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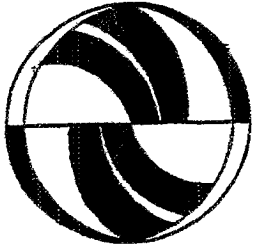
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Authors

Bagley, Michael N.
Mokhtarian, Patricia L.
Kitamura, Ryuichi

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UCTC
No 608

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University of California
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108 Naval Architecture Building
Berkeley, California 94720
Tel 510/643-7378
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**A Methodology for the Disaggregate, Multidimensional Measurement of
Residential Neighbourhood Type**

Michael N. Bagley

South Texas Community College
P O Box 9701
McAllen, TX 78502-9701
mnbagley@stcc cc tx us

Patricia L. Mokhtarian

Department of Civil and Environmental Engineering
University of California, Davis CA 95616
plmokhtarian@ucdavis edu

Ryuichi Kitamura

Department of Transport Engineering
Kyoto University
Sakyo-ku, Kyoto 606, Japan
rkitamura@term.kuciv.kyoto-u.ac.jp

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A Methodology for the Disaggregate, Multidimensional Measurement of Residential Neighbourhood Type

Michael N. Bagley, Patricia L. Mokhtarian and Ryuichi Kitamura

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Summary. Binary designation of a residential neighbourhood as either traditional or suburban is a distortion of reality, since a location may have some characteristics of both types and since residents in different parts of the neighbourhood may perceive its character differently. This paper presents and applies a methodology for assessing neighbourhood type that results in a measure that is continuous rather than binary, disaggregate rather than aggregate, and potentially multidimensional. Specifically, 18 variables identified by the literature as distinguishing traditional and suburban locations are measured for 852 residents of 5 San Francisco area neighbourhoods. These data are factor-analysed to develop scales on which each individual has a person-specific score. Although we expected a single 'traditionalness' dimension to result, instead we found two factors: traditional and suburban. Study neighbourhoods could and did score highly on both dimensions, and considerable individual variation within neighbourhood was observed. By more accurately capturing the complexity in classifying a neighbourhood and the heterogeneity of individual perception within a neighbourhood, use of this methodology to measure neighbourhood type is expected to improve models involving residential location as an endogenous or exogenous variable.

1. Introduction

The need to identify residential neighbourhood types arises in at least two main contexts. In residential choice or location studies, the residential neighbourhood is the dependent variable. In a number of transport studies, neighbourhood is an explanatory variable, with different types of neighbourhood demonstrated to be associated with different travel patterns. Many approaches to characterising neighbourhoods have ap-

peared in the residential choice and transport literatures. In some cases (for example, Lansing and Marans, 1969; Lu, 1998), neighbourhood boundaries were not defined at all; 'neighbourhood' took on individual meanings for each respondent. At the opposite extreme, neighbourhood boundaries have sometimes been chosen to coincide with census tracts or zip code areas (for example, Boarnet and Sarmiento, 1998, Cervero and

Michael N Bagley is in the South Texas Community College, PO Box 9701, McAllen, Texas 78502 9701, USA Fax. 956 688 2117 E-mail mnbagley@stcc.cc.tx.us Patricia L Mokhtarian is in the Institute of Transport Studies, University of California, Davis, California 95616, USA Fax 530 752 6572 E-mail plmokhtarian@ucdavis.edu. Ryuichi Kitamura is in the Department of Transport Engineering, Kyoto University, Sakyo-ku, Kyoto 606, Japan. Fax 81 75 753 5135 E-mail rkitamura@term.kuciv.kyoto-u.ac.jp The data analysed in this paper were collected under Contract No A132-103 with the California Air Resources Board. The authors wish to express their thanks to the many important contributors to this study, including Laura Laidet, Carol Buckanger and Fred Gianelli of UC Davis, and Terry Parker, Fereidun Feizollahi and Anne Geraghty of the Air Resources Board.

Kockelman, 1997; Heikkila *et al.*, 1989; Horowitz, 1995; Waddell, 1993; Weisbrod *et al.*, 1980)

It can be argued that characterising neighbourhoods in generic terms would yield results that are more likely to be transferable to other contexts, compared to defining them in terms of their unique census tract designation. Hence, other studies have defined neighbourhoods in terms of various characteristics rather than as a geographical location *per se*. Among these studies, some researchers have viewed proximity to the urban city centre as paramount, defining neighbourhoods with terms such as urban (located in or close to the central business district area) and suburban (see, for example, Aldana *et al.*, 1973; Boehm and Ihlanfeld, 1991; Kam and Quigley, 1970; and Prevedouros, 1992).

Other researchers have focused more on the internal characteristics of the neighbourhoods themselves, rather than on their location within the region. In those studies, 'suburban' refers more to a particular mix of intrinsic traits than to the distance from the central business district, and the opposite extreme is generally labelled 'traditional', 'neo-traditional', 'new urban' or simply 'urban'. As discussed further in section 2.2, traditional neighbourhoods (see, for example, Calthorpe and Richmond, 1992; Fulton, 1996) are characterised by higher densities, mixed land uses, a grid street pattern and support for non-automobile modes such as transit, walking and cycling. Suburban neighbourhoods are characterised by segregated land uses, curvilinear streets with cul-de-sacs and an automobile orientation.

Although many neighbourhood traits other than 'suburbanness' have been the subject of study (74 such traits were used to define Jacksonville, Florida, in a study by Sawicki and Flynn, 1996), the suburban-traditional dichotomy has been particularly prominent in the transport literature, in which the travel patterns of residents of each kind of neighbourhood are contrasted. In light of a number of studies demonstrating that traditional developments are associated with fewer ve-

hicle-trips and less distance travelled (for example, Ewing *et al.*, 1994, Frank and Pivo, 1994, Friedman *et al.*, 1994, Rutherford *et al.*, 1996; Kitamura *et al.*, 1997), the notion of employing land-use policy as a tool to reduce vehicular travel continues to be a popular one. For example, the US Environmental Protection Agency has developed guidelines for allowing air quality improvement credit for developments considered to exhibit traditional characteristics (see, for example, Jack Faucett Associates and Sierra Research, 1999; US EPA, 2001)

Obviously, a central element of this approach, both in research on the subject and in practical policy-making, is the classification of a particular neighbourhood as traditional or suburban. There are several problems with this dichotomous approach to classifying neighbourhoods. First, traditionalness-suburbanness is not an either-or condition; rather, it is a continuum along which it is possible to fall. Further, it is not a monolithic construct; rather, neighbourhood type designation is a composite of a number of traits and it is possible for a neighbourhood to look more traditional on some traits and more suburban on others. Thus, neighbourhood type may involve multiple dimensions rather than a single continuum. A number of empirical studies (for example, Ewing *et al.*, 1994; Handy, 1993, 1996) implicitly acknowledge this diversity of land-use patterns through separately analysing more than two specific neighbourhoods, but do not quantify it. Finally, within the same area identifiable as a neighbourhood, characteristics will vary such that some residents may experience (or perceive) a more traditional neighbourhood, while others will find it more suburban. As neighbourhoods should be defined in terms of what they mean for residents (Handy, 2002), a disaggregate measure is more appropriate for capturing the variations in individuals' perceptions of where they live.

For all of these reasons, restricting the designation of an entire neighbourhood to one of two discrete types either results in discarding considerable data (for 'hybrid' neighbourhoods) or distorting the subsequent

analysis (through misclassification). Thus, for example, a person living in a high-density, transit-served corner of a census tract that otherwise appears to be a suburb (and is categorised as one by a researcher) may bias travel demand model results by increasing the average number of transit trips taken by a 'suburban' respondent.

In response to these problems, this paper presents and applies a factor-analysis-based approach for assessing neighbourhood type. This methodology yields a measure that is continuous rather than binary, disaggregate rather than aggregate, and multidimensional if appropriate (as was the case in our empirical application). By more accurately capturing the complexity in classifying a neighbourhood, and the heterogeneity of individual perception within neighbourhood, use of this methodology to measure neighbourhood type is expected to improve models involving residential location as an endogenous or exogenous variable.

The organisation of this paper is as follows: the next section describes the empirical context and some key characteristics of the sample. Section 3 presents the factor analysis approach and results, including a comparison of the one-dimensional aggregate and disaggregate solutions to the two-dimensional disaggregate solution. Section 4 summarises and discusses the results.

2. Empirical Setting and Data Available

2.1 Empirical Context

The data used for this study were originally collected for a land use-travel behaviour project sponsored by the California Air Resources Board in 1992. Micro-scale data on land use, the roadway network and public transit were obtained from site surveys of five San Francisco Bay Area neighbourhoods (selected sections of approximately 1 square mile within the cities or areas of Concord, Pleasant Hill, North San Francisco, South San Francisco and San Jose). In addition, demographic, socioeconomic, attitudinal, lifestyle and travel-related data were col-

lected through mail-out surveys and travel diaries completed by residents in the same neighbourhoods. The main objective of the original study was to examine the impacts of neighbourhood type (i.e. land use) and individual attitudes on travel behaviour (Kitamura *et al.*, 1997). Thus, the neighbourhoods were selected to represent a range of values on key characteristics of land-use type, including public transit accessibility, land-use mix, residential density and employment mix.

About 18 per cent of those initially contacted (randomly selected from address lists covering the study neighbourhoods) agreed to participate and 60 per cent of those completed all 3 surveys involved. From the 963 households completing any of the surveys, 852 individuals from different households, having relatively complete information on the key variables used here, were selected for this study.

Since demographic composition is not a central focus of this analysis, a detailed tabulation of the sample characteristics is omitted for brevity (but is available in Bagley, 1999). Respondents tended to be professional, well-educated, with moderate incomes. The average age was 50, the average household size was 2.3 people. Respondents were long-time residents of the Bay Area—29 years on average. Each driver typically had a vehicle available and the average one-way commute distance was 12 miles. The average 4.2 person-trips per day is consistent with travel diary results from other studies such as the 1995 Nationwide Personal Transportation Study (FHWA, 1997).

2.2 Variables Associated with Neighbourhood Type

A respondent in this study lives in one of five neighbourhoods, each of which could be considered an indicator of residential choice. However, to develop residential choice models that are robust and transferable, the generic characteristics of a neighbourhood are of greater interest than a specific geographical location itself. In view of its potential im-

portance for travel behaviour, the concept of 'traditionalness' is the key characteristic chosen for this study (although in different contexts, many other traits such as aesthetic appeal could be relevant).

A review of the literature on land use and travel (see, for example, Cervero and Radisch, 1996; Southworth, 1997; and Tong and Wong, 1997) identifies many characteristics distinguishing traditional from suburban neighbourhoods. Friedman *et al.* (1994, p. 64) categorised 550 San Francisco Bay Area communities geographically defined by census tracts as suburban if they: "[were] developed since the early 1950s with segregated land uses", "[had] a well-defined hierarchy of roads", "concentrate[d] site access at a few key points" and "[had] relatively little transit service". The authors established the following criteria for communities to be characterised as traditional: "were mostly developed before World War II", "had a mixed-use downtown commercial district with significant on-street curbside parking" and "had an interconnecting street grid and residential neighbourhoods in close proximity to nonresidential land uses" (p. 64).

Cervero and Kockelman (1997), in a study of how the built environment impacts travel demand, considered a large number of neighbourhood variables, including pedestrian-related factors such as sidewalk and bike path supply, automobile-related factors such as amount of parking and average arterial speed limits and density-related factors such as nearness to stores and number of jobs per acre. Ryan and McNally (1995) presented design concepts for neotraditional neighbourhoods (i.e. areas similar to traditional neighbourhoods but built at a later time-period) and noted that the main design goal of 'neotraditionalists' was to implement neighbourhood design characteristics that would create a "coherent neighbourhood unit" that, while still useable by car, would "de-emphasise and discourage its use" (p. 93). Design characteristics viewed as supporting this goal included interconnected street networks, centralised retail and office space, and pedestrian and bicycle pathways.

Measures on 18 of these characteristics were available in our data-set: 15 at disaggregate levels, obtained from the questionnaires (for example, perceived pleasantness of walking and cycling in the neighbourhood, parking availability, distance to nearest public transit and grocery store, presence of sidewalks) and 3 only at aggregate (neighbourhood-wide) levels, obtained from the site surveys (average speed limit, indicator of grid street system and indicator of population density). The average value by neighbourhood for each of these characteristics is shown in Table 1.

The variables shown in Table 1 relate to various aspects of traditionalness or suburbaness. For example, 'number of parking spaces available for household use' is a proxy for residential density and/or household dependence on personal vehicles. A high mean value for this trait would tend to be associated with a suburban residential location. Conversely, a high mean value on 'good local public transit in your neighbourhood' would be more indicative of a traditional neighbourhood. Both of these examples support the prior field-visit conclusions that the North San Francisco neighbourhood is a good example of a traditional location (note the low mean value for parking, 1.43, and the high mean value for transit, 0.98) and that the San Jose neighbourhood is a good example of a suburban location (with a high mean value for parking, 4.02, and a low mean value for transit, 0.72).

In some cases, neighbourhoods have high values on some characteristics that are representative of traditional locations and also have high values on other, typically suburban, characteristics. For example, Pleasant Hill has a high mean value for the traditional characteristic 'good local public transit in your neighbourhood' and a high value for the suburban characteristics 'distance in miles to nearest park' and 'grocery store'. This is an indication that neighbourhoods can have both traditional and suburban characteristics, and lends support to the contention that a continuous measure of location type is more

appropriate for modelling than the common binary measures.

3. Factor Analysis Approach

Factor analysis, or principal component analysis (Rummel, 1970), is a method for extracting a smaller number of essentially independent dimensions from a larger number of correlated variables. This approach has previously been used to develop residential location characteristics. Cervero and Kockelman (1997), for example, identified two dimensions that defined their study neighbourhoods 'walking quality' (a factor based on attributes such as sidewalk availability and block length) and 'intensity' (a factor based on attributes such as population density and retail store availability). To *et al* (1983) used principal components analysis to define a housing quantity variable. The current study, however, is distinctive in its use of such factors as endogenous measures of residential location type, to be embedded in a structural equations model expressing interrelationships between travel behaviour and land-use patterns (Bagley and Mokhtarian, forthcoming).

To develop those measures, we applied factor analysis to the 18 variables shown in Table 1. Various factor structures were hypothesised *a priori*. One hypothesis was that a single dimension of traditionalness would emerge, with the factor analysis essentially providing the 'optimal' weights for combining the 18 variables into a single composite index. Another hypothesis was that 3 dimensions might emerge, along the lines of density, accessibility and pedestrian-friendliness. Multiple factor analyses were performed to determine what structures were most appropriate

For purposes of comparison, factor analyses were conducted on both disaggregate and aggregate (neighbourhood-level) data. In Table 1, the first three characteristics—speed limit of road, grid-like street configuration and population density—are aggregate values in that they are not differentiated by

respondent. Though it is acknowledged that the values for these characteristics could differ across participants in the same neighbourhood, disaggregate data were not available, and, consequently, in the disaggregate database, the mean value for each neighbourhood was assigned to each respondent in the corresponding neighbourhood. The remaining 15 characteristics, on the other hand, vary across respondents. For those variables, in the aggregate database, the mean value across all respondents in a given neighbourhood was assigned to that neighbourhood.

Thus, separate data-sets with aggregate and disaggregate values for the 18 characteristics were constructed. The aggregate approach is of interest because so many residential location studies characterise location at an aggregate level, typically in terms of zonal averages. However, the aggregate analysis has at least two weaknesses. First, reducing individuals' responses to neighbourhood averages leaves a database that has only 5 cases (each neighbourhood being a case or sample point). Secondly, as has been discussed previously and as the standard deviations of Table 1 confirm, most of the 15 disaggregate characteristics vary within each neighbourhood and using an aggregate measure may seriously misrepresent certain respondents. Both of these weaknesses are addressed by the disaggregate analysis.

Analyses extracting three, two and one factors, respectively, were performed using SPSS 8.0 on the disaggregate ($N = 852$) data-set and a one-factor extraction was completed on the aggregate ($N = 5$) data-set (with so few cases, extracting more than one dimension was not appropriate). Several extraction (principal components and principal axis factoring) and rotation (varimax and oblique) methods were conducted in the factor analysis. Results were consistent among all combinations of methods, but the outcomes reported below are based on principal components extraction and (for the two-factor disaggregate analysis) oblique rotation, since this combination explained the most variation in the data and was the most interpretable.

Table 1. Characteristics used to measure neighbourhood type ($N = 852$)

Characteristic ^a	Data type ^b	Mean value of characteristic (standard deviation within neighbourhood)				
		NSF ($N = 155$)	SSF ($N = 168$)	CON ($N = 165$)	PH ($N = 192$)	SJ ($N = 172$)
Speed limit of road (S)	C, A	25.19 (0.00)	25.31 (0.00)	25.54 (0.00)	25.82 (0.00)	25.52 (0.00)
Grid-like street configuration (T) high = 1, medium = 0.5, low = 0	B, A	1 (0.00)	0 (0.00)	0.5 (0.00)	0 (0.00)	0.5 (0.00)
Population density (T) high = 1, low = 0	B, A	1 (0.00)	1 (0.00)	0 (0.00)	1 (0.00)	0 (0.00)
Size of home in square feet (S)	C, I	1366.6 (805.6)	1837.9 (834.4)	1551.5 (452.7)	1348.6 (608.4)	1687.2 (379.8)
Have a back yard (S) yes = 1, no = 0	B, I	0.47 (0.50)	0.93 (0.25)	0.97 (0.17)	0.54 (0.50)	0.97 (0.17)
Streets in neighbourhood pleasant for walking/jogging (T) yes = 1, no = 0	B, I	0.84 (0.37)	0.90 (0.30)	0.91 (0.29)	0.86 (0.35)	0.95 (0.23)
Cycling is pleasant in your neighbourhood (T) yes = 1, no = 0	B, I	0.63 (0.48)	0.49 (0.50)	0.90 (0.29)	0.94 (0.24)	0.84 (0.37)
Good local public transit in your neighbourhood (T) yes = 1, no = 0	B, I	0.98 (0.14)	0.94 (0.23)	0.86 (0.34)	0.91 (0.28)	0.72 (0.45)
Enough parking space near your home (S) yes = 1, no = 0	B, I	0.48 (0.50)	0.77 (0.42)	0.89 (0.32)	0.76 (0.43)	0.91 (0.29)
Problems of traffic congestion in your neighbourhood (T) yes = 1, no = 0	B, I	0.35 (0.48)	0.24 (0.43)	0.32 (0.47)	0.59 (0.49)	0.36 (0.48)

Distance in miles from your home to nearest public transit option (S)	C, I	0.24 (0.52)	0.28 (0.48)	0.25 (0.23)	0.35 (0.50)	0.51 (0.61)
Sidewalks are in your neighbourhood (T) yes = 1, no = 0	B, I	1.00 (0.00)	1.00 (0.00)	0.60 (0.49)	0.76 (0.43)	0.99 (0.11)
Bike paths are in your neighbourhood (T) yes = 1, no = 0	B, I	0.31 (0.46)	0.04 (0.20)	0.79 (0.41)	0.91 (0.29)	0.44 (0.50)
Public transit is convenient in your neighbourhood (T) yes = 1, no = 0	B, I	0.97 (0.18)	0.92 (0.27)	0.95 (0.23)	0.98 (0.14)	0.63 (0.49)
Number of parking spaces available for household use (S)	C, I	1.43 (1.04)	2.23 (1.15)	4.06 (2.08)	2.83 (3.24)	4.02 (1.48)
Distance in miles to nearest grocery store (S)	C, I	0.45 (0.50)	0.64 (0.56)	0.77 (0.57)	1.06 (0.79)	0.95 (0.66)
Distance in miles to nearest gas station (S)	C, I	0.47 (0.74)	0.91 (0.67)	0.72 (0.57)	0.82 (0.55)	0.90 (0.84)
Distance in miles to nearest park or playground (S)	C, I	0.51 (0.79)	0.65 (0.77)	0.70 (0.60)	1.45 (1.21)	0.68 (0.52)

^a(T) indicates that a traditional location is hypothesised to have a higher mean value for this characteristic than a suburban (S) location
^bThe characteristic data, being either effectively continuous (C) or binary (B), are taken from both aggregate (A, averages based on each neighbourhood as a whole) and disaggregate sources (I, averages based on individual responses)

Table 2. Factor loadings for one-factor aggregate and disaggregate structures (level of traditionalness)

Characteristic ^a	Loading	
	Aggregate	Disaggregate
Enough parking available near home ^b	-0.95	-0.36
Number of parking spaces for HH use	-0.94	-0.41
Good public transit	0.88	0.28
Distance to nearest grocery store (miles)	-0.84	-0.53
Streets are pleasant for walking	-0.81	-0.16
Distance to nearest gas station (miles)	-0.74	-0.35
Population density (1 = high, 0 = low)	0.73	0.41
Distance to nearest public transit (miles)	-0.73	-0.26
Speed limit of roads (mph)	-0.70	-0.79
Cycling is pleasant	-0.66	-0.44
Have own backyard	-0.65	-0.21
Public transit is convenient	0.63	0.18
Bike paths are present	-0.46	-0.56
Level of grid-like street network (1 = high, 0 = low)	0.42	0.45
Sidewalks are present	0.37	0.36
Distance to closest park (miles)	-0.34	-0.35
Home size (1000 square feet)	-0.31	-0.05
Traffic congestion is present	-0.21	-0.10

^aThe characteristics are ranked by the magnitudes of their loadings on the single aggregate factor for neighbourhood type—*traditionalness*

^bCharacteristics based on a statement like 'enough parking available near home' have a value equal to 1 if the respondent answered yes, and a value equal to 0 if the respondent answered no (see Table 1)

3.1 One-dimensional Aggregate and Disaggregate Factor Analyses

Table 2 presents the factor loadings for the one-factor aggregate and disaggregate structures. Both factor structures represent the measurement of the attribute, level of traditionalness, along a single continuum. The single aggregate factor explains 44.7 per cent of the total variation in the 18 neighbourhood characteristics. Characteristics that are primary determinants of this factor include: 'enough parking available near home' (loading = -0.95), 'good public transit' (loading = 0.88) and 'population density' (loading = 0.73). Neighbourhoods that have high, positive scores for this factor are considered to be more traditional than neighbourhoods that have a low value for it. The standardised scores for the five neighbourhoods on this aggregate factor are 1.51 for

North San Francisco, 0.38 for South San Francisco, -0.29 for Pleasant Hill, -0.48 for Concord and -1.13 for San Jose (see Figure 1)

The single disaggregate factor for level of traditionalness explains 15.2 per cent of the total variation in the 18 neighbourhood characteristics. The disaggregate data have far more variability to explain than do the aggregate data ($N = 852$ versus $N = 5$) and, consequently, the fact that the disaggregate factor explains a far smaller proportion of that variance than does the aggregate factor is not viewed as an indication that the aggregate factor is superior. Characteristics that are primary determinants of the single disaggregate factor include: 'speed limits of roads' (loading = -0.79), 'bike paths are present' (loading = -0.56) and 'level of grid-like street network' (loading = 0.45). As before, neighbourhoods that have high, positive

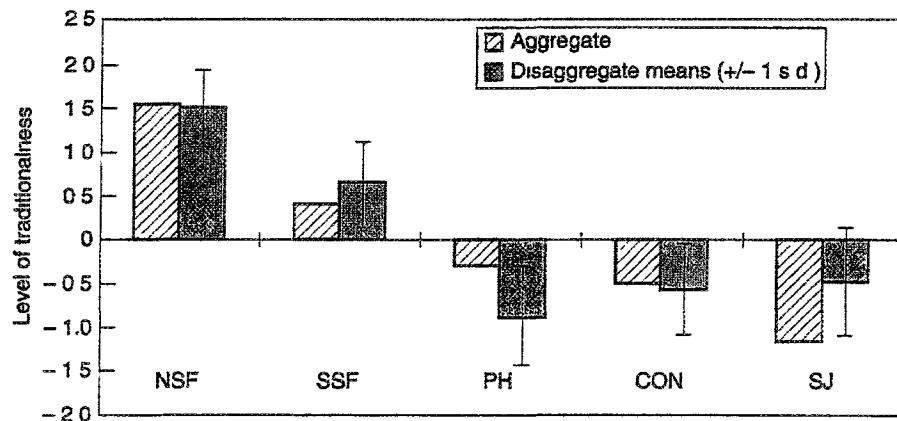


Figure 1. Factor scores for one-dimensional solutions

scores for this factor are considered to be more traditional than neighbourhoods that have a low value for it. The means (and standard deviations) of the disaggregate standardised factor score for the 5 neighbourhoods are 1.47 (0.44) for North San Francisco, 0.63 (0.48) for South San Francisco, -0.85 (0.53) for Pleasant Hill, -0.55 (0.50) for Concord and -0.46 (0.60) for San Jose.

The empirical findings generally match expectations, as the two San Francisco neighbourhoods cluster on the 'traditional' side of the neighbourhood measure with the only positive scores, while the other three neighbourhoods cluster on the suburban side with negative scores. The quintessentially traditional neighbourhood of North San Francisco has the highest positive mean factor score on both the aggregate and disaggregate measures of level of traditionalness (having high values on traditional characteristics such as grid-like street networks and public transit accessibility), while the stereotypical suburban neighbourhood San Jose has a negative mean factor score on both measures (having high values on suburban characteristics such as number of parking spaces and distance to shopping). Although the ordering among the three suburban neighbourhoods differs between the two solutions, each aggregate score falls within about one standard deviation

of the corresponding mean disaggregate score.

Inspection of Table 2 shows that the factor loadings for all characteristics have the same sign in each of the two structures, an indicator of some convergence between the two methods. However, the magnitudes of the factor loadings differ between the aggregate and disaggregate solutions. For example, the loading on the characteristic 'enough parking available near home' is -0.95 for the aggregate solution (it is the characteristic with the highest loading), but only -0.36 for the one-factor disaggregate solution. This discrepancy makes it difficult to identify confidently which characteristics are the most important determinants of a neighbourhood's level of traditionalness.

The signs of the factor loadings (which represent the correlation between the characteristics and the level of traditionalness dimension) matched expectations for 15 of the 18 characteristics. For example, 'enough parking available near home' and 'distance to nearest grocery store' had large negative loadings, indicating that neighbourhoods that have high mean values for these characteristics would align more on the suburban dimension than on the traditional dimension. The three characteristics with unexpected loadings (all negative) were 'streets are pleasant for walking', 'cycling is pleasant'

and 'bike paths are present'. These were expected to have positive loadings since previous research has shown that respondents in traditional neighbourhoods are more likely to take non-motorised modes of travel than respondents from suburban neighbourhoods (see, for example, Kitamura *et al.*, 1997). An inspection of Table 1 shows that the three neighbourhoods categorised as suburban (Concord, Pleasant Hill and San Jose) had the highest neighbourhood means for the characteristics 'cycling is pleasant' and 'bike paths are present' (while also having very high means on the characteristic 'streets are pleasant for walking'). Thus, the negative factor loadings make sense given the data, though they do not conform to the romanticised image of traditional neighbourhoods being the places for relaxed walk and bike trips. Instead, they suggest a different stereotype—of broad, quiet, tree-lined suburban streets contrasted with noisy, congested urban streets. In a similar vein, Handy (1996) found that suburban residents engaged in undirected walking trips (i.e. strolling around the neighbourhood) almost as much as their urban counterparts, and that motivations to walk or not were rooted more strongly in personal than in urban form characteristics (However, she found significantly higher rates of directed walking trips – to an intended destination such as a store – among the urban-dwellers)

For the aggregate solution, NSF and SSF had the lowest means on negatively loading traits and the highest on positively loading traits for most of the top-ranked characteristics (such as 'enough parking available near home' and 'good public transit'), giving them the highest magnitude factor score means, while the reverse tended to be true for SJ. In the disaggregate solution, however, while the pattern for NSF and SSF still holds on the positive side, it is now PH tending to have the highest means on negatively loading traits and the lowest means on positive ones. Thus, we see that while NSF, SSF and Concord are fairly consistent across the 18 traits, SJ and PH are more heterogeneous. SJ is more 'suburban' than PH on traits such as

parking availability, relative lack of transit services and population density, while PH is more suburban than SJ on traits such as having higher speed limits and not having a grid-like street network.

It can be seen, then, that given the same neighbourhoods and the same characteristics, the use of aggregate and disaggregate data yield somewhat different results. This finding has serious consequences for modelling residential choice. In another study of the same data (Bagley and Mokhtarian, 1999), a binary model of residential choice was developed, where NSF was the traditional alternative and SJ and CON were the suburban alternatives. This classification is supported by the one-factor aggregate structure, for which NSF has the highest factor score and SJ and CON have the lowest scores. On the other hand, the one-factor disaggregate structure would suggest using PH or CON as one of the suburban alternatives. Had that been done, modelling results would probably be different; thus, conclusions based on the models need to be viewed cautiously.

It is important to note some qualifications on the use of these single-factor solutions. First, as mentioned earlier, the aggregate measure is based on a very small sample size ($N = 5$), which could be considered problematic (see, for example, Guadagnoli and Velicer, 1988). However, it may be argued that the small sample is only a problem when making statistical inferences (such as assigning validity to the amount of variance explained), not when determining underlying dimensions. Secondly, unlike the two-factor disaggregate solution discussed next, the aggregate and disaggregate single factors are unrotated. Rotation in these cases was not only unnecessary but undesirable, as the point was to create a single index incorporating the contribution of all the neighbourhood characteristics to the traditionalness dimension. Rotating the axis would have increased the contribution of some characteristics while minimising the contribution of others. An unrotated factor solution is just as valid as a rotated solution, with both outcomes explaining the same amount of variance in the data.

Table 3. Factor loadings for two-factor disaggregate structure

Characteristic ^a	Loading	
	Suburban	Traditional
Speed limit of roads (mph)	0.84	
Distance to nearest grocery store (miles)	0.62	
Distance to closest park (miles)	0.58	0.33
Bike paths are present	0.57	
Level of grid-like street network	-0.56	
Distance to nearest gas station (miles)	0.38	
Cycling is pleasant	0.36	-0.23
Distance to nearest public transit (miles)	0.26	
Traffic congestion is present	0.26	0.25
Sidewalks are present	-0.26	0.26
Home size (1000 square feet)		-0.39
Have own backyard		-0.67
Enough parking available near home		-0.50
Number of parking spaces for HH use		-0.62
Good public transit		0.38
Population density (1 = high, 0 = low)		0.72
Streets are pleasant for walking		-0.25
Public transit is convenient		0.39

^aThe characteristics are ranked by the magnitudes of their loadings on the suburban dimension. Loadings smaller than 0.2 in magnitude are suppressed for ease of interpretation.

and delineating the same number of relevant dimensions (Rummel, 1970).

3.2 Two-dimensional Disaggregate Factor Analysis Results

Although the single-factor solutions described above were conceptually interpretable, traditionalness could theoretically be a meta-scale composite of several subordinate dimensions. As noted earlier, possible dimensions such as pedestrian friendliness and accessibility were postulated for conceptual reasons. Inspection of the three-factor structure determined that three logical dimensions could not be identified with this set of data. The inability to identify a three-factor structure could have been the result of many things, including insufficient data variation (and type) and/or neighbourhoods varying along one or two of the hypothesised dimensions but not all three. On the other hand, a review of the two-factor structure showed that the data could be usefully described by two different dimensions, labelled

suburban and traditional. Table 3 contains the ranked pattern matrix loadings for the two-factor disaggregate structure.

Together, the two factors explain 28.2 per cent of the variation in the data, indicating that most of the 18 traits analysed have a sizeable amount of variation unique to that trait rather than common to the other traits. This two-factor solution is a rotated solution, as is common practice to improve interpretability. The oblique rotation option was selected as exhibiting the cleanest factor structure; however, since the correlation between the two factors is only -0.066 , they are nearly orthogonal.

Objectively measured characteristics were dominant in the formation of the factor structure, having at least the top three loadings for both the suburban and traditional factor dimensions. For example, the neighbourhood characteristic 'speed limit of roads' had the loading with the greatest magnitude for suburban (0.84) and the characteristic 'population density' had the highest loading for traditional (0.72).

Parking, transit and distance to places were three main characteristics found to be heavily weighted in the creation of the neighbourhood measures. This finding is significant in that it supports the utility of using a data reduction technique such as factor analysis to group correlated characteristics into a representative dimension. For example, four characteristics relating to distance to a destination (such as a park or a grocery store) were in the top nine loadings for the suburban factor (all with a positive loading indicating that greater distances are more representative of suburbs than of traditional neighbourhoods). Two characteristics related to parking were in the top four loadings for the traditional factor (both with negative loadings, reflecting the relative scarcity of parking in traditional neighbourhoods).

The suburban disaggregate factor shown in Table 3 explained 15.2 per cent of the total variation in the 18 neighbourhood characteristics. Characteristics such as 'distance to nearest grocery store' and 'distance to nearest park' had strong positive loadings on this factor, with high values on these variables indicative of suburban neighbourhoods with low mixed use. Further, 'level of grid-like street network', a characteristic commonly associated with traditional neighbourhoods, had a high, negative loading on the suburban disaggregate factor. In short, the traits loading positively on this factor are especially characteristic of suburban neighbourhoods and hence provided the basis for naming the factor. As expected, the three suburban neighbourhoods had the highest mean factor scores on this dimension, while North and South San Francisco (the traditional neighbourhoods) had large, negative mean factor scores, this lends support to the validity of the suburban factor.

The traditional disaggregate factor explained 13.0 per cent of the variance in the 18 neighbourhood characteristics. Characteristics that are strongly positively associated with this factor include 'population density' and 'public transit is convenient', both of which have been linked with traditional

neighbourhoods in other studies (see, for example, Kitamura *et al.*, 1997). Further, traits commonly associated with suburban neighbourhoods such as 'number of parking spaces' and 'have own backyard' had large, negative loadings on the traditional factor. As expected, North San Francisco had the highest positive traditional factor score mean, while San Jose had the most negative traditional factor score mean.

To look at both dimensions together, and obtain a better understanding of the variation within and overlap between neighbourhoods along these two dimensions, Figure 2 plots the disaggregate factor scores for each individual in the sample, distinguished by residential neighbourhood. The 'centroids' for each neighbourhood (i.e. an X, Y point where the horizontal co-ordinate X is the neighbourhood mean factor score on the suburban dimension and the vertical co-ordinate Y is the mean traditional factor score) are indicated in the key and denoted by letter on the plot.

The plot illuminates several important points. First, one can see that North San Francisco aligns very clearly on both dimensions, indicating a strong level of traditionalness by both measures. South San Francisco is also traditional by both measures, although not as strongly as North San Francisco. There is no corresponding neighbourhood that aligns as strongly on the suburban side of both dimensions as North San Francisco does on the traditional side. This suggests greater diversity as to what constitutes 'suburbaness' than is suggested by the stereotypical descriptions often found in the literature. San Jose and Concord have similarly negative scores on the traditional dimension, but neither comes close to the high mean factor score that Pleasant Hill has on the suburban dimension. In fact, San Jose (a neighbourhood expected to be highly suburban) had a mean score near zero on the suburban dimension. On the other hand, Pleasant Hill not only scores highest on the suburban dimension, it also scores second-highest on the positive side of the traditional dimension, illustrating a neighbourhood that is a blend of both traditional and suburban

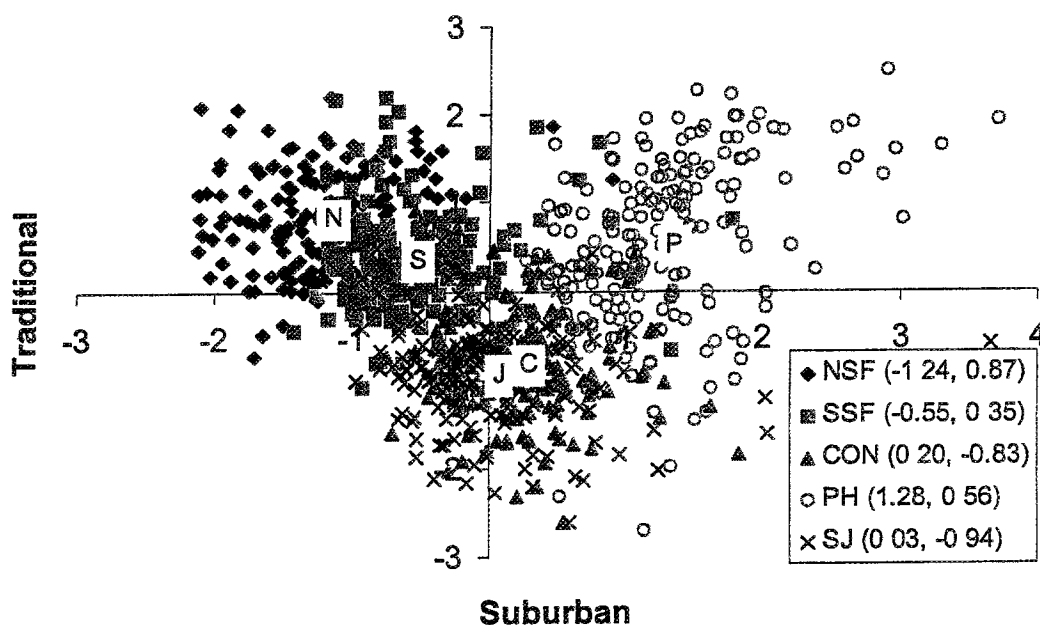


Figure 2. Disaggregate factor scores by neighbourhood ($N = 852$)

characteristics. This is also shown in the high variability of the individual factor scores plotted in Figure 2.

To summarise, Figure 2 shows quite clearly the folly of attempting to characterise the type of an entire neighbourhood in terms of a single binary variable. First, at least two dimensions appear to be important and neighbourhoods can fall on each dimension independent of the other. Secondly, the range and variation of characteristics that define a neighbourhood are more aptly modelled as continuous than binary. Thirdly, individuals within the same neighbourhood can have vastly different values for neighbourhood type.

3.3 Comparison of Solutions

It is of interest to compare the two-dimensional solution to the two one-factor solutions. From Figures 1 and 2 it can be seen that the traditional dimension of the two-factor structure has a mean factor score neighbourhood ordering (traditional—NSF, PH, SSF, CON, SJ—suburban) that is close to the same ordering as the one-factor aggregate

solution (traditional—NSF, SSF, PH, CON, SJ—suburban). The neighbourhoods that represent the two extremes are the same (i.e. NSF is the most traditional neighbourhood and SJ is the most suburban neighbourhood) and only PH and SSF switch ordering. The suburban dimension of the two-factor structure has the exact same ordering of mean factor scores as the one-factor disaggregate structure (traditional—NSF, SSF, SJ, CON, PH—suburban). In this case, the neighbourhood that is most identified with the suburban dimension is Pleasant Hill. Thus, the aggregate structure seems to have identified one of the two dimensions of neighbourhood type revealed by the best solution, while the one-factor disaggregate structure identified the other. Clearly, the two-factor disaggregate solution offers a more finely nuanced assessment of neighbourhood type and is therefore preferred to either of the one-factor solutions.

4. Summary and Conclusions

This paper presents and applies a methodology for assessing neighbourhood type that

results in a measure that is continuous rather than binary, disaggregate rather than aggregate, and potentially (as in the current application) multidimensional. Specifically, 18 objective and subjective variables identified by the literature as distinguishing traditional and suburban locations were measured for 852 residents of 5 San Francisco area neighbourhoods. These data were factor-analysed to develop scales on which each individual had a person-specific score.

We had hypothesised the existence of a single traditionalness construct, with the principal component analysis identifying the optimal weighting of each variable in determining the construct. Instead, two distinct dimensions emerged from the analysis: a *traditional* factor (with variables related to population density and public transit convenience loading positively, and variables related to home size, presence of a backyard and parking availability loading negatively) and a *suburban* factor (with variables related to speed limit, distance to nearest grocery store and park, and ease of cycling loading positively, and the indicator of a grid street network loading negatively). Rather than traditionalness being a single 'either-or' characteristic, neighbourhoods could and did score high or low on both characteristics. For example, Pleasant Hill not only had the highest mean score on the suburban factor, but also the second-highest mean score on the traditional factor. The implication is that the concept of traditionalness versus suburbaness may be better viewed as two different dimensions instead of two ends of the same dimension. We also saw considerable variation in both factor scores across individuals within the same neighbourhood, confirming the importance of using a disaggregate measure.

The empirical results reported here were based on data originally collected for another purpose. It would be of interest to explore the extent to which the qualitative results found here (two dimensions, hybrid neighbourhoods, heterogeneity within neighbourhood) are replicated in other contexts, especially with new surveys and data-sets developed

specifically for that purpose. It would also be of interest to expand the set of characteristics on which a neighbourhood was being measured beyond the two dimensions of traditionalness and suburbaness. Many other traits are potentially relevant to describing a neighbourhood, such as aesthetic appeal, safety, sense of community, school quality, location in the region and so on. Factor-analysing a large number of correlated variables measuring, at the disaggregate level, different aspects of these and other dimensions could be a useful tool for developing a small number of key measures of neighbourhood type, as perceived by residents.

In any case, the empirical findings presented here show quite clearly that the binary designation of an entire neighbourhood as traditional or suburban can be a serious distortion of reality (see Etzioni and Lehman, 1967). By more accurately capturing the complexity in classifying a neighbourhood and the heterogeneity of individual perception within neighbourhood, use of this methodology to measure neighbourhood type is expected to improve models involving residential location type as an endogenous or exogenous variable. A useful side-benefit is that in multiple-equation systems modelling residential location together with, say, travel demand (Bagley and Mokhtarian, forthcoming), continuous endogenous variables are econometrically more tractable than discrete ones.

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