Modelling the Factors of Neighbourhood Attractiveness Reflected in Residential Location Decision Choices

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Abstract

Characteristics of neighbourhoods are important in the decisions of people to move. Such characteristics, if collapsed into a small number of components, enable measures of neighbourhood attractiveness to be derived and the patterns mapped in a GIS. This paper employs this procedure for suburbs across the Brisbane–South East Queensland region, the third largest and a rapidly growing metropolis in Australia, using data collected in a survey of quality of life. Three factors of neighbourhood attractiveness—*aesthetic*, *amenity*, and *social interaction*—are identified. To map those factors, a set of surrogate measures that replace survey data derived subjective importance scores with objective measures derived from a series of GIS data overlays are developed. A factor score coefficient matrix is used to derive a set of parameterised linear equations which permits a spatial representation of the factors across the suburbs comprising the Brisbane–SEQ region. This results in a set of maps which display spatial variations in the attractiveness of suburbs *vis a vis* the derived dimensions of subjective attractiveness for residential selection by people.

JEL Classification : C81, R23

Keywords : Neighborhood Attractiveness, GIS, Residential Location Choice

1. Introduction

The effects that a neighbourhood and its characteristics have on residential location decision choices are well documented ; see Stimson [50], Minchege and Brown [41], Maher and Saunders [36], Dökmeci and Berköz [18], and Vogt and Marans [55]. Both objective and subjective approaches have been adopted to explore the importance of neighbourhood characteristics in decision-making. However, only a few studies investigating subjective components of quality of life have tried to bridge this objective–subjective gap in late-eighties using a combined approach ; see Cutter [17], Johnston [28], and Rogerson et al. [47]. But still little progress has been made in combining subjective assessments or evaluations of the attractiveness of neighbourhoods as places to live with objective data and how such data integration identifies characteristics of suburbs which people select as important when making decisions about where to live. Studies by Cutter [17] and Johnston [28] partly addressed this question, but the methodology proposed and applied in this paper provides a significant advance toward this end.

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The objective evaluation approach—for instance hedonic modelling—uses *a priori* selection and weighting of criteria as judged by the researcher on a value system external to the population being studied, whilst in the subjective evaluation approach, criteria are typically assessed on the basis of the perceived importance of attributes using the judgements of the persons involved. Expert judgements are often used to derive objective measures using the quantifiable attributes of such phenomenon as crime rates, income levels, proximity to local amenities, and access to open space. Some studies however indicate that the objective indicators are generally found to be weak predictors of subjective assessments of overall quality of life or well-being; see Cummins [16], and Evans and Husley [20].

Studies that have adopted objective evaluation techniques to investigate the effect of neighbourhood characteristics in predicting quality of life, health or property price; for example Blomquist et al. [3], Cicerchia [14], Johnston [29], and Oxford [44], typically use aggregated data at various spatial levels (Collection Districts, Statistical Local Areas, etc.). Such data driven mosaics of residential areas within which residential location decision choices are made are studied in terms of their social space characteristics using factorial ecology and residential typology classification methods (Golledge and Stimson [23]). Alternatively, subjective evaluation studies, for example, Stimson [50], Dökmeci and Berköz [18], and Vogt and Marans [55], explore relationships between the decision to move and the ways the quality of the destination neighbourhood is perceived in terms of its attractor characteristics. Data are often collected by administering questionnaires at an individual or household level, and the factors underlying the residential location decision choice are then examined. Combining these two components into a new set of indicators—sometimes referred to as ‘perceptual indicators’ (Cutter [17]) or ‘weighted objective indicators’ (Gehrmann [22]) enable the way people form their preferences and undertake activities within the constraints of the objective environment to be better conceptualised.

The factors that underlie residential location decision choice process are complex, being multi-dimensional and multi-scaled in nature; (Stimson [51] and Orford [44]). Such factors are related to people’s perceived dwelling needs, their locational preferences, and their knowledge about the area. Those decisions are also related to life-cycle events (e.g. children leaving home, marriage, separation and divorce, retirement, and so-on), and they are also embedded in socio-economic factors including housing as a status symbol, an investment vehicle, and a form of stored wealth (Golledge and Stimson [23]). Despite the fact that each residential location decision choice is unique, when these individual choices are aggregated the results may reflect a degree of commonality. People may experience their environment in similar ways due to similarity in social background, demographic characteristics, or psychological profiles, and therefore the basic elements of individual experiences would have some commonality across individuals even though their individual experiences are inherently personal and developed independently (Mark and Frank [38]). Consequently, the preferences reported about the importance of particular characteristics of neighbourhood may link to some underlying dimensions. Extraction of these dimensions and their mapping is potentially useful in urban planning and design as they may provide a better understanding of the complexity of residential location decision choice processes and therefore enable the prudent allocation of infrastructure and services funding in appropriate areas.

This paper proposes a methodology for integrating subjective indicators underpinning residential location decision choices collected via a metropolitan-wide probability sample social survey with objective socio-economic and spatial measures across the residential mosaic comprising the metropolis. In particular, the utility of the methodology developed is assessed as a mapping technique for exploring geographic variations and territorial expression of the underlying factors affecting the attractiveness of neighbourhoods or suburbs over urban social space. Using Geographic Information Systems (GIS), a set of objective measures for neighbourhood characteristics are developed, and where there is no direct measure a surrogate indicator is derived.

This paper proceeds as follows. The next section discusses the concept of neighbourhood and examines the neighbourhood attributes that seem to be important in affecting the decision choices of people about where they live. The paper then proceeds to outline the methodology developed to integrate the subjective dimension of neighbourhood attractiveness derived from survey-based data with the socio-economic and spatial objective data for suburbs across the Brisbane-South East Queensland region. Finally, the paper discusses the utility of the application of the methodology.

2. Neighbourhood and Its Components

2.1 A definition

Traditionally, the word 'neighbourhood' had meant simply a geographically localised community within a city or suburb. Keller [30] defined neighbourhood as pieces of urban territory with their own identity that provides for specific economic activity and contain physical boundaries and social features. However, in recent decades the perception of and the importance of neighbourhood has changed to serve as a 'community', 'context' 'commodity', and 'consumption niche' (Forrest [21]). At times neighbourhood represents the community, whereas at others it provides a context for controlling and regulating spatial interactions, social relations and participation. Neighbourhoods are also viewed and consumed as a commodity or are viewed as online products, astutely profiled on lifestyle and demographic databases to serve particular consumption niches. The appearance of 'elite corridors', 'protected privatopias' (McKenzie [40]), and 'gated communities' (Blakely and Snyder [4]) are examples of commodification.

With the emergence of the postmodern and post-industrial era, the traditional functions of neighbourhoods as a shared space for social interaction, for building kinship networks, and for preserving community values might appear under threat. Our identities are becoming virtual and remote as opposed to real and proximate; therefore the place where we live is increasingly becoming fluid and permeable (Forrest [21]). The possibility that the formation of identities is based on virtuality, anonymity and individualism cannot be ignored. Despite the declining importance of neighbourhood in the age of electronic networking, borderless societies, cyber dating and online shopping, its significance as the place where we act, react and interact remains noteworthy context for our lived experience. It is the neighbourhood where our social identities evolve and life trajectories develop. With an expected rise in home life through working at home, the possibility exists for a rejuvenation of the neighbourhood as a social milieu for creating trust, reciprocity and a sense of

belonging.

2.2 Components

Neighbourhoods can have both material or tangible and non-material or non tangible components. Material components are typically physical features such as land use, housing elements, social and community infrastructure and the like. Non-material components on the other hand range all the way from aesthetic elements (for example, beauty, mystery, serenity, coherence, legibility) to community and social networks. Previous research on the tangible components indicates that neighbourhood can be divided into site, contextual and compositional attributes. Site attributes are physical properties such as slope, aspect, and elevation, while the contextual attributes are the way a location is spatially arranged, connected, and organised in relation to other features of socio-economic importance. Compositional attributes are the characteristics of people living in the neighbourhood.

Many studies have explored the reasons why people move between cities or within them ; see, for example, Rossi [48], Stimson [50], Cadwallader [9], Cheshire and Sheppard [13], Tyrvaïnen and Vaananen [54], Hornsten and Fredman [27], and Vogt and Marans [55]. In an early study in Australia, Stimson [50 ; 51] surveyed Adelaide residents and found their residential aspirations to be complex. He concluded that the most important considerations out of a list of 20 items were : (i) proximity to convenient shopping and transport ; (ii) the newness of a residential area ; (iii) access to the Central Business District ; (iv) prestige and status of a residential area ; and (v) convenience and facilities for children. Minchge and Brown [38] listed a number of explicit measures, in terms of aesthetic attributes, pollution levels, and proximity to local amenities for measuring neighbourhood quality.

On the other hand, Dubin and Sung [19] relied more on surrogate measures, such as socio-economic class, local municipal services, and racial composition. Contextual attributes—such as close to work (Kim et al. [31]), presence of scenic views, natural habitat (Tyrvaïnen and Vaananen [54] and Hornsten and Fredman [27]), and access to parks and open space, (Greenberg and Lewis [24], Colwell et al. [15]) and to retail and service facilities (Bowes and Ihlanfeldt [6])—are also found to be significant determinants of people's residential location decisions. Most recently, Vogt and Marans [55] identified four factors that affected the home-owner decision making among residents who had recently moved to urban fringe areas in and around the city of Detroit. These factors included natural and openness features, social and neighbourhood variables, and housing design and access.

It is difficult to arrive at a definitive list of indicators that can reasonably predict residential location decision choices. Contextual attributes such as availability of amenities, access to services and facilities, are not given enough importance in hedonic price modelling studies (Cheshire and Sheppard [13]). This is partly because the derivation of locational or contextual information requires more time and effort, it is difficult to quantify, and it is conceptually more complex than data relating to structural attributes of dwellings (Orford [41]). Hedonic price modelling has made extensive use of structural attributes in predicting property price and residential decision choices. Nevertheless, some additional dimensions have emerged in several studies which perhaps hold more predictive value that has recently been acknowledged. For example, amenity, open space, jobs, family and friends and house-

hold composition have been repeatedly used in recent times. However, even if we agree on a list of indicators, the interactions between various components of neighbourhoods and their effect on residential location decisions are still quite complex. Such interactions often develop 'locational externalities' that have positive as well as negative influences on neighbourhood quality (Pinch [45]). For example, a property close to a shopping centre facilitates ease of access but at the same time produces negative impacts such as noise and traffic congestion. Therefore, the integration of subjective and objective indicators is desirable because the effects of locational externalities on survey data points (coded on preferences and reasons to move) can be more easily comprehended given a backdrop of GIS information.

3. Research Methods

3.1 Study area

The Brisbane—South East Queensland (SEQ) region has been experiencing rapid growth and socio-economic transformation over the last two to three decades. The region is characterised by a poli-centric urban structure, connecting the State capital Brisbane with two coastal growth corridors, south to the Gold Coast and north to the Sunshine Coast, and with a less radically growing western corridor through Ipswich, a long-established industrial and mining city. The region's population has increased from 1.8 to 2.35 million between 1991 and 2001, and it is forecasted to reach 3.2 million by 2011.

There are two main reasons why this study has importance for the region. First, the region comprises the largest component of population growth in the region. In order to strategically plan infrastructure and sustain the current rate of growth, it is important for planners to understand the reasons that are attracting people to suburbs across the region. Mapping of these reasons may enable identification of areas deficient or rich in a particular characteristic or a combination of characteristics. Studies such as this add to the evidence base for understanding residential location decision choices of people and households and the attributes that attract them to live in particular areas.

Second, the region has been referred to as a space of post-modern urban consumption (Mullins [42]). Such spaces are particularly discernible among coastal communities, and display a lifestyle that characterises consumerism and fragmented culture, eclecticism, and an aspiration for variety, choices and freedom of expression. To cater for the needs of people following this lifestyle, their expectations and preferences need to be understood. Can the region, which is believed to be in the early stage of developing towards a megalopolis, continue to offer variety and vibrancy in the future? It is argued that designs based on standard plans would perhaps be less effective for such a lifestyle because the demography, socio-economic profile and aspirations of the inhabitants living in the region are more likely to be different from those living in other parts of Australia.

3.2 Survey data

In 2003, a stratified probability sample survey of Quality of Life (QOL) in the Brisbane-SEQ region was conducted by researchers at the University of Queensland using the Computer Assisted Telephoning Interviewing facility at the University. A total of 1,612 survey participants aged 18 years and older were interviewed. However, only 776 respondents

participated in this particular section of the survey. Survey participants were selected using a spatially stratified sample survey design to generate a minimum of 100 respondents in 10 sub-regional areas of the SEQ region. Other socio-economic and demographic characteristics along with locational information were collected as a part of the broader quality of life survey.

Respondents were asked to indicate the relative importance of each of a series of items in their decision to move to their current place of residence. 'Importance' in this study was defined as a state or quality of being significant, influential or worthy of note. The relative importance of each of the thirteen items was ascertained on a five-point Likert scale where 1 represented 'not at all important' and 5 'very important'. Survey items included in the survey questionnaire were in part derived from a QOL study conducted in the city of Detroit so that a comparative analysis of the two areas could be undertaken. The survey items have been used by Marans [37], and their dimensions have been tested by Vogt and Marans [55]. The items included are: 'close to work'; 'convenience to shopping centres and schools'; 'good schools'; 'people similar to you'; spaciousness of the area'; close to natural areas (creeks, parks, beaches etc): 'cost of housing'; 'close to family and friends'; 'familiarity with area'; close to public transport'; 'attractive appearance of neighbourhood'; 'lots of recreational opportunities'; and 'size of the community'.

3.3 Digital data

Digital data were acquired from MapInfo StreetPro (8.0.1) database, Department of Local Government and Planning and the Australian Bureau of Statistics 2001 Census. Objective indicators were primarily derived from these databases. StreetPro data contain numerous geographic layers (Highways and Main Roads, Railway lines and Railway Stations, Features, Parks and Reserves and Drainage) with their attributes. More specific sub-layers—such as shopping centres, schools and recreation facilities (Sport Facility, Cricket, Soccer, Hockey, Baseball, Entertainment Venues and the like)—were extracted as separate layers from the 'Features' layer in StreetPro database. The data from Queensland Department of Local Government and Planning were used to identify areas assigned as industrial and commercial zones. Australian Bureau of Statistics Census data related to 'Socio-Economic Indexes For Areas' (SEIFA) and to the geography of Statistical Local Areas (SLA) such as dwellings, population and median monthly rent were also extracted.

3.4 GIS Analysis

As a mapping and analytical tool, GIS offers a range of techniques to measure and visualize social relationships and interactions at the level of neighbourhood, and its scope is far beyond that of a simple graphic tool. GIS provide procedures for integrating, storing, manipulating and representing spatial objects in multi-dimensional space. Here we use GIS tools to integrate spatial objective data and individual unit record survey data to generate synthetic territorial-wide data variables for neighbourhoods.

The *neighbourhood operation* is a GIS function that is employed in this paper to generate objective indicators for accessibility and proximity measures. It allows spatial relations of point-based survey data to be quantified and visualised as a surface. Spatial relations

provide information about what, where and how features of socio-economic importance are spatially distributed, arranged and organised within a given neighbourhood. Since the output generated by neighbourhood operation stores data in a raster format, the manipulation, visualization and modelling of spatial relationships and patterns of interaction are easier and faster than by the use of more traditional methods. The data layer can be easily manipulated via standard statistical operations such as mean or median, range, and standard deviation on a range of data formats including nominal and ordinal.

4. Modelling and Mapping Drivers of Residential Location Decision Choices

Modelling and mapping of underlying factors of residential location decisions were conducted in four sequential steps. Principle Component Analysis (PCA) enabled statistical modelling, whilst mapping and spatial analyses were undertaken using GIS. Following a sequential order, Step 1 extracts the factors underlying residential location decisions, Step 2 identifies objective indicators of neighbourhood characteristics, Step 3 standardises the objective indicators, Step 4 develops a parameterised linear equation for each factor and builds a spatial model for mapping the underlying dimensions, Step 5 quantifying socio-spatial patterns and finally Step 6 and 7 interpret the underlying map structures across the entire South East Queensland region.

4.1 Step 1: Underlying dimensions of neighbourhood characteristics

PCA and factor analysis are commonly used multivariate data analysis techniques; see Hair et al. [25]; Burley and Brow [8]. PCA facilitates the exploration of manifest data to identify latent components from a set of interrelated variables. A reduced number of new variables, known as components, are obtained from highly correlated variables. Statements about variables and observations are listed in columns and rows respectively using R-mode analysis; see Nei et al. [43]. The calculated Kaiser-Meyer-Olkin of 0.811 clearly exceeds the 0.5 level considered to be acceptable for the use of PCA. In order to maximise the specificity of the items, they were retained if their loadings on one of the factors was greater than 0.40. Items that did not fulfil this criterion were deleted. Two items 'Good school' and 'Street layout' were eliminated from the modelling. The Eigenvalues were plotted against the order of extraction and visual inspection, using the rules of the scree test indicating the number of principal components for extraction. This rotation was used to extract the appropriate number of factors. The varimax rotation identifies an orthogonal simple structure, meaning that the technique generates a solution in which high factor loadings are maximised and low factor loadings are minimised.

The selected model generated by PCA with varimax rotation, extracted three components with eigenvalues greater than 1 (refer to Table 1). These components were also tested for internal reliability using Cronbach's alpha. The first component accounts for the greatest proportion of variance (eigen value 3.4) and the five items defining have high loadings from 0.48 to 0.795. The second component has a lower eigen value (1.6) and the four items defining it have loadings from 0.487 to 0.793. The third component with an eigen value greater than 1 (1.1) defined by three items with loadings from 0.62 to 0.723 (For more details see Table 1). These components are descriptively, not normatively labelled and together

Table 1: Factor loadings and reliability statistics of neighbourhood importance scales

Factors	Aesthetic	Amenity/ Access	Social Interaction	Eigen-value	Cronbach's Alpha
Aesthetics factor				3.4	.75
Openness/spaciousness	.795	-.027	.010		
Close to natural areas	.789	-.078	.133		
Attractive appearance of neighbourhood	.679	.199	.098		
Lots of recreational opportunities	.548	.023	.424		
Community's size	.480	.382	.255		
Amenity/accessibility factor				1.6	.68
Convenience to shopping centres, schools	.063	.793	.175		
Close to public transport	-.018	.709	.155		
Close to work	-.006	.582	.122		
Housing costs	.389	.487	-.181		
Social interaction factor				1.1	.62
Familiarity with area	.105	.137	.723		
Close to family and friends	-.021	.076	.658		
People similar to you	.292	.229	.626		

explain 53.83 percent of the variability in observations.

The items that load heavily on Component 1 are : openness or spaciousness ; closeness to natural areas (bush, creeks, beaches etc.) ; attractive appearance of neighbourhood ; many recreational opportunities and community size. This has been labelled the *aesthetic factor*. It accounts for 21.35 percent of the total variance. This factor could be understood by the fact that people perhaps perceive neighbourhoods in terms of their visual features or biophysical components. The quality of those features is evaluated by people when making residential location decisions. Therefore, the visual appearance and aesthetic appeal of the neighbourhood are the driving factors of residential location decisions for some residents.

Component 2 is defined by : closeness to work ; convenience to shopping centres and schools ; affordable housing costs and proximity to public transport. This component is named the *amenity/accessibility factor* as it is related to the relative availability of housing services and facilities. The importance of being adjacent to features of socio-economic importance, including workplaces, is represented by this factor as is the availability of affordable housing. The significance of neighbourhood is assessed by its ability to facilitate easy access to amenities such as shopping centres and schools. It allows people to be connected and less restricted by the constraints imposed by space and time. It is important for people to know how certain locations are organised in relative space and how well they are connected to features of social and economic significance.

Social interaction is identified by component 3. Items with high loadings include : familiarity with area ; people similar to you ; and close to friends and family. This component has been termed the *social interaction factor*. It seems that neighbourhoods are not

merely geographic localities, but also are viewed in terms of the social processes they include (Massey [39] and Harvey [26]) or the ‘nets of social relations’ (Massey [39]). The social interaction factor manifests people’s desire to affiliate and socially interact with friends and members of their family. It is targeted to reduce social anomie (e.g. isolation and loneliness) (McCrea et al. [35]), frequently found as a feature of the metropolitan lifestyle. It has, generally, been argued that distance can have a negative effect, whilst, time has a positive effect on the degree of social interaction or the ways these interactions are channelled. People may develop social relations with neighbours or a feeling of neighbourliness, if they stay at a place for a reasonable period of time and this then may enable them to cooperate, manage and adjust their daily life events for mutual benefit (for example, baby-sitting or picking up children from school). It is anticipated that diminishing social capital and lack of social infrastructure in postmodern society can potentially increase the importance of the need for the social interaction factor.

4.2 Step 2: Identifying objective indicators for survey items

Objective indicators have been quantified or approximated using digital data and some have been directly derived from spatial and biophysical characteristics—such as distance, accessibility, and proportion of open space to total area. Others are more complicated (e.g. occupational diversity, elevation diversity) or surrogate based indicators. The surrogate indicator is a quantity or combination of quantities that can be used to acquire information about the target *in lieu* of measuring the target more directly (Resource Assessment Commission [46]). It is often used to measure a phenomenon when more specific data sets are either not available or accessible. The survey items for which surrogate indicators were used include: spaciousness; familiarity with the area; and close to family and friends.

Two layers were used to measure attractive appearance of landscape. These include open space index and elevation diversity. The open space index was calculated as the proportion of open space to the total area for each suburb. Earlier studies suggested that topography is one of the important dimensions of neighbourhood attractiveness, as it determines patterns and forms for many other landforms and land cover features; see Linton [34]; Bishop and Hulse [7]. Using a digital terrain model, elevation diversity was calculated as the standard deviation of height within a 2.5 km radius of the spatial filter. The higher value indicates the greater elevation diversity. It was calculated as:

$$\text{Elevation diversity} = \text{FOCALSTD}(\text{Height}, \text{KERNEL}, 2.5 \text{ km})$$

Neighbourhood operation was employed to calculate two other objective indicators. These include ‘lots of recreational opportunity’ and ‘access to shopping centre and school’. The access measure based on neighbourhood operation was preferred over other methods like ‘container approach’, which calculates the count of facilities within a suburb or SLA or the ‘distance approach’ that measures the shortest distance to the nearest facility. The container approach does not incorporate a spatial dimension (e.g. if clustered, a large area will be unserved) and it does exclude areas, despite juxtaposition to a facility, from the measure if they fall into other suburbs (Talen and Anselin [53]). Whereas the access measure used in this paper includes both the number and size of the opportunities accessible

within a commutable distance.

The survey item 'lots of recreational opportunity' was measured as the number of recreation facilities available for contact or interaction from a given point or location within its surrounding neighbourhood. The radius for the neighbourhood operation is defined as a limit beyond which people are less likely to travel to visit a facility. A radius of 2.5 km, as people often drive to those facilities, was assumed as a commutable distance which roughly corresponds to the average size of a neighbourhood, except in rural areas. Using the StreetPro database, neighbourhood operation was conducted on a point data layer of sporting facilities and a count for each cell in the output grid was calculated as:

$$\text{Recreational opportunity} = \text{FOCALVARIETY} (\text{Sporting facilities, KERNEL, 2.5 km})$$

The other item 'access to shopping centre and school' was calculated in a similar way, except that the element of size was also incorporated. Two layers of shopping centre and school were used separately and then overlaid onto a single layer. Shopping centres (SC) were ranked according to their sizes from 1 to 3 (Regional SC 3, Neighbourhood SC 2 and Local SC 1). The attribute field was used instead of point feature, to calculate the 'Sum' of the total value of an assigned field on shopping centre layer within the defined radius of 2.5 km. It is calculated as:

$$\text{Access to shopping centre} = \text{FOCALSUM} (\text{ShoppingCentreRanking, KERNEL, 2.5 km})$$

The remaining three survey items—'close to work', 'close to natural areas,' and 'proximity to transport'—were estimated using a measure based on Euclidean distance. Distance to Central Business District and distance to industrial and commercial areas were calculated and merged to derive the item 'close to work'. While for proximity to transport, distance to City Cat Ferry route, distance to railway station and distance to main roads and motorway were calculated. Similarly, the survey item 'close to natural areas' was also generated by amalgamating three layers: distance to creeks, distance to parks and reserves, and distance from the coast.

A number of surrogate measures were generated using the Australian Bureau of Statistics Census data available at Statistical Local Areas (SLAs) level. Dwelling density was used to represent 'spaciousness', which was calculated as the number of dwellings per square kilometre. Similarly, the survey item 'community size' was calculated as the number of people per square kilometre, while the median weekly rent, obtained from census data, was a surrogate for the item 'cost of housing'. Monthly housing loan repayment was also considered as a potential candidate, but it was dropped due to its inappropriateness to represent more established areas where the monthly loan repayment for houses bought several years ago might not be a good indicator of the current cost of housing.

The longer people are resident at one place, the greater will be their familiarity with the area and therefore the greater the likelihood of buying a home or staying at that locality. Assuming this assumption is correct, the survey item 'familiarity with area' was estimated by calculating the proportion of people living in the same SLA for at least 5 years. The survey item 'close to family and friends' was also measured through a friendliness index, defined as the proportion of people visiting others from the same suburb.

Two variables were combined to represent the item 'People similar to you'. These include occupational diversity and lifecycle diversity. Using the Simpson Diversity Index, Simpson [49], occupational categories were converted into the occupational diversity index. Simpson's index (SI) is the first of a set of non-parametric approaches to calculating heterogeneity. The index ranges from 0 to 1 where the closer to 1 the less diverse the community. It is calculated as:

$$\text{Simpson's Index (SI)} = \sum p_i^2$$

where

$$p_i = \frac{n_i}{N}$$

N = the total number of individuals in the groups
 n_i = the number of groups
 P_i = the relative proportion of individuals in group i

It defines the probability of two individuals from a random sample belonging to the same category or type. In other words, if the index value is 0—everyone in the population has a different occupation, the probability of finding someone with the same occupation is zero. The nine major groups of one digit Australian Standard Classification of Occupations codes were reclassified into five groups based on their levels of skill. These include: (i) 'Managers, Administrators and Professionals'; (ii) 'Associate Professionals'; (iii) 'Tradepersons and advanced clericals'; (iv) 'Intermediate'; and (v) 'Elementary and labourers'. Using the same method, a lifecycle diversity index was calculated for: (i) 'Couple with children'; (ii) 'Couple without children'; (iii) 'One parent family'; and (iv) 'Other family'. Both indices were combined to represent a surrogate for the survey item 'people similar to you'. However, had the SEQ region been culturally and linguistically more diverse, the inclusion of these would have perhaps had higher priority.

4.3 Step 3: Standardising objective indicators

The GIS layers created in Step 2 were in different metrics. For example, distance can not be readily comparable with the number of shopping centres or with dwelling density. Therefore, the data were standardised in order to remove the effect of measurement units. The data were converted to standard scores by subtracting the mean and dividing by the standard deviation for each variable (Hair et al. [25]). This converts raw data into a standardised value with a mean of 0 and a standard deviation of 1.

Furthermore, few data layers like distance from natural areas, proximity to transport network, dwelling density and close to work were negatively related to the survey items. In other words, lower values indicate better access, greater proximity and spaciousness. Consequently, these variables were reversed on scoring. Mapping was conducted at the level of Statistical Local Areas (SLA) for two reasons. First, it roughly corresponds to suburbs—an areal unit commonly perceived as a neighbourhood. Second, census data are readily available. For those variables, which were in the grid format (for example, close to transport and natural areas, access to shopping centres etc.) data were tabulated by 'summarising' them against the SLA geography of the region. The *Summarised Function* in GIS calculates *Poly-on-Grid Statistics* including average of all cell values that lie within each SLA and adds it as an attribute to the SLA geography in a tabular format.

4.4 Step 4: Developing linear parameterised equations for mapping the underlying factors

The factor-score coefficients matrix was used to generate parameterised linear equations for mapping the derived factors described in Step 1. The matrix is an array of coefficients which are similar to ‘regression weights’ and are used to generate factor scores from variables; see Neil et al. [43] and Tabachnick and Fidell [52]. The use of factor scores for mapping is commonplace in the geographical literature; see Burley and Brown [8]; Western and Larnach [56]; Kliskey [32] the employment of factor score coefficients matrix as a set of linear equations is also supported; see Nei et al. [43], Tabachnick and Fidell [52], Arrowsmith and Inbakaran [1], Chhetri and Arrowsmith [11]. The objective indicator data for each factor were simply multiplied by their respective factor coefficient scores and were then added. There were three linear equations representing the factors, as a result three maps were produced. The following linear models were used:

$$\begin{aligned} \text{“Aesthetic factor map”} &= -.068v_1 + .175v_2 + -.061v_3 + -.089v_4 + .150v_5 + .285v_6 + .176v_7 \\ &+ .014v_8 + -.083v_9 + .352v_{10} + .372v_{11} + -.126v_{12} \\ \text{“Amenity/accessibility factor map”} &= .317v_1 + .287v_2 + .425v_3 + .386v_4 + .150v_5 + .046v_6 + \\ &-.113v_7 + -.003v_8 + -.060v_9 + -.130v_{10} + -.079v_{11} + -.074v_{12} \\ \text{“Social interaction factor map”} &= -.019v_1 + -.282v_2 + -.031v_3 + -.016v_4 + .027v_5 + \\ &-0.81v_6 + 2.32v_7 + 3.51v_8 + .468v_9 + -.025v_{10} + -.121v_{11} + .454v_{12} \end{aligned}$$

where,

- v_1 = standardised value of close to work
- v_2 = standardised value of cost of housing
- v_3 = standardised value of convenience to shopping and school
- v_4 = standardised value of close to transport
- v_5 = standardised value of lots of recreation opportunities
- v_6 = standardised value of attractive appearance
- v_7 = standardised value of size of community
- v_8 = standardised value of similarity of people
- v_9 = standardised value of familiarity with area
- v_{10} = standardised value of close to natural areas
- v_{11} = standardised value of openness/spaciousness
- v_{12} = standardised value of close to family and friends

4.5 Step 5: Mapping the patterns and associations of the importance of neighbourhood characteristics

Using the parameterised linear equations, three maps representing the factors were generated. In doing so we first determined the absence or presence of spatial patterns on the mapped data and second, established the associations that spatial patterns hold with socio-demographic and economic characteristics. If the patterns and characteristics are found to be associated, we will term such patterning *socio-spatial structures*.

Spatial patterns in terms of clustering, randomness or dispersal embedded in these maps were quantified employing two common global indices—Moran’s (I) and Geary’s (C), of

Table 2 : Geary's and Moran's statistics for the factor maps

	Aesthetic	Amenity	Interaction
Moran's I	0.398	0.655	0.298
Expected Moran	-0.0034	-0.0034	-0.0034
Variance Under Normality	0.00130	0.00130	0.00130
z-value	11.134	18.246	8.359
Variance Under Randomization	0.00128	0.00129	0.00129
z-value	11.224	18.282	8.369
Geary's C	0.558	0.238	0.715
Expected Geary	1	1	1
Variance Under Normality	0.00236	0.00236	0.00236
z-value	-9.093	-15.675	-5.862
Variance Under Randomization	0.00482	0.00295	0.00272
z-value	-6.357	-14.004	-5.451

spatial autocorrelation. Moran's I index ranges from +1 to -1 with values close to +1 indicating clustering and values near -1 indicating dispersion. Geary's C ranges from 0 to 2. When C is less than 1, events which are close together are more similar than those further apart. Values greater than 1 indicate that events close together are dissimilar. Statistical significance of the observed clustering or dispersion can be determined by the use of a Z score. These indices were calculated using ArcView scripts developed by Lee and Wong [33].

Table 2 shows that both I and C values evidenced the presence of positive spatial autocorrelation for the aesthetic, amenity and social interaction factors. The suburbs that are close together have similar values than those that are further apart. It should also be noted that the amenity dimension when compared to the others exhibits a greater tendency of spatial clustering. The Z scores indicate that there is less than 1 percent likelihood that these clustering could be the result of random chance.

Clear spatial patterning was detected in the aesthetic, amenity/accessibility and social interaction maps. We will investigate now whether this patterning is a reflection of the presence of socio-spatial structures. To incorporate socio-demographic and economic characteristics in the analysis the 'Index of Relative Socio-Economic Disadvantage' from the Australian Bureau of Statistics 'Socio-economic Indexes For Areas' (SEIFA) was used. In addition, a range of data sets such as generated geographic layers and the 'social structures' identified by Western and Larnach (1998) in the SEQ region were also used to interpret socio-spatial structures based on the maps of aesthetic, amenity/accessibility and social interaction.

To measure the relationships of the derived factors of aesthetic, amenity/accessibility and social interactions with these indexes, correlations were calculated. The results indicate that areas that are more accessible and aesthetically endowed are also the areas of relative advantage. Correlations between aesthetic and amenity/accessibility and SEIFA index were found to be significant at the 0.01 level. This indicates the areas that scored high on aesthetic and amenity are also the areas that have high proportion of high household

income or a skilled labour force or more people with higher education qualifications. More disadvantaged areas with attributes such as families with low income, a greater proportion of less educated people working in unskilled occupations or unemployed, are more likely to have low scores on accessibility and aesthetics. Such areas are not only socially and economically disadvantaged but also comprise suburbs that are less aesthetically appealing and relatively fewer facilities nearby. Willingness to move to a neighbourhood of one's choices is constrained as the actual move needs to go through a range of socio-economic filters. On the other hand, there were no significant correlations between the social interaction factor and index of relative disadvantage. It can, therefore, be inferred that social interaction is not a characteristic that is restricted to advantaged or disadvantaged areas.

4.6 Step 6: Interpreting the socio-spatial structures of residential location decision choices

Having established the presence of patterns and socio-spatial structures, the maps need to be interpreted at the levels of region and suburb. On the regional level, the first map (refer to Figure 1) dealing with the *aesthetic factor* indicates that areas with highest scores are neatly aligned along the coast, indicating the effects of proximity to natural areas such as creeks, beaches and parks. Some interior parts of the Brisbane-SEQ region, despite their closeness to natural areas, have low to moderate scores, perhaps due to the presence of few recreational opportunities, while the coastal areas—particularly around the Gold Coast and the Sunshine Coast—seem to have the comparative advantage of considerable investment on recreation infrastructure in recent years. Broader areas, such as Ipswich in the western corridor of the region, the western part of Logan, Beaudesert, Caloundra (Hinterland) and Caboolture (Part B) along with other interior regions, had low scores on this factor.

The second map (See Figure 2) identifying the *amenity/accessibility factor* also reveals a definitive pattern of contiguous areas. The areas identified in the map with high scores are potentially attractive to those people who consider accessibility and housing cost as important in their residential location decision choices. The overall pattern is CBD-centric and exhibits a somewhat concentric pattern with distortions along the transport arteries producing a wedge like structure. The final map, Figure 3, concerns the *social interaction factor*. It exhibits a mixed spatial patterning. As discussed before, this factor represents respondents who consider family relations, friendliness and similarity with others as the most important reasons for moving to their current place of residence. Increasing social exclusion, individualism, and independence often thrive in the inner city, and are anticipated to affect the patterning of this dimension. While on the other hand, strong family ties, greater social capital, residential permanency, and a stronger sense of belonging is expected to drive this factor, particularly in rural areas and suburbia. Overall, the spatial pattern indicates that the listed social processes have some control over the magnitude of social interaction in a comparison between rural and urban areas. With the exception of SLAs around the Sunshine Coast and the Gold Coast, which score low on this factor—partly because of the presence of larger number of floating residents, with stronger urban ties and cosmopolitan lifestyle—this argument appears to hold some truth.

Figure 1: Geographic variation in the aesthetic factor in the Brisbane-South East Queensland

4.6.1 Socio-spatial Structures on the Aesthetic Map

The spatial patterning of these factors is not only exhibited at a regional level ; they are also expressed at the suburb level. As depicted in the *aesthetic factor map* in Figure 1, Nudgee Beach, Belmont-Mackenzie, Pinkenba-Eagle Farm, Mount Ommaney, City-Inner, Fig Tree Pocket, Sandgate, Boondool, Brighten, Nathan, Main Beach-Broadwater, Surface Paradise, Mermaid Waters, Gumdale, Brookfield (including Mt. C'tha), Noosa and Miami are among those suburbs which ranked highest on the aesthetic factor. Inner-city Brisbane—which is located on the Brisbane River with a range of recreational opportunities—also scored highly. Within the Brisbane metropolitan area, the suburbs in the western part of the city—because of diverse terrain characteristics and proximity to parks (e.g. Fig Tree Pocket, Pullenvale, Chapel Hill, Kenmore, Pinjarra Hills, Upper Kedron, and Ferny Grove)—are among suburbs which also scored high on the aesthetic factor. The land values of suburbs which are endowed with the aesthetic factor are also relatively high and their SEIFA scores on the index of disadvantage are among the highest in the region. Whilst many suburbs in the eastern part of the Brisbane City (Inala, Woolloongabba, Coorparoo, Annerley, Highgate Hill, Greenslopes, Holland Park) scored low, with the exception of Nathan and a small pocket comprising Belmont-Mackenzie, Carindale, Chandler and Gumdale. Some southern suburbs of Brisbane—despite their proximity to the Brisbane River—have relatively low scores, due to little undulation in terrain or perhaps the effect of industrial 'blight'. The suburbs aligned along motorways within the metropolitan area of Brisbane have low scores, indicating the need for scenic highways to enhance attractiveness, particularly along routes leading to tourist destinations.

4.6.2 Socio-spatial Structures on the Amenity/Accessibility Map

As depicted in the *amenity/accessibility map* in Figure 2, the suburbs in inner Brisbane are generally found to provide greater accessibility to job opportunities and amenities, while areas in outer parts of Brisbane are relatively disadvantaged in this regard. Those suburbs situated along the Brisbane River are also found to have greater accessibility. Inner-city, Chelmer, Milton, Mount Ommaney, and Graceville are among those with high scores, while Moreton Island, Esk (S), Redland Balance, Bribie Island, Boonah and Caboolture Part B have among the lowest scores on this factor. It should also be noted that those SLAs advantaged by their adjacency to industrial areas such Darra-Sumner, Wacol, Rocklea, Richlands and Acacia Ridge also have high scores on the amenity factor, indicating greater accessibility to jobs from nearby industries. Consequently, there is a resultant segregation of people employed in blue collar jobs. The suburbs in the inner parts of Brisbane City are predominately occupied by non-traditional households (for example, couples without children, single and group households) with a high concentration of rental and medium density dwellings. The suburbs within inner Brisbane also hold high land values, greater ethnic diversity and high socio-economic status. It appears that the greater accessibility to jobs and amenities has attracted a particular socio-demographic profile.

The suburbs in the northern and interior parts of the Brisbane-SEQ region display lowest amenity scores, indicating the need to strategically plan infrastructure. Whilst the Gold Coast and the surrounding suburbs appear to have moderately high scores they demonstrate the need for additional investment to accommodate a further influx of inter-state migrants.

Figure 2 : Geographic variation in the amenity/accessibility factor in the Brisbane–South East Queensland

The Gold Coast also has higher proportion of rental and high density housing along its coastal strip. However, it should be noted that the scores are mapped in relative terms (comparing large city to rural areas), further study will be required to assess the levels of adequacy of amenities based on demand. It should be noted that an amenity, for instance a shopping centre or school, requires a threshold population to make its services economically viable. Care needs to be taken, if these maps are considered for developing regional plan and social policy for the region.

4.6.3 Socio-spatial Structures on the Social Interaction Map

The *social interaction map* is shown in figure 3. On the regional level, the differences found in the degree of social interaction between rural and urban areas are easily interpretable. The communities in these two areas are different in the way they are socially structured (e.g. family networks), economically dependent and spatially restricted. But when it comes to analysis within the Brisbane metropolitan area, there is no clear evidence of spatial patterning. Nonetheless, suburbs with high social interaction scores exhibit sporadic concentrations, particularly around outer Brisbane.

The areas of high concentration, typically comprises traditional households are of low socio-economic status, display relative segregation of ethnic minorities in some cases, and social disadvantage. The SLAs with high scores include Inala, Ipswich (C)-Central, Ipswich (C)-East, Durack, Darra-Summer, Pallara, Kingston, Middle Park and Woodridge. These suburbs have also low scores on the SEIFA index indicating their relative disadvantage. Cultural affiliation is an important attractor that perhaps determines some of the residential location decision outcomes for people with non-English speaking backgrounds, primarily because it can enhance social interaction (Castles and Vasta [10]). However, the map also shows that social interaction is also high in relatively more established areas which feature the predominance of traditional households with high socio-economic status, and perhaps stronger social networks due to a lower rate of residential mobility. People in these areas are perhaps in their latter stage of the life cycle, or the suburbs themselves (typically middle and outer suburbs) are in the latter stage of their lifecycle and are more stabilised (Golledge and Stimson [23]). Pinkenba-Eagle Farm, Chelmer, Sherwood, Graceville, Ashgrove, Bardon and Chapel Hills are among those which scored high on the social interaction factor. Whilst on the other end of spectrum, most SLAs in inner Brisbane, suburbs around Gold Coast and Sunshine Coast and those suburbs with new developments have scored low in social interaction factor. Higher mobility rate, non-traditional household structure, demographic and economic composition (e.g. relatively young age cohorts, symbolic analysts) and lack of cultural coherence might be the likely culprits for causing lower social interaction in these areas.

4.7 Step 7: The Overall Socio-Spatial Structures

In order to further our understanding of the spatial patterning, the maps developed for the three factors discussed above were merged to form a composite map of neighbourhood attractiveness for SLAs across the study region (see Figure 4). By modifying the 'Max' Function in Excel a new categorical variable was created that retains the name of the factor with the highest score of the three. Because these factors are orthogonal and uncorrelated,

Figure 3: Geographic variation in the social interaction factor in the Brisbane-South East Queensland

Figure 4: Overall geographic variation in the factor distribution in the Brisbane-South East Queensland

Table 3: ANOVA statistics for factors to move and SIEFA indexes

Indexes	Factors to move	Mean	Standard deviation	F-Ratio	Sig.
Disadvantage (<i>Low income, low educational attainment, high employment, unskilled occupation</i>)	Aesthetic	1,021	56.5	22.56	0.000
	Amenity	1,032	57.5		
	Social Interaction	968	81.3		

* Correlation is significant at the 0.001 level (2-tailed)

it is assumed that the likelihood of suburbs displaying high scores on all factors is low. The output map, Figure 4, reveals a more definitive spatial contiguity on these factors. Most suburbs along the coast are classified as aesthetic, whilst a large majority of suburbs in inner Brisbane and along the motorways are described as ‘amenity’ oriented. The social interaction, on the other hand, characterises those suburbs that are predominately rural or defined areas of high cultural diversity and low scores on the index of disadvantage (for example, Inala, Pallara, Darra–Sumner, Ipswich including the North and the East Ipswich).

It would be interesting to see whether associations that our factors held with the index of relative socio-economic disadvantage will change after generalising the factors into a single categorical variable. Using Analysis of Variance (ANOVA), the categories of aesthetic, amenity and social interaction were tested for differences in their scores against SEIFA index of disadvantage. From Table 3, it can be seen that aesthetic, amenity and social interactions show significant differences at the 95 percent confidence level. It is also apparent that mean scores for areas with greater accessibility have scored well above the national average of 1000; whilst areas endowed with high social interactions have low mean scores against SEIFA indexes. However, further analysis using a Bonferroni test indicates that the differences in means of aesthetic and amenity factors against SEIFA index of relative disadvantage are not significant ($p < 0.005$). Overall, the outcomes support the earlier argument that there are notable socio-economic differences across suburbs.

5. Discussion and Conclusions

The methodology used in this paper demonstrates that the underlying factors important for people in their residential location decision choices can be described in terms of three major dimensions. The main drivers detected in the data analysis were aesthetic, amenity and social interaction. Factor structures and associated items confirm previous research (Vogt and Marans [55]). The reduction of items into few components has made the process of understanding decision making somewhat more simplified.

The three factor maps were generated by integrating perceived levels of importance of neighbourhood characteristics into a range of objective indicators. Clear spatial differences were captured across the entire SEQ region. The data suggest that there are some areas which have more access to amenities, particularly around inner Brisbane and along Brisbane River and Motorways, leaving vast areas relatively less connected to job opportunities and regional activity centres. It was also evident that areas with greater accessibility have typically a non-traditional household structure and high socio-economic status. On the other hand, social interaction factor exhibits more sporadic distribution but depicts contrast

between rural and urban areas where rural being in more possession of social capital. The intra-city distribution of scores indicates greater social interaction in areas that comprise traditional families with low socio-economic status and greater cultural diversity. It was clear that these dimensions have large geographic variations which perhaps could be attributed to the differences in the urban morphological landscape (for example, nature features, transportation networks and land use) or urban ecological patterning (for example, demographics, lifecycle stages, income status, and ethnic segregations). It can therefore be inferred that people perhaps adjust their residential location decision choices as a trade-off between their concurrent needs for accessing job availability, amenities, recreational opportunities and social events. They perhaps accommodate to a neighbourhood that they perceived to be able to fulfil some of the imminent needs rather than all needs.

The methodology used enabled measurement of the performance of SLAs against three perceived factors of neighbourhood attractiveness. It has enabled identification of areas important either on aesthetic, amenity, or social interaction considerations. People who give more importance to a particular aspect of neighbourhood can easily choose their localities which have already been sorted in different levels. Therefore, it enables preference based 'residential self-selection' to take place; see Boarnet and Crane [5] and Cervero and Duncan [12]. The methodology measured the performance of SLAs on, overall quality of life, liveability, or residential preference space). The SLAs are separately evaluated on three different dimensions and therefore it had enabled identification of areas that have scored high one dimension but low on others. In other words, use of multi-dimensional space allowed the latent structures to become more prominent rather than subdued.

Overall, integration of subjective evaluation with objective measure provides some interesting findings. Mapping outputs present stories about the way neighbourhoods are perceived, spatially structured, socially constructed, and, to some extent, consumed. Areas were clearly differentiated on the underlying dimensions indicating the presence of advantaged and disadvantaged neighbourhoods. However, whether the gap between objective and subjective realities was filled still remains inconclusive, but we believe that this effort is a step forward towards a better understanding of 'geographic reality' which constitutes both subjective and objective elements (Johnston [28]).

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