forrest *et al.* (2003, p. 500) 'The nature and extent of urban ethnic segregation is traditionally thought of as a homogeneity-heterogeneity continuum from ghettoisation of disadvantaged/ discriminated-against groups at one end of the spectrum, towards assimilation or acculturation into the 'host' society – the group which is economically, socially, culturally and politically hegemonic – at the other.'

In contrast to the preceding theories economic research on ethnic enclaves stresses that ethnic minorities benefit from living concentrated in separated neighbourhoods, and that it is easier to find your way in the new world when other immigrants are living near to you (Heckmann 1981; Elwert 1982; Miyares 1997). In the words of Van Kempen & Ozuekren (1998, p. 1635): 'the existence, development and nurturing of social contacts – which are made possible by the proximity of like-minded people – can be seen as an extremely useful aspect of spatial segregation and concentration'. They are giving you the opportunity to talk to your neighbours, use their refrigerator, borrow money from them, and live in their home for a while. These contacts guarantee a better position on the labour market and the housing market, and better chances to start your own company (Wilson & Portes 1980; Kapphan 1999; Edin *et al.* 2003). Especially in a closed labour market, ethnic companies give the opportunity to improve the social position (van Kempen & Ozuekren 1998, p. 1635). If an ethnic group living in a concentrated area reaches a critical size, services can better be suited for that group (Dunn 1998) and social, religious and educational services directed to that group have more chance to be developed, encouraging future immigrants to start living there (Balakrishnan & Hou 1999). This positive interpretation of segregation can be found in many European studies and in Canadian and Australian literature.

Segregation and the scale level – Research on segregation inevitably requires choices of the scale level at which segregation will be studied. At a high level, the ethnic compositions of the quarters of a town can differ. At a low level, the ethnic composition can change over short distances. The scale level is important, because it is related to the causes and consequences of segregation. Segregation at a high level is often associated with economic, political and legal characteristics of areas, whereas segregation at a low level is usually more related to the housing market. Scale level however, strangely enough is not a central issue in segregation research, and the implications are neglected to a large extent (Reardon *et al.* 2006). In most research scale level is chosen rather arbitrarily. One explanation is that much research is carried out using secondary data of predefined areal units, such as for instance census tracts. Another explanation is that in most literature the theory about the relation between scale level and segregation is rather vague.

We are interested in segregation at the micro level. Is that an important level, and what aspects of segregation are relevant at that level? Some researchers emphasise the macro level. According to Germain (2000), the census tract is not suitable to evaluate the ethnic enclave hypothesis or the social network theory, because economic activities of immigrants fit better to a more extended area such as the French 'quartier'. Morin & Rochefort (1998) indicate that public service centres and churches, important institutions in supporting underprivileged groups, have a wider reach too.

But a lot of other studies stress the importance of the micro level. According to Oliver & Wong (2003), in a multi-ethnic neighbourhood the exposure to minority groups due to residential proximity is an important force to prevent conflicts between different groups. The research of Rosenbaum *et al.* (2002) shows that positive influences and social learning mainly depend on observations close by. Briggs (2003) states that social contact between ethnic groups is intensified by physical proximity. Lupton (2003, p. 9), summing up a large part of British and American studies on neighbourhood effects, concludes that the geographical units used in these analyses are very often too large to have any relevance. Drever & Clark (forthcoming) show that at the level of German neighbourhoods Germans and immigrants are well mixed, but at the level of buildings they live very segregated lives. Because Germans and immigrants almost never live in the same building, there is very little contact between them. Although modern methods of communication nowadays allow people to have contact with others far away, physical contact is still crucial, so the micro level is important. Omer & Benenson (2002), looking at the Jewish-Arabic residential segregation in parts of Tel Aviv, asked their respondents about the size of their 'being at home area' and their 'residential choice area'. On average, the size of these areas were respectively just over 10,000 square metres and just over 70,000 square metres; much smaller than the smallest administrative areas, which are on average 260,000 square metres. Their conclusion is that segregation has to be studied at the level of buildings or small neighbourhoods. Dixon *et al.* (2005) express the need to focus on face-to-face contacts between neighbours. Lloyd *et al.* (2004) state that administrative areal units are not suitable for the analysis of segregation, and prefer the low level associated with the perception of their neighbourhood by the people themselves. According to Marschall & Stolle (2004), most studies of neighbourhood effects use areal units that are not suitable for the daily life of people in their direct environment.

In short, many researchers have stressed the importance of the micro level in segregation research. So there is the need for a relevant measure of segregation at that level. We recommend the use of the M measure, which will be discussed later.

SEGREGATION MEASURES AND THE MICRO LEVEL

Sociological segregation measures – During the course of time, many ways have been thought up to determine how strong the segregation of a population group is. The most well-known measure is the segregation index referred to as IS and the related dissimilarity index known as D, propagated by the sociologists Duncan & Duncan (1955). This measure emerged as the great winner of the measure war of 1947–1955, and became especially popular under the influence of the excellent overview of segregation measures by Taeuber & Taeuber (1965). When IS or D is used, the study area has to be divided into subareas. Traditionally these subareas were administrative units, but when places of residence of the inhabitants are known exactly they can also, for example, be the cells of a raster that is spread out over the research area. In essence IS is based on the degree to which the population has to be redistributed to ensure an equal distribution of the various population groups in all these subareas. The measure therefore has an intuitive interpretation. The D measure is a direct derivative of IS. The difference is that in D the distribution of a group is compared with that of a different group, usually a minority group with the majority group or reference group. To date, D has remained the most widely-used segregation measure in studies of ethnic and residential segregation.

It has long been acknowledged that D has certain drawbacks, and these drawbacks make the measure unsuitable for our research. First of all, the result of the measure is dependent on the form, size and location of the subareas used, the so-called modifiable areal unit problem (MAUP) (Openshaw 1984). That is why D is best used to compare the segregation for different points in time for the same subdivision. However, that is not meaningful for our research because we study the segregation within an individual ethnic cluster, and within such a cluster a natural subdivision does not exist, and moreover we do not compare over time. A second problem, already noticed by Duncan & Duncan (1955) and Taueber & Taueber (1965) is the fact that it does not make any difference for the outcome of the measure whether the subareas with an 'excessive' percentage of immigrants are close together or are, in fact, spread far and wide across the study area. This problem is often indicated as the checkerboard problem (White 1983), and the measure has been said to lack geography, or has been described as a non-spatial measure (Cortese *et al.* 1976). Especially in our research, ethnic residential segregation, this is a serious deficiency of the measure, because theory in this field indicates that the probability of social interaction decreases with spatial distance (Reardon & Firebaugh 2002). Finally, a third drawback of the dissimilarity index is also directly associated with our research. In our case very small subareas ought to be used, because our ethnic clusters in Amsterdam have a diameter of only some hundreds of metres. However, in such a cluster, the composition of the population living in it, considering the small number of residents, will never exactly correspond to the composition of the population of the ethnic cluster as a whole and, as a result, segregation will always be found when using D.

A number of alternative measures for D are to be found in the sociological literature; for an overview see, for example, White (1986). Massey & Denton (1988) provide five principles on which segregation measures can be based, including the degree of uniformity (to which the dissimilarity index applies), as well as the degree to which people of various groups can come into contact with each other. See also Massey *et al.* (1996), Reardon & O'Sullivan (2004), Wong (2005b) and US Census Bureau (2005). Of these alternatives especially the isolation index (Bell 1954; Lieberson 1981; Lieberson & Carter 1982) has obtained quite a lot of supporters. This index, which is often denoted as P*, measures the probability of meeting someone from your own or from a different ethnic group, again, as is the case for the segregation index, on the basis of data for a subdivision of the research area. More than the dissimilarity index does, the isolation index focuses on the degree in which a group dominates subareas. However, this measure has the same three disadvantages mentioned earlier: the MAUP, the checkerboard problem and the small subareas that are required for our research. Moreover, the philosophy of the isolation index, given its search for a dominant group, does not affiliate well with our research question.

Inspired by the classical segregation measures such as D and P* many measures have been developed to solve the checkerboard problem as well as the MAUP. The checkerboard problem has inspired scientists to invent a number of spatial (distance-based) segregation measures based on the dissimilarity index. For example, Jakubs (1981) and Morgan (1983) proposed measures based on standardised values of the distance over which people belonging to the minority group should move to reach an even distribution. However, their measures never reached a high level of popularity, especially because at that time calculating them was very time consuming. White (1983) developed an index of spatial proximity, which calculates the weighted average of the distance between members of the same group and between members of different groups. Grannis (1998) suggested that social distance may be in part a function of the presence of connecting tertiary street networks. Morrill (1991, 1995) introduced another spatial version of the dissimilarity index by including information about the contiguousness of the subareas. Based on this idea, Wong (1993, 2005a) proposed that the calculation of D should take account of the length of the boundary and the composition of the population between contiguous subareas. However, although the measures of Morrill and Wong are ingenious, they have their shortcomings too. One of which is that there is no guarantee that they are bounded between 0 and 1. Furthermore, although that is not relevant for the present study, they have been criticised for their limitation in comparing population mix in the immediate neighbourhood or at a local scale without referring to regional spatial patterns (Wong 2005b). In the latest developed measure of Wong, the GD (Wong 2005b), the environment can indeed be defined flexible, but this measure too is based on predefined subareas, and does not take into account the internal heterogeneity of these subareas.

So, all these new measures, just as the traditional ones, are based on the composition of the population of subareas that are supposed to be internally homogeneous, and are therefore, in many ways, not suitable for measuring segregation within our ethnic clusters in Amsterdam, where it is all about the segregation of adjacent households.

Social scientists have also tried to develop methods to identify clusters in point patterns. These methods are used for instance in analysing urban crime patterns and in detecting clusters of rare diseases. In search for such clusters one has to take into account that the population is not spread evenly over the area of interest; see for instance Conley *et al.* (2005). Clark & Evans (1954) used quadrat counts to analyse clusters of the locations of firms, and more recently Morphet (1997) performed a similar analysis, denoted as grid-based clustering, using very small quadrats. Other methods to solve the problem of the uneven spread of the population are the geographical analyses machine GAM (Openshaw *et al.* 1987) and the spatial scan statistic (Kulldorff 1997). But neither of these methods proposed new measures that are suitable for analysing segregation at the local level.

Spatial segregation measures in ecological biology – Alternatives for the sociological segregation measures can be found in spatial measures which have been developed for pattern description in ecological biology. In this field one has, for a very long time, been interested in the question of whether, for example, the locations of trees (or any other biological phenomenon) in a study area follow an arbitrary (random) pattern or whether they cluster together or indeed avoid each other. In order to assess this, originally a grid was laid over the research area, after which an examination would take place as to whether the trees were evenly distributed across its cells. If the trees were spread across the area very evenly they are avoiding each other, denoted as dispersion. However, if they were primarily concentrated in a number of grid cells, they are attracting each other, denoted as clustering.

Because people were aware of the above-mentioned disadvantages of working with subareas (here in the form of grid cells) alternative methods were developed. One of the first of these involved measuring the distance between each tree and the nearest other tree, that is its nearest neighbour (Clark & Evans 1954). If the other trees were, on average, very close by, the trees were said to be clustering. However, if the neighbouring trees were, in fact, far apart, the situation was referred to as one of avoidance. Such an analysis is, of course, only possible if the exact location of the trees is known. The space is regarded here as a continuum. The example outlined can easily be translated into relevant social-geographical situations based on questions such as 'Are the villages in a developing country spread arbitrarily across that country? Are the supermarkets in a municipality spread arbitrarily across the municipal territory? Are the residents of a city spread arbitrarily within the city boundaries?' Such applications were indeed made immediately; see for example, Dacey (1962), King (1962) and Rogers (1965).

The nearest neighbour method is prone to obvious problems. Limiting the analyses of the pattern of dots to the distance to the nearest neighbour means that very different patterns can lead to the same result. One consequence of this is that it is impossible to ascertain that there is clustering at a high level of scale (in an area as a whole, the trees cluster together to form forests) but, avoidance at a low scale level (inside the forest, the trees create a regular pattern so that they all have space). Thompson (1956) extended the method using distances not only to the first nearest neighbour but also to the second one, the third, and so on, but his method did not solve all problems and also created some others.

An attempt to create a better and more differentiated picture is the K measure developed by Ripley. See for example Ripley (1977, 1981) and Dixon (2002). Suppose we are interested in the distribution of birch trees across a particular area. A circle is drawn around each birch tree with the radius r, and the number of other birch trees located inside that circle is counted. The average of all the resulting figures is then calculated. That average is related to the density of the phenomenon, in other words the total number of birch trees per surface area unit in the area. If, on average, there are more birch trees inside the circles than can be expected on the basis of the density, as is in the case of a completely random distribution, then one can talk of a clustering of birch trees. In the event of an average which is lower than expected, the situation is referred to as one of avoidance. The measure can be calculated for each value of r, allowing a specification of the degree of clustering at various scale levels. Besag (1977) used normalisation to convert Ripley's K into the so-called L measure. L is used more often in literature instead of K because L can be interpreted more easily. $L > 0$ indicates quite simply that the observed distribution is geographically clustered while $L < 0$ indicates geographical avoidance.

If we want to find out whether two different objects, such as birch and oak trees, attract or avoid each other, the Ripley K can be easily adapted for that purpose. In that case a circle is drawn around each birch tree, after which the average number of oak trees in those circles is ascertained, while again taking account of the density of the oak trees in the area in question. If that average is higher than expected on the basis of that density, the oak trees apparently prefer to be located close to birch trees. An average that is lower than expected means birch and oak trees in fact avoid each other. The measure has then become a segregation measure since it indicates whether the various sorts of trees attract or avoid each other. The measure can therefore also be used to assess whether, for example, immigrants live in a segregated manner by checking, in the same way, whether they and native Dutch people attract or avoid each other. This is only possible, however, if the exact residential locations of all the people concerned are known.

In the field of ecological biology, various authors have developed computer software for Ripley's K, for example Moeur (1993) and Haase (1995), and the measure has become very popular. It is also used a great deal in medical epidemiology (Gatrell *et al.* 1996). Occasionally you come across K and L in social-scientific research. For example, Okabe & Sadahira (1994) applied the measure in their study of the link between the distribution of the population and the distribution of retail outlets, and Hillier (2003) applied the measure in order to analyse redlining in cities. K and L also feature in the CrimeStat criminological software package (Levine 2006).

However, Ripley's K also has its deficiencies. The first problem is that some circles are partially outside the research area, and adjustments need to be made for those circles. There is not yet any consensus on the best approach. A summary of the proposed correction methods can be found in Stoyan & Stoyan (1994, pp. 279–284). Yamada & Rogerson (2003) compare four popular correction methods but conclude that numerous factors influence the effect of the correction, such as the size and shape of the study area, the density of the points, and the relative location of clusters in the area. For example, clusters close to the edge of the study area contribute greatly to the boundary effect. Haase's (1995) toroidal correction method, which tests showed to be one of the best correction methods, can only be used for rectangular study areas and is less suitable if all the points in the study area belong to a single cluster that is located eccentrically on the boundary. Whatever correction method is chosen, it always implies that an irregular study area produces a less satisfactory result. It is, of course, also the case that the smaller the study area, the more the boundary correction problem starts to play a role, even in the case of smaller values of the distance r in the K measure. Because our examination of the Amsterdam ethnic clusters actually involves small and irregular formed areas (see Figures 2 and 3), the conclusion is that the application of Ripley's K can be severely criticised because the boundary correction problem plays an over-dominant role.

Moreover, there is a second problem. If one first looks at the biological applications and ascertains that certain parts of the research area are less suitable for trees, and therefore for both birch trees and oak trees, for example due to the presence of a swamp or an unfavourable type of soil, the K application automatically generates a picture of attraction between birch trees and oak trees. However, we are (usually) not interested in a clustering caused by such

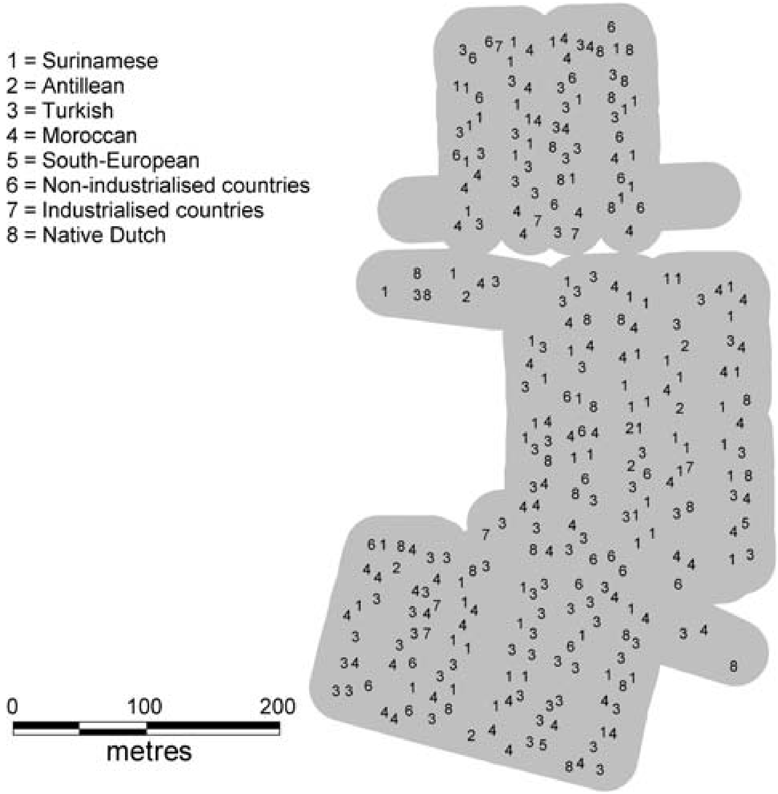

Figure 2. *Ethnic cluster 415.*

circumstances. In the biological applications this problem is often solved by choosing a research area which is homogenous as regards soil type and which has no swamps and other exceptional circumstances. The same problem exists, and even to a much greater extent, if we want to ascertain whether immigrants and native Dutch people in a city attract or avoid each other. After all, a city consists of all kinds of areas such as industrial estates and parks where almost no one is able to live. That problem could still be solved by removing those locations from the research area, albeit that it is not usually that easy to determine the borders of the areas to be removed. However, the problem in this case is even greater. In cities, the population density in certain parts where there are a lot of high-rise buildings is much greater than in other parts where there are mainly low-rise buildings. This also results, through K, in an overestimation of the degree to which immigrants and native Dutch people attract each other.

Marcon and Puech's M measure – Recently, Marcon & Puech (2003a, 2005) proposed a new segregation measure which was inspired by Ripley's K, but where the two problems related to K do not occur. Marcon and Puech's sphere of activity is economic geography. In that field of research – more generally in regional science – measures are used to quantify the clustering of various types of companies. The best-known of these are the coefficient of localisation (which is identical to the dissimilarity index in sociological literature), the location quotients, and Ellison & Glaeser's (1997) γ. Marcon and Puech express the familiar criticism of these measures, namely that they are dependent on the zoning of the study area, the MAUP. They therefore advocate measures in which space is

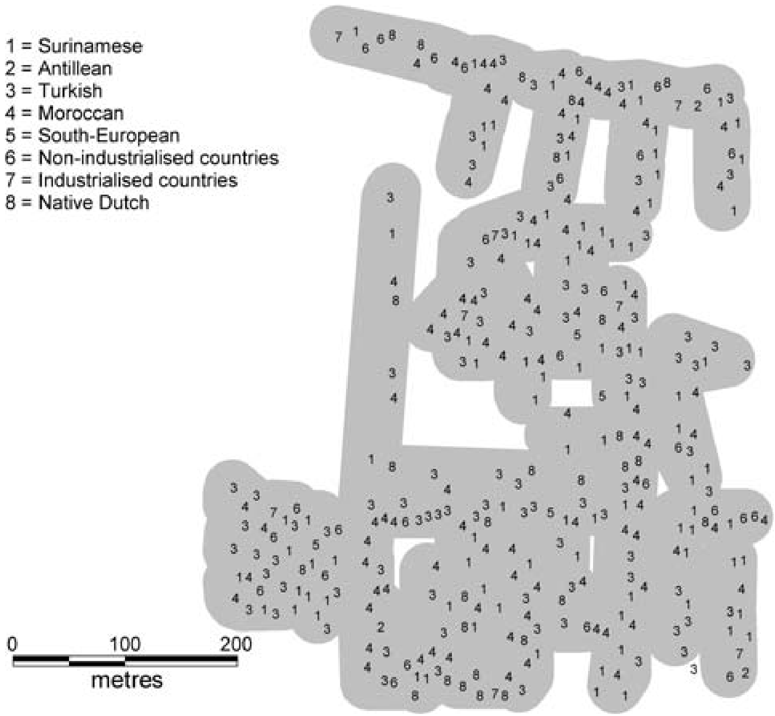

Figure 3. *Ethnic cluster 424.*

regarded as continuous instead of discrete, and make a concrete proposal for such a measure, referred to as M. We focus directly on the bivariate situation: do two different types of companies attract each other or indeed avoid each other. We compare, for example, the distribution of furniture companies (type 1) with those of textile companies (type 2). Their solution appears to be similar to Ripley's but is still clearly different. A circle with radius r is drawn around each furniture company. Then, not only is the number of textile companies counted in each of those circles, but also the number of other furniture companies. Those two numbers are then used to calculate the quotient for each furniture company, after which the quotients are used to calculate the average over all those circles. Finally, that average, that is the average ratio between the number of textile companies and the number of furniture companies in the circles of radius r, is divided by the expected proportion of the two types of companies in the case of a random distribution, in other words by the quotient of the total number of textile companies and the total number of furniture companies (minus one) in the research area as a whole. That produces the measure M_{12}, which can be calculated for all kinds of values of the radius r. The way in which we use this measure means that the following formula is used:

$$M_{12} = \frac{\frac{1}{n}\sum_{i=1}^{n} A_{2i}/A_{1i}}{A_2/(A_1 - 1)} \qquad (1)$$

whereby the following codes are used:

A_1 = the number of furniture companies in the research area as a whole;

A_2 = the number of textile companies in the research area as a whole;

A_{1i} = the number of other furniture companies in the circle around the i^e furniture company;

A_{2i} = the number of textile companies in the circle around the i^e furniture company;

n = the number of furniture companies.

The neutral value of this measure is 1, where the distributions of the furniture companies and of the textile companies over the area are unrelated. Values greater than 1 indicate that the furniture companies attract the textile companies, meaning that the two sorts of companies are often located close together, while values less than 1 indicate that they avoid each other. As noted before, the measure can be calculated for each value of r, meaning that attraction and avoidance can be determined at each scale level. In addition, M is very easy to interpret. Let us say that $M_{12} = 2$ for the circles with radius r. Then in these circles the average ratio of textile companies and furniture companies is twice as high as may be expected on the basis of the ratio in the entire study area. Incidentally, as was the case with K, the measure is asymmetric, meaning that the M_{12} between the furniture companies and the textile companies is not exactly the same as the measure M_{21} between the textile companies and the furniture companies. Of course, the exact locations of the companies have to be known in order to calculate the measure.

In contrast to the K measure, the boundaries of the area play absolutely no disruptive role in the case of the M measure. No correction is needed because the comparison always involves the two sorts of companies in exactly the same area. This advantage applies both to the extent of the study area, which may be arbitrarily small, and the shape of the area, which may be arbitrarily complex. This advantage of the M measure is not expressed that strongly in the Marcon and Puech applications because their study areas are large, for example, covering the whole of France or the whole of Paris. However, at the micro level of our ethnic clusters, the advantage of the M measure is clear and for such situations we believe it deserves more attention than has been the case up to now. Moreover, in the case of the M measure, the presence of swamps, industrial estates, parks, and the interchange of high-rise and low-rise buildings do not generate any problems.

It is also possible to ascertain whether the result of the measure differs *significantly* from 1. Although it is very difficult to calculate the measure's standard error exactly, Monte Carlo simulations can be used to make an estimate. These simulations allow two different strategies to be used. As an example we use the Amsterdam ethnic clusters, and want to check whether Moroccans significantly attract or avoid Turks. In the case of the first strategy, which Marcon and Puech consequently apply (personal communication), the Moroccans continue to live in their dwellings for all simulations, while the Turks for each simulation are arbitrarily distributed across their dwellings and those of all other population groups together. In our opinion, however, an alternative method is preferable. This involves both the Turks *and* the Moroccans being arbitrarily distributed across the dwellings of all population groups together for each simulation. This alternative strategy fits in better with the philosophy of the M measure than the first one. After all, if the distribution of the Moroccans is regarded as fixed, as Marcon and Puech do, and the Moroccans cluster somewhat, as can be expected, the neutral value of the M measure is no longer equal to 1, but is less than 1. In constructing M, deliberately the denominator is chosen to be the quotient of the number of Turks and the number of Moroccans in the area as a whole because that is the expected ratio in the case of a completely random distribution of both Turks and Moroccans. Moreover, it is impossible to apply the strategy of Marcon and Puech in a situation in which only two groups are identified, for example immigrants and native Dutch people. In the following applications we have therefore applied the alternative simulation strategy.

APPLICATION OF THE M MEASURE

In this study we perform a geographical analysis of the ethnic composition and the spatial distribution of the various population groups in two multi-ethnic clusters in Amsterdam. An obvious hypothesis is that the community tends to be more of a harmonious society the more the various ethnic groups live mixed together. The more the various ethnic groups are segregated into ethnic clusters and live apart, the more reason there is to expect a situation of confrontation and opposing attitudes and tensions in the area.

Ethnic clusters in Amsterdam – Since 1970, the Netherlands has indisputably become an immigration country. That fact has created a situation whereby, on 1 January 2003, there were more than 1.6 million non-Western immigrants in the country, that is 10 per cent of the total Dutch population. These migrants are not spread evenly throughout the country but, at the level of municipalities, the social and ethnic segregation in the Netherlands is not that high (Breebaart *et al.* 1996). The four major cities of Amsterdam, Rotterdam, The Hague and Utrecht have a high percentage of non-Western immigrants. The share is highest (36%) in the capital Amsterdam. The three most important immigrant populations in Amsterdam are Surinamese, Moroccans and Turks. All three groups have increased significantly in number since 1970, albeit for a wide variety of reasons. The numbers of Moroccans and Turks increased due to their position as guest workers, and the number of Surinamese increased due to the fact that the former colony became independent. Indeed, for all these groups their number is still increasing to this day.

Over time, Moroccans and Turks have changed their locations (Van Amersfoort 2002). This is because the composition of these population groups changed. In around 1970, the population of Turkish and Moroccan guest workers consisted almost exclusively of single men residing in the city centre in lodgings provided by the private rental sector. After 1985, family reunions meant that these groups consisted primarily of family households which had different needs on the housing market. They took up residence in post-war council housing, which was ideal accommodation for low-income households. Moroccan and Turkish population concentrations emerged in areas in which, due to increased prosperity, the houses had become less attractive for an increasingly large proportion of native Dutch households. Currently therefore, the majority of Turks and Moroccans are to be found in post-war council housing areas, including the former areas of urban renewal, particularly those in the western part of Amsterdam. While the settlement patterns of Moroccans and Turks are very similar, that of the Surinamese immigrants is totally different. They tended to settle in the oldest parts of Amsterdam-Zuidoost ('the Bijlmer'). The start of this process is based on an historical coincidence. The honeycomb flats which native Dutch people were not interested in were completed at exactly the point in time that many Surinamese fled their country due to imminent independence. Because the Surinamese migration has always been of the family migration type, the desire to accept any house available was considerable. In addition, Surinamese more than Turks and Moroccans were prepared to spend a relatively large proportion of their budget on rent. Once this kind of settlement had started, it continued over time. Although a lot of Surinamese moved on to other parts of Amsterdam-Zuidoost or to the suburb of Almere, the accommodation they left behind was soon home to other Surinamese newcomers.

In the meantime Amsterdam has acquired a number of small areas in which one or more ethnic groups are so strongly represented in an absolute sense that this has become visible in the form of their own institutions and in the functioning of the general institutions. These ethnic concentrations are caused primarily by generally active mechanisms on the housing market, particularly with regard to level of income and the composition of the household. However, no clear large-scale ethnically homogenous residential areas have yet developed in Amsterdam.

The segregation in Amsterdam has therefore been caused by a process of succession in residential areas by migrant groups whose living situation reflects their social position. The same has been observed in other countries such as the United Kingdom, Sweden and France (Forrest & Murie 1990). Analyses from the United States and Canada (Peach & Byron 1993) contain indications that this process of increasing concentration of ethnic groups in the public housing stock is a fairly general phenomenon.

Data and choice of ethnic neighbourhoods – In this paper the M measure is illustrated using two ethnic clusters in Amsterdam. In this section we reveal the origin and choice of these neighbourhoods and describe their ethnic composition.

Figure 1 shows the ethnic clusters of (non-Western) immigrants in Amsterdam as of 1 January 2003. These 12 ethnic clusters have been constructed using GIS from a very detailed database at the level of six position postcodes. For a detailed description of the construction method applied, as derived from the Stadsmonitor Amsterdam (Amsterdam city monitor), please see Deurloo & Musterd (1998). The following is a short description.

Table 1. *Number of households of each ethnicity in the two ethnic clusters.*

Cluster ID	Surinamese	Antillean	Turkish	Moroccan	South European	Non-industrialised countries	Industrialised countries	Native Dutch
415	137	16	260	360	27	163	49	256
424	148	9	206	392	18	136	47	289

In total, Amsterdam has approximately 18,000 postcodes. The (x, y) co-ordinates of all addresses of each postcode are known. This means that a postcode can be spatially represented by an area, namely the convex hull of the points which belong to those addresses. In addition, the number of residents of each of the eight ethnic groups distinguished in Amsterdam is also known for each postcode area. Of those eight ethnic groups, five are classed as consisting of (non-Western) immigrants: Surinamese, Antilleans, Moroccans, Turks and residents from the other non-industrialised countries. In total these groups represented 265,224 residents, or 36 per cent of the Amsterdam population, on 1 January 2003. The 12 ethnic clusters in Figure 1 were created in a three-stage process. First, all the postcode areas were selected in which the percentage of (non-Western) immigrants was relatively high on 1 January 2003, namely more than 50.7 per cent (that is two binomial standard deviations above the city percentage of 36%). Each postcode area was extended by a 25 metre buffer zone. Thereafter, those postcode areas, if they overlapped spatially, were combined to form an ethnic cluster. Finally, only those ethnic clusters were selected for which the percentage of immigrants was at least 80 per cent and for which the number of immigrants was at least equal to 1,327 (that is half a percent of the total number of immigrants in the city on 1 January 2003). Of the 12 ethnic clusters, five are in the western part of Amsterdam (of which two are so close together that they appear to share boundaries in Figure 1), and the other seven are in the Zuidoost district.

For the illustration in this study we selected the two ethnic clusters with identification numbers 415 and 424. These are the two largest clusters in which both native Dutch and the four large groups of non-western immigrants (there are clearly fewer Antilleans) are represented in substantial numbers. Both areas are located in the western part of Amsterdam. Hardly any Turk or Moroccan lives in the ethnic clusters in the Zuidoost district.

Our analyses are not based on the segregation of the residents but on the segregation of the households. That seems to be a more logical choice because the household, and not an individual person, is the unit of decision as regards living and residential mobility. This does generate one minor problem because there are also mixed households. These households, which are very rare, are categorised on the basis of the ethnicity of the head of the household.

Table 1 shows the number of households of each ethnicity in both ethnic clusters. As regards the number of households and the ethnic composition, the two clusters are very similar. However, as will be shown in the next paragraph, they differ considerably as regards the degree of segregation.

M measure analysis of the ethnic clusters 415 and 424 – In order to ascertain whether the various ethnic groups live among each other arbitrarily in an ethnic cluster, or whether attraction or avoidance occurs, the residential locations of all households in the ethnic cluster were analysed. This does, however, produce a slight inaccuracy. We only know the 6 position postcode of the households, but not the exact address, and we therefore do not have the exact (x, y) co-ordinates of the residential address. On average in Amsterdam a postcode comprises 42 persons, and 23 households. To solve the problem we used a random procedure to allocate (x, y) co-ordinates to each household within the 10 metre buffered convex hull of the postcode area to which the household belongs. Using this approach means there may be a difference of about 40 to 50 metres as regards the exact residential location. The interpretation of the segregation results should take account of this inaccuracy. However, the error in the M measure for distances above 50 metres is very small, because a single postcode only covers a very small part of the cluster area; in our approximation we only lose segregation at the level of staircase and immediate neighbour.

Figure 2 shows the irregular and whimsical shape of ethnic cluster 415 and gives an impression of the locations of the different ethnic households in that cluster (only non-overlapping labels are shown). Figure 3 shows the same information for ethnic cluster 424.

Figure 4 shows the results of the M analysis for ethnic cluster 415. We only report the results for the five large population groups in the areas that is Surinamese (SUR), Turks (TUR), Moroccans (MOR), residents from other non-industrialised countries (NIN) and native Dutch (NL). The illustration at the top left shows for example, whether Surinamese households live near to native Dutch households. As is the case in all illustrations, the M measure is calculated for values of r going from 20 metres, in 20 metre steps, to the maximum distance between locations of households' houses; in this case 560 metres. These results are linked together by the thick line. In order to estimate the boundaries of the critical region, 20 Monte Carlo simulations were carried out for each value of r. As stated above, the simulations were carried out by randomly reallocating all households within the cluster across all dwellings. The minimum and maximum value of M that were found in those 20 random runs are also shown in the figure and are connected by a dotted line for successive values of r. These dotted lines therefore are an estimate of the bounds of the critical region when testing for segregation with a significance level of 5 per cent Therefore, only when the actual pattern falls outside the dotted lines, one has a significant segregation at that level.

In ethnic cluster 415 hardly any segregation tendencies are evident and the mix between the various ethnic groups is almost perfect. There are slightly less Turkish households near the native Dutch households (see the NL→TUR illustration) than may be expected on the basis of chance. The same applies to native Dutch households in the vicinity of Turkish households, to a distance of around 150 metres. Between 100 and 300 metres, slightly more Surinamese households can be found nearby native Dutch households. However, the deviations are only just in the critical region.

Figure 5 shows, in a similar fashion, the results of the M analysis for ethnic cluster 424. In this ethnic cluster there is both attraction and avoidance between ethnic groups. Native Dutch households are not very often located near Turkish and Moroccan households and not in the vicinity of Surinamese households either. However, to a distance of 150 metres, they are often located in the vicinity of households from other non-industrialised countries. Conversely, we find few Turkish and Moroccan households in the vicinity of native Dutch households up to a distance of 200 metres, and not many Surinamese households either. However, we do find many households from the other non-industrialised countries. In addition, Turkish and Moroccan households often live close to each other and, to a slightly lesser extent, Surinamese households also often live nearby Turkish and Moroccan households. In short, this ethnic cluster exhibits segregation between native Dutch households on the one hand and Moroccan, Turkish and (to a slightly lesser extent) Surinamese households on the other. At short distances the households from the other non-industrialised countries tend to live nearby native Dutch households.

The differences between the clusters 415 and 424 presumably are closely related to differences in the housing stock. It is supposed that the stock in cluster 415 is more homogeneous than the stock in cluster 424. In cluster 415 therefore one finds more mixing than in cluster 424, where 'white bastions' remain. It is worthwhile therefore to portray larger parts of the city which are homogeneous in the sense of cluster 415.

We also carried out analyses for the other three ethnic clusters in the western part of Amsterdam. In one of these there is also clear ethnic residential segregation (the cluster south of cluster 424), in another that is less so (the cluster immediately south of cluster 415 and almost connected to that cluster) and in the third (the cluster left of cluster 415) there is none at all.

We did not carry out a more detailed analysis of the ethnic clusters in the Zuidoost district.

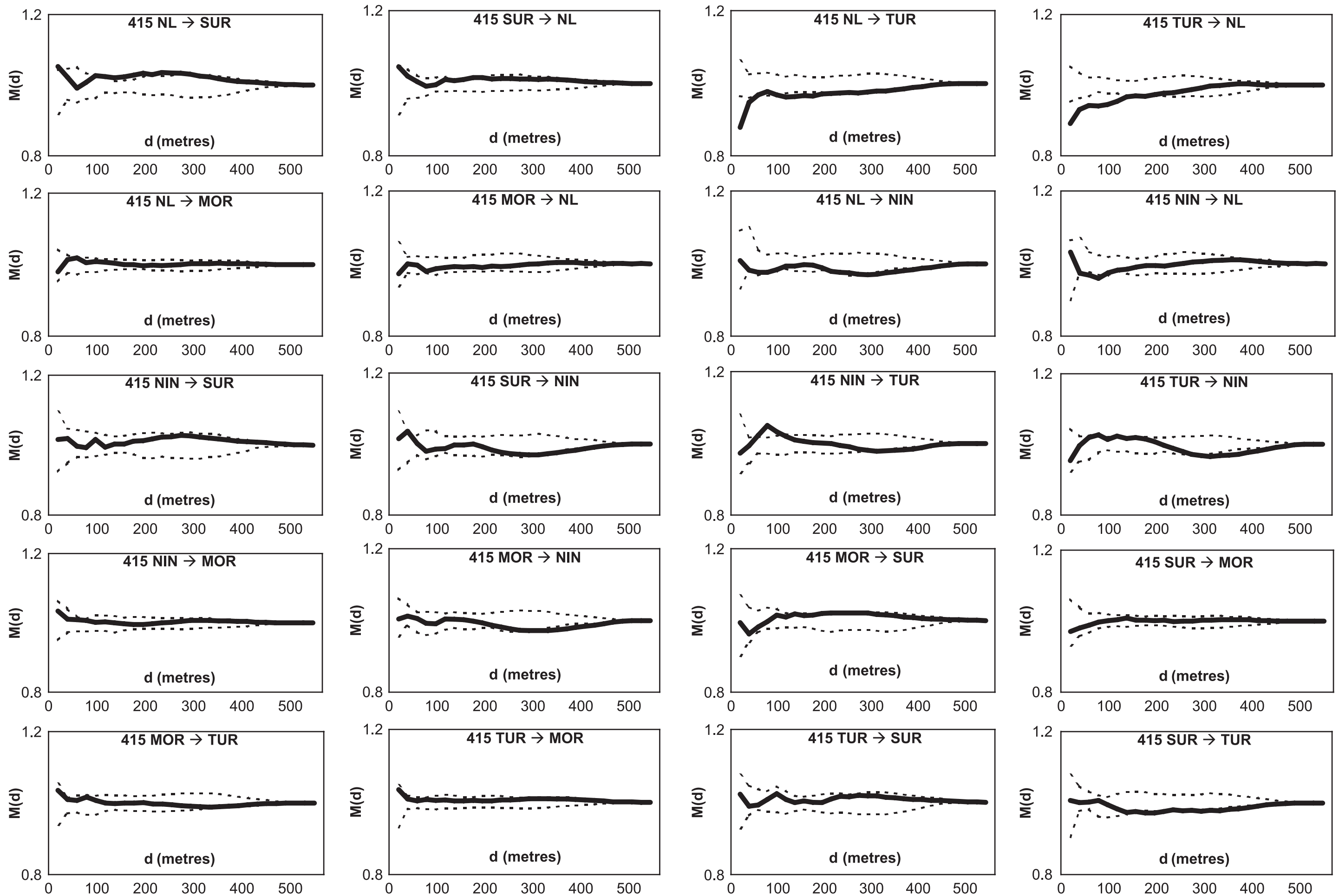

Figure 4. *M values in ethnic cluster 415.*

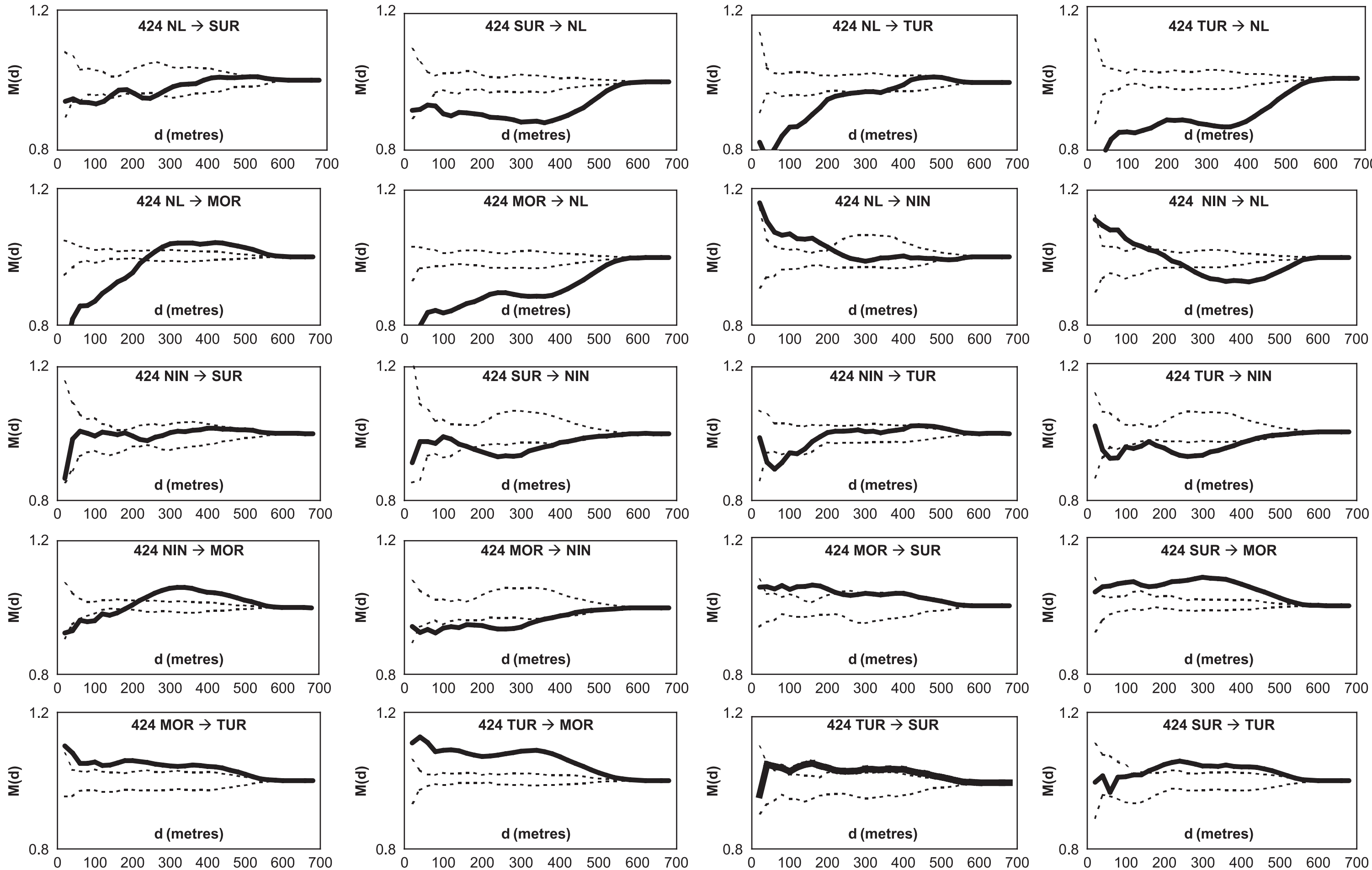

Figure 5. *M values in ethnic cluster 424.*

They are a lot less interesting because very few Turks or Moroccans live there.

Looking at all five clusters in the western part of Amsterdam together, and paying attention especially to the three largest ethnical population groups, we notice a certain trend. At shorter distances up to a few hundred metres native Dutch households are less often present near Moroccan and Turkish households. Moroccan and Turkish households more often live near each other at those shorter distances.

Finally, it has to be stressed that our illustration of the M measure refers to segregation within small areas; not to the overall patterns of segregation in Amsterdam that were set out earlier on.

CONCLUSION

The idea of Robert Park that residential patterns provide an insight into the social relationships between population groups is now widely endorsed. These days, segregation statistics are fully accepted and are regularly referred to in the media and political documents. The segregation measures being used are, however, not very sensitive. In the period 1950–1980, when they were being developed, they were generally satisfactory. However, they are inadequate when it comes to representing today's ethnic diversity which has increased dramatically due to globalisation. Neither do they fit in with the shift in attention in social-scientific research to the micro level, as is currently taking place due to the increasing popularity of geographical information systems (White *et al.* 2005). That popularity is stimulated by the fact that for more and more data a fairly exact location becomes available, especially if the postcode is known.

These changed circumstances require new residential concentration measures. The M measure, which was developed recently in regional science, has the potential to be such a new measure. In this study we have demonstrated the power of this measure in an analysis of the residential segregation at the micro level in mixed-ethnic clusters in Amsterdam. In this context, the M measure performs better than the usual segregation measures. In our opinion, the M measure should therefore be included in the research arsenal of social scientists involved in urban society issues.

REFERENCES

Balakrishnan, T.R. & F. Hou (1999), Socio-economic Integration and Spatial Residential Patterns of Immigrant Groups in Canada. *Population Research and Policy Review* 18, pp. 201–217.

Bell, W. (1954), A Probability Model for the Measurement of Ecological Segregation. *Social Forces* 32, pp. 357–364.

Besag, J.E. (1977), Comments on Ripley's Paper. *Journal of the Royal Statistical Society B* 39, pp. 193–195.

Breebaart, M., S. Musterd & W. Ostendorf (1996), *Etnische Segregatie en Beleid. Een Internationaal Vergelijkend Onderzoek.* Amsterdam: AME.

Briggs, X. de Souza (2003), Bridging Networks, Social Capital, and Racial Segregation in America. Paper presented at the University of Cambridge, January 28.

Burnley, I. (1999), Levels of Immigrant Residential Concentration in Sydney and their Relationship with Disadvantage. *Urban Studies* 36, pp. 1295–1315.

Clark, K. (1965), *Dark Ghetto: Dilemmas of Social Power.* New York: Harper & Row.

Clark, P.J. & F.C. Evans (1954), Distance to Nearest Neighbor as a Measure of Spatial Relationships in Populations. *Ecology* 35, pp. 445–453.

Conley, J., M. Gahegen & J. Macgill (2005), A Genetic Approach to Detecting Clusters in Point Data Sets. *Geographical Analysis* 37, pp. 286–314.

Cortese, C.F., F.R. Falk & J.K. Cohen (1976), Further Considerations of the Methodological Analysis of Segregation Indices. *American Sociological Review* 41, pp. 630–637.

Dacey, M.F. (1962), Analysis of Central Place and Point Patterns by a Nearest Neighbour Method. *Lund Studies in Geography, Series B, Human Geography* 24, pp. 55–75.

Deurloo, M.C. & S. Musterd (1998), Ethnic Clusters in Amsterdam, 1994–96: A Micro-area Analysis. *Urban Studies* 35, pp. 385–396.

Dixon, J., C. Tredoux & B. Clack (2005), On the Micro-ecology of Racial Division: A Neglected Dimension of Segregation. *South African Journal of Psychology* 35, pp. 395–411.

Dixon, P.M. (2002), Ripley's K Function. *In*: A.H. El-Shaarawi & W.W. Piegorsch, eds., *Encyclopedia of Environmetrics* 3, pp. 1796–1803. Chichester: John Wiley & Sons Ltd.

Drever, A.I. & W.A.V. Clark (forthcoming), *Mixed Neighborhoods, Parallel Lives? Residential Proximity* *and Inter-ethnic Group Contact in German Neighborhoods.*

Duncan, O.D. & B. Duncan (1955), A Methodological Analysis of Segregation Indexes. *American Sociological Review* 20, pp. 210–217.

Dunn, K.M. (1998), Rethinking Ethnic Concentration: The Case of Cabramatta Sydney. *Urban Studies* 35, pp. 503–527.

Edin, P.-A., P. Fredriksson & O. Aslund (2003), Ethnic Enclaves and the Economic Success of Immigrants – Evidence from a Natural Experiment. *Quarterly Journal of Economics* 118, pp. 329–357.

Ellison, G. & E.L. Glaeser (1997), Geographic Concentration in US Manufacturing Industries: A Dartboard Approach. *Journal of Political Economy* 105, pp. 889–927.

Elwert, G. (1982), Probleme der Ausländerintegration. Gesellschaftliche Integration durch Binnenintegration? *Kölner Zeitschrift für Soziologie und Sozialpyschologie* 34, pp. 717–731.

Fairbairn, K. & H. Khatun (1989), Residential Segregation and the Intra-urban Migration of South Asians in Edmonton. *Canadian Ethnic Studies* 21, pp. 45–64.

Forrest, J., M.F. Poulsen & R.J. Johnston (2003), Everywhere Different? Globalisation and the Impact of International Migration on Sydney and Melbourne. *Geoforum* 34, pp. 499–510.

Forrest, R. & A. Murie (1990), *Moving the Housing Market: Council Estates, Social Change and Privatisation.* Avebury: Aldershot.

Gatrell, A.C., T.C. Bailey, P.J. Diggle & B.S. Rowlingson (1996), Spatial Point Pattern Analysis and its Application in Geographical Epidemiology. *Transactions, Institute of British Geographers NS* 21, pp. 256–274.

Germain, A. (2000), Immigrants and Cities: Does Neighborhood Matter? Paper presented at the Transatlantic Learning Committee special meeting Montreal, May 23.

Gober, P. (2000), Immigration and North American cities. *Urban Geography* 21, pp. 83–90.

Grannis, R. (1998), The Importance of Trivial Streets. *American Journal of Sociology* 103, pp. 1530–1564.

Haase, P. (1995), Spatial Pattern Analysis in Ecology Based on Ripley's K-function: Introduction and Methods of Edge Correction. *Journal of Vegetation Science* 6, pp. 575–582.

Heckmann, F. (1981), *Die Bundesrepublik: Ein Einwanderungsland?* Stuttgart: Klett-Cotta.

Hillier, A.E. (2003), Spatial Analysis of Historical Redlining: A Methodological Exploration. *Journal of Housing Research* 14, pp. 137–167.

Jakubs, J.F. (1981), A Distance-based Segregation Index. *Socio-economic Planning Sciences* 15, pp. 129–136.

Kapphan, A. (1999), Berlin: Zuwanderung, Segregation und Arbeitsmarkt. *In*: A. Kapphan, ed., Paris-Berlin: Formen und Folgen der Migration, pp. 9–32. Paris: Les Travaux du Centre Marc Bloch Cahier.

Kempen, R. van & A.S. Ozuekren (1998), Ethnic Segregation in Cities: New Forms and Explanations in a Dynamic World. *Urban studies* 35, pp. 1631–1656.

King, L.J. (1962), A Quantitative Expression of the Pattern of Urban Settlements in Selected Areas of the United States. *Tijdschrift voor Economische en Sociale Geografie* 53, pp. 1–7.

Kozol, J. (2005), *The Shame of the Nation: The Restoration of Apartheid Schooling in America.* New York: Crown.

Kulldorff, M. (1997), A Spatial Scan Statistic. *Communications in Statistics: Theory and Methods* 26, pp. 1481–1496.

Levine, N. (2006), Crime Mapping and the CrimeStat Program. *Geographical Analysis* 38, pp. 41–56.

Lieberson, S. (1981), An Asymmetrical Approach to segregation. *In*: C. Peach, V. Robinson & S. Smith, eds., *Ethnic Segregation in Cities*, pp. 61–82. London: Croom Helm.

Lieberson, S. & D.K. Carter (1982), Temporal Changes and Urban Differences in Residential Segregation: A Reconsideration. *The American Journal of Sociology* 88, pp. 296–310.

Lloyd, C., I. Shuttleworth & D. McNair (2004), Measuring Local Segregation in Northern Ireland. International Population Geography Conference, University of St. Andrews, August.

Logan, J.R., D.R. Alba & W. Zhang (2002), Immigrant Enclaves and Ethnic Communities in New York and Los Angeles. *American Sociological Review* 67, pp. 299–322.

Lupton, R. (2003), *Neighbourhood Effects: Can We Measure Them and Does It Matter?* CASE paper 73. London: CASE.

Marcon, E. & F. Puech (2003a), *Measures of the Geographic Concentration of Industries: Improving Distance-based Methods.* Paris: Université Paris I, Cahiers de la MSE, 18.

Marcon, E. & F. Puech (2003b), Evaluating the Geographic Concentration of Industries Using

Distance-based Methods. *Journal of Economic Geography* 3, pp. 409–428.

MARCON, E. & F. PUECH (2005), Measures of the Geographic Concentration of Industries: Improving Distance-based Methods. Working paper. Université Paris I, Cahiers de la MSE.

MARSCHALL, M.J. & D. STOLLE (2004), Race and the City: Neighborhood Context and the Development of Generalized Trust. *Political Behavior* 26, pp. 125–153.

MASSEY, D.S. (1985), Ethnic Residential Segregation: A Theoretical Synthesis and Empirical Review. *Sociology and Social Research* 39, pp. 315–350.

MASSEY, D.S. & N.A. DENTON (1988), The Dimensions of Residential Segregation. *Social Forces* 67, pp. 281–315.

MASSEY, D.S. & N.A. DENTON (1993), *American Apartheid: Segregation and the Making of the Underclass*. Cambridge, MA: Harvard University Press.

MASSEY, D.S., M.J. WHITE & V.-C. PHUA (1996), The Dimensions of Segregation Revisited. *Sociological Methods and Research* 25, pp. 172–206.

MIYARES, I.M. (1997), Changing Perceptions of Space and Place as Measures of Hmong Acculturation. *The Professional Geographer* 49, pp. 214–224.

MOEUR, M. (1993), Characterising Spatial Patterns of Trees Using Stem-mapped Data. *Forest Science* 39, pp. 756–775.

MORGAN, B.S. (1983), A Temporal Perspective on the Properties of the Index of Dissimilarity. *Environment and Planning A* 15, pp. 379–398.

MORIN, R. & M. ROCHEFORT (1998), Quartier et Lien Social: Des Pratiques Individuelles à l'action Collective. *Revue Internationale de l'action Communautaire. Lien Social et Politiques* 39, pp. 103–114.

MORPHET, C.S. (1997), A Statistical Method for the Identification of Spatial Clusters. *Environment and Planning A* 29, pp. 1039–1055.

MORRILL, R.L. (1991), On the Measure of Geographical Segregation. *Geography Research Forum* 11, pp. 25–36.

MORRILL, R.L. (1995), Racial Segregation and Class in a Liberal Metropolis. *Geographical Analysis* 27, pp. 22–41.

MYRDAL, G. (1944), *An American Dilemma: The Negro Problem and Modern Democracy*, 2 vols. New York: Harpers.

OKABE, A. & Y. SADAHIRA (1994), A Statistical Method for Analysing the Spatial Relationship between the Distribution of Activity Points and the Distribution of Activity Continuously Distributed over a Region. *Geographical Analysis* 26, pp. 152–167.

OLIVER, J.E. & J. WONG (2003), Intergroup Prejudice in Multiethnic Settings. *American Journal of Political Science* 47, pp. 567–582.

OMER, I. & I. BENENSON (2002), Investigating Fine Scale Residential Segregation by Means of Local Spatial Statistics. *Geography Research Forum* 12, pp. 41–60.

OPENSHAW, S. (1984), *The Modifiable Areal Unit Problem. Concepts and Techniques in Modern Geography* 38. Norwich: GeoBooks.

OPENSHAW, S., M. CHARLTON, C. WYMER & A. CRAFT (1987), A Mark 1 Geographical Analysis Machine for the Automated Analysis of Point Data Sets. *International Journal of Geographical Information Systems* 1, pp. 335–358.

PARK, R.E. (1926), The Urban Community as a Spatial Pattern and a Moral Order. *In*: E.W. BURGESS, ed., *The Urban Community*, pp. 3–18. Chicago: University of Chicago Press.

PARK, R.E., E.W. BURGESS & R.D. MCKENZIE (1925), *The City*. Chicago: University of Chicago Press.

PEACH, C. & M. BYRON (1993), Caribbean Tenants in Council Housing: Race, Class and Gender. *New Community* 19, pp. 407–423.

RAY, B. (1994), Immigrant Settlement and Housing in Metropolitan Toronto. *The Canadian Geographer* 38, pp. 262–265.

RAY, B. (1999), Plural Geographies in Canadian Cities: Interpreting Immigrant Residential Spaces in Toronto and Montreal. *Canadian Journal of Regional Science* 22, pp. 65–86.

REARDON, S.F. & G. FIREBAUGH (2002), Measures of Multigroup Segregation. *Sociological Methodology* 32, pp. 33–67.

REARDON, S.F. & D. O'SULLIVAN (2004), Measures of Spatial Segregation. *Sociological Methodology* 34, pp. 121–162.

REARDON, S.F., S.A. MATTHEWS, D. O'SULLIVAN, B.A. LEE, G. FIREBAUGH & C.R. FARRELL (2006), The Segregation Profile: Investigating How Metropolitan Racial Segregation varies by Spatial Scale. The Pennsylvania State University, Population Research Institute, Working Paper 06-01.

RIPLEY, B.D. (1977), Modelling Spatial Patterns. *Journal of the Royal Statistical Society* B 39, pp. 172–192.

RIPLEY, B.D. (1981), *Spatial Statistics*. Chichester: John Wiley.

ROGERS, A. (1965), A Stochastic Analysis of the Spatial Clustering of Retail Establishments. *Journal* *of the American Statistical Association* 60, pp. 1094–1102.

Rosenbaum, J., L. Reynolds & S. Deluca (2002), How Do Places Matter? The Geography of Opportunity, Self-efficacy, and a Look Inside the Black Box of Residential Mobility. *Housing Studies* 17, pp. 71–82.

Stoyan, D. & H. Stoyan (1994), *Fractals, Random Shapes and Point Fields, Methods of Geometrical Statistics.* Chichester: Wiley.

Taeuber, K.E. & A.F. Taeuber (1965), *Negroes in Cities.* Chicago: Aldine.

Thompson, H.R. (1956), Distribution of Distance to nth Neighbor in a Population of Randomly Distributed Individuals. *Ecology* 37, pp. 391–394.

US Census Bureau (2005), *Housing Patterns, Appendix B: Measures of Residential Segregation.* Accessed at <http://www.census.gov/hhes/www/housing/resseg/app_b.html>.

Van Amersfoort, H. (2002), Immigratie, Hoogconjunctuur en Uitsortering. *In*: S. Musterd & H. Ottens, eds., *Strijd om de Stad*, pp. 19–31. Assen: Van Gorcum.

White, M.J. (1983), The Measurement of Spatial Segregation. *American Journal of Sociology* 88, pp. 1008–1018.

White, M.J. (1986), Segregation and Diversity Measures in Population Distribution. *Population Index* 52, pp. 198–221.

White, M.J. (1987), Neighborhood Diversity and Segregation. *In*: M.J. White, ed., *American Neighborhoods and Residential Segregation*, pp. 82–116. New York: Russell Sage.

White, M.J., J.E. Glick & A.H. Kim (2005), Mapping Social Distance: Ethnic Residential Segregation in a Multiethnic Metro. *Sociological Methods and Research* 34, pp. 173–203.

Wilson, K. & A. Portes (1980), Immigrant Enclaves: An Analysis of the Labor Market Experiences of Cubans in Miami. *American Journal of Sociology* 8, pp. 135–169.

Wong, D.W. (1993), Spatial Indices of Segregation. *Urban Studies* 30, pp. 559–572.

Wong, D.W. (2005a), Desktop and Internet GIS Development for Spatial Segregation Analysis. Accessed at <http://gis.esri.com/library/userconf/proc01/professional/papers/pap275/p275.htm>.

Wong, D.W. (2005b), Formulating a General Spatial Segregation Measure. *The Professional Geographer* 57, pp. 285–294.

Yamada, I. & P.A. Rogerson (2003), An Empirical Comparison of Edge Effect Correction Methods Applied to K-function Analysis. *Geographical Analysis* 35, pp. 97–109.