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Mixed-Use Urban Planning and Development

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Preface

This study aimed to address item #3 of the Building Research Levy Prospectus: *“What are the opportunities and barriers that exist around growth and expansion of mixed use housing/commercial developments? What is the potential for mixed use development to support increased high quality densification in cities? What lessons can be learnt from good practice from New Zealand and overseas?”* In particular, it aimed to identify the characteristics of mixed-use development, and their effect on success or failure of mixed-use development projects by means of an in-depth literature review. Furthermore, it aimed to identify the opportunities and barriers with mixed-use development in Christchurch, by means of an empirical study using stated preference and choice modelling techniques.

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Note

This report is intended for transport and urban planners as well as developers and architects involved in design and planning of mixed-use development projects in New Zealand, in particular in Christchurch.

Abstract

Urban sprawl, commonly associated with car dependency, is a major worldwide concern for urban planners and policy makers, with “sustainable development” becoming a common policy goal in cities’ long-term plans. Mixed-use development is often perceived as the path toward a sustainable city, by encouraging more sustainable travel behaviour and lowering car dependency.

In this study, different aspects of mixed-use development were investigated; they included density of development, diversity of land use, social (and cultural) diversity, design, distance accessibility, and public transport accessibility. An empirical study was conducted in Christchurch to identify important factors that Councils, planners and architects need to consider, to make mixed-use neighbourhoods attractive to residents of Christchurch and its surrounding districts.

Further investigation is needed to identify the preferences of residents of other cities (e.g. Wellington and Auckland), as their preferences might differ from those of residents of Christchurch. It would then be possible to assess whether there is a need to develop city-specific mixed-use guidelines or whether a national mixed-use guideline would suffice.

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1 Introduction

Mixed-use was a ubiquitous feature of urban areas when urbanisation began. As walking was the primary means of transportation, urban amenities (housing, working, and entertaining) were built within walking distance, restraining the spreading of city boundaries (or urban sprawl). Mixed-use remained a feature of urban areas until the industrial revolution brought heavy industrial activities, which were considered incompatible with residential and other land uses (Levitt and Schwanke, 2003). This led to zoning regulations to separate different land uses. The subsequent advances in transportation, including increasing car ownership and use, further accelerated the segregation and separation of different land uses and contributed to the development of large, low-density cities.

The expansion of urban areas has substantially increased the average trip lengths and people's reliance on private motorized vehicles (Weber and Sultana, 2007), escalating urban transportation problems, such as traffic congestion, accidents and air pollution. As big cities became less sustainable and less able to ensure inhabitants' wellbeing, various movements arose around the world for restoring the (traditional) mixed-used neighbourhoods (e.g. Jacobs, 1961). This has led to planning, design and implementation of mixed-use development projects at various scales within urban areas. The underlying idea behind mixed-use is to mix land uses (e.g. residential, commercial and recreational) in compact neighbourhoods so that people can access different activity locations by foot, bicycle, or public transport, thereby reducing car dependency and improving urban quality of life.

However, despite the benefits above and a large number of successful mixed-use developments around the world, there are many failed applications. For instance, in many mixed-use neighbourhoods, there is a considerable amount of empty retail space. It can be argued that the failure of mixed-use neighbourhoods is caused by poor planning or design, and by incorrectly equating multi-use and mixed-use development. While both concepts embrace a variety of uses within a community, mixed-use (unlike multiple-use) considers integration, density and compatibility of land uses to create a pedestrian-friendly community (Herndon, 2011). In addition, a trend has been observed for retailers selling similar types of products (e.g. clothing and electronic goods) to seek the agglomeration benefits of locating near to each other. This can benefits shoppers, as they can conveniently compare the price and quality of products sold by different stores, but it can undermine the goal of mixed-use development.

Recent efforts to reverse the trend of city sprawl, via mixed-use developments, have very largely been driven by the desire to increase the sustainability of urban areas, especially transport sustainability. This belief has been supported by a large number of overseas studies (e.g. Cervero and Radisch, 1996; Ewing and Cervero, 2010) which concluded that compact and mixed-use development will lower car dependency, reduce trip lengths and increase walking, cycling and public transport use. A study in NZ by Badland et al. (2012) found that residents of inner-urban neighbourhoods travel less distances to work and are more likely to take public transport, compared to those who are living in outer-urban neighbourhoods. In addition, the results of a literature study by McIndoe et al. (2005) for the NZ Ministry for the Environment suggest that mixed-use can encourage walking and cycling and reduce the need to own a car. Thus, such a development type would significantly reducing household expenditure on transportation.

However, despite some empirical evidence supporting the positive influence of mixed-use on travel behaviour, thorough evaluation suggests that the relationship between travel behaviour and land use pattern is much more complex than it was initially thought to be (Van Acker and Witlox, 2010). Depending on the methodology and data used to analyse the relationship, inconclusive outcomes can be obtained (Handy, 1996). For instance, when traditional transport models and aggregate level data of different types of neighbourhoods (mixed-use vs. single-use) are used, the results indicate that the levels of car use (trip frequency and length) in higher density mixed-use neighbourhoods are significantly lower than those in lower density single-use neighbourhoods. However, when using disaggregate level data, the results become less conclusive, as they change depending on the trip characteristics and urban features included in the analysis.

Besides the above, the results of a study by Boarnet and Crane (2001) suggest that the built environment (including mixed-use development) has an immediate influence on travel behaviour. In particular, as people value travel for work and non-work purposes differently, mixed-use development has more potential to influence non-work trips rather than work trips. However, the results of studies by Dellaert et al. (2008) and Handy and Clifton (2001) imply that mixed-use development may not be effective in influencing shopping trips (a type of non-work trips). Dellaert et al. (2008) investigated the choice between neighbourhood, district, and city centres for clothing and grocery shopping in the Netherlands, and found that the neighbourhood shopping area was selected by only a small number of participants for grocery shopping and none of the participants for clothing shopping. Furthermore, Handy and Clifton (2001) evaluated the potential of local shopping for reducing car dependency in the USA and found that people often prefer distant stores to local ones, despite the significantly greater travel cost. Those studies might have partially explained why there are many vacant retail spaces in mixed-use neighbourhoods.

The complexity of the relationships between mixed-use development and travel behaviour is further highlighted by many recent studies (e.g. Cao et al., 2009a), which have found that those relationships are also influenced by other inter-twined factors, namely residential location selection, socio-demographic, lifestyle and attitudinal factors. Residential location selection, for instance, has been confirmed by a number of studies (Bohte et al., 2009; Cao et al., 2009a; Næss, 2009; Van Wee, 2009) to have a strong influence on travel behaviour. However, it is rarely taken into account in models which evaluate the effect of mixed-use development on travel behaviour. As a result of this, biased outcomes can be obtained and accordingly misleading conclusions can be drawn. For example, people who enjoy urban settings, walking and shopping, tend to choose to live in mixed-use neighbourhoods. Therefore, it is not the mixed-use which influences travel behaviour, but it is the choice of residential location that enables the people to address their lifestyle preferences. There is consequently a real risk of over-estimating the capacity of mixed-use development to alter people’s travel behaviour and improve the sustainability of cities.

In addition to the problem of over-estimating the change in travel behaviour of residents of mixed-use neighbourhoods, there is another real risk, namely over-estimating the attractiveness of such neighbourhoods. Recent efforts to reverse the trend of city sprawl, via the creation of mixed-use developments, are based on the assumption that a substantial proportion of people are attracted to living in mixed-use neighbourhoods, and conducting most of their daily activities there. Living in such neighbourhoods might not be attractive to New Zealanders, in the short-medium term at least, as they have traditionally preferred to live in low-density areas (Research Solution, 2001).

In addition, even if they wish to live in a mixed-use neighbourhood in a desirable location, there is a major problem with affordability. Walters (2014) reported, based on the results of the 10th annual Demographia International Housing Affordability Survey, that housing has become unaffordable in many parts of New Zealand cities, such as Auckland, Christchurch, Tauranga-Western Bay of Plenty, Wellington and Dunedin. Such a conclusion was made based on the comparison between housing prices in those cities and income levels of New Zealanders living there. It is commonly believed that building housing development projects on the outskirts of those cities will solve issues related to housing affordability (Roberti, 2014). However, such an approach will intensify transportation problems, leading to less sustainable cities and urban environments.

As noted above, mixed-use developments have often failed to achieve the desired travel behaviour changes. This research will however focus on identifying and understanding the factors which affect residential location choice and how those factors affect that choice. The research will also identify the level of interest of New Zealanders in living in high-density mixed-use neighbourhoods.

To understand people's housing location choice, two main theories have been developed: utility maximization and *Tiebout* theories. The former suggests that people will select a house location which will minimize commuting costs and maximize accessibility to their workplace, or a location with less expensive house purchase price at the expense of increased commuting costs. The *Tiebout* theory (Tiebout, 1956), suggests that the quality and cost of municipal services are the determinant components of housing location decision. While still influential, there are many critics of those theories (e.g. Montgomery and Curtis, 2006). For instance, they are criticized for ignoring other important determinants, such as housing quality and social status (Phe and Wakely, 2000). Moreover, a study done by Zondag and Pieters (2005), assessing the influence of accessibility on residential location choice in the Netherlands, suggest that accessibility to a specific location is not a significant factor influencing location decisions by some households types. However, they found that travel time appears to be significant for all household types. Therefore, changes in the transport system (e.g. a better road network) will influence the size of the housing market and people's preferences for distant housing locations.

Given the complexity of issues described above and conflicting research outcomes of various mixed-use development projects, the objectives of this research project were as described below.

The first objective was to identify, through extensive literature study, the characteristics of high-density, mixed-use developments, and their effect on success or failure. Furthermore, complex relationships between mixed-use and travel behaviour have led to further questions: can mixed-use alone alter people's travel behaviour, and if it can, then by how much? Accordingly, the next objective of this research was to identify, through an extensive literature study, the extent to which mixed-use affects travel behaviour. This involved assessing how the socio-demographic, lifestyle and attitudinal factors are inter-twined and interact, and how they affect residential location selection and travel behaviour. Moreover, we identified trip characteristics that are more amenable to change through mixed-use development and the scope for altering travel behaviour via mixed-use development, given the role of socio-demographic, lifestyle and attitudinal factors, along with residential location preferences. We further investigated factors which have been identified in the literature to have an influence on housing location decisions, focusing on high-density mixed-use and low-density single-use neighbourhoods.

Finally, given the importance of residential location selection in influencing travel behaviour and the scarcity of relevant NZ-based studies, our last objective was to address this issue, using Christchurch as a case study. At first, we evaluated relevant factors that residents of Christchurch and its surrounding districts consider when deciding upon house location. Afterwards, we designed and undertook a stated preference survey in Christchurch. The survey was based upon the results of our literature study, with the aim of assessing the weight that the residents place on the cost of house purchase, relative to other important factors, such as transport and other living costs, when deciding on residential location. The results of this study allowed us to identify and evaluate the opportunities and barriers with mixed-use development in Christchurch and to investigate how to promote and implement mixed-use developments there. The results would also allow us to evaluate different policies and actions that should be implemented to support mixed-use developments.

The expected outcomes of this study were the identification of the opportunities for and barriers to mixed-use developments, and the extent to which mixed-use development supports high quality densification and greater sustainability. Similar studies need to be done in other

NZ big cities, such as Auckland and Wellington, and combined results should be used as inputs to developments of a planning guideline for government organizations/bodies and practitioners in NZ. Furthermore, such combined results would be needed to identify how to plan and design high-density mixed-use developments, to maximise their attractiveness to New Zealanders, their likelihood of choosing to live in such developments, and the increase in the sustainability of urban areas in New Zealand.

2 Research questions

The project aimed to address all three research questions in item #3 (p.12) of the Building Research Levy Prospectus: *"What are the opportunities and barriers that exist around growth and expansion of mixed use housing/commercial developments? What is the potential for mixed use development to support increased high quality densification in cities? What lessons can be learnt from good practice from New Zealand and overseas?"*

These questions were addressed in two stages of this project.

The first stage aimed to identify the characteristics of high-density, mixed-use developments, and their effect on success or failure. An in-depth literature review was conducted, to:

- identify the characteristics of high-density, mixed-use developments in NZ and overseas to date and how these characteristics affect the success and failure of mixed-use development projects;
- identify the extent to which mixed-use affects travel behaviour and the scope for altering travel behaviour via mixed-use development, given the role of socio-demographic, lifestyle and attitudinal factors, along with residential location preferences, in influencing travel behaviour.

The second stage aimed to investigate the opportunities and barriers with mixed-use development in Christchurch by undertaking a revealed and stated preference survey of residents of Christchurch and its surrounding districts. The survey was designed to answer the following questions:

- how much weight do residents place on the cost of house purchase, versus the transport and other living costs, when deciding on residential location?
- how should mixed-use developments be promoted and implemented in Christchurch, to maximise the efficiency and effectiveness of efforts to achieve better cities and communities (e.g. more resilient and sustainable, higher quality of life)?
- what policies and actions should be implemented to support mixed-use developments?

3 Literature review

A literature search on mixed-use development was carried out using a combination of methods: the Web of Science portal, the University of Canterbury Library (online catalogue), Google/Google Scholar and Transport Research International Documentation (TRID) portal. Web of Science (http://apps.webofknowledge.com) is an online academic and scientific citation indexing service that accommodates multiple databases, allowing users to carry out interdisciplinary search of specific subjects. Similarly, TRID (http://trid.trb.org/) integrates multiple databases and provides access to more than a million transportation research records worldwide. It includes records from Transportation Research Information Service of Transportation Research Board and International Transport Research Documentation Database.

Considering the research objectives and questions detailed in the previous sections, this literature review section is divided into four subsections. In Section 3.1, the definition of mixed-use is described and its dimensions or characteristics are identified. Next, in Section 3.2, the applications of mixed-use concepts in real-life settings are discussed. In Section 3.3, the results of research studies that can shed light on the influence of mixed-use on transportation behaviour are reviewed. At last, In Section 3.4, the results of several existing studies about residential choice decision are summarized with a particular emphasis on identifying the underlying factors that influence house purchase decisions. The results of this literature review were used as input to the design of our survey that aims to investigate factors influencing New Zealanders' house location decisions.

3.1 Mixed-use development

3.1.1 'Mixed' definitions of mixed-use development

Mixed-use is a term commonly used in planning and policy documents but is rarely defined (Hoppenbrouwer and Louw, 2005). At first glance, mixed-use seems to be a simple concept, suggesting a type of development that mixes several land uses and it is equated with multiple-use (Herndon, 2011). Nevertheless, further examination of the concept reveals that mixed-use does not simply mean multiple-use. The Urban Land Institute (ULI) clarifies that multiple-use development, unlike mixed-use development, does not take into account integration, density and compatibility of land uses to create pedestrian-friendly environments (Levitt and Schwanke, 2003). In fact, multiple-use is only a single component of mixed-use. The ULI further suggests that mixed-use should integrate at least three substantial revenue-producing uses (Levitt and Schwanke, 2003). However, other studies (e.g. Hoppenbrouwer and Louw, 2005) indicate that having two compatible uses within a mixed-use neighbourhood is already adequate. These diverse thoughts about what mixed-use development should look like have revealed that mixed-use is a complex urban development concept which integrates multiple dimensions and aspects. Rowley (1996) stated: *"Mixed-use development is an ambiguous, multi-faceted concept but essentially it is an aspect of the internal texture of settlements".* In addition, Angotti and Hanhardt (2001) states: *"…how ambiguous the term is. Mixed-use is a relative term. It can only be defined in contrast to 'single-use'"*.

Rowley (1996) argues that urban texture has three features that determine its quality, namely grain, density and permeability. They are derived from the layout of districts, buildings, street blocks and streets. The grain of urban texture signifies how people, activities/functions, land uses, buildings, spaces and other urban components are mixed together. A fine or close grain happens when similar urban components are sparsely scattered in a geographical space and are mixed with the dissimilar ones. On the contrary, a coarse grain happens when similar urban components are clustered together and are separated from the dissimilar ones. Grain also refers to the size and subdivision of urban blocks (Coupland, 1996). Thus, the finer the grains of the built environment, the closer it resembles a traditional historical town. Besides, blurred and sharp grains are conceptualized. They in turn indicate gradual and sudden transitions from similar to dissimilar urban components.

Moreover, permeability indicates the extent to which urban texture allows pedestrian movement (Jacobs, 1961). Shorter building blocks create higher permeability (Figure 3.1). Long blocks with unbroken streets form psychological barriers, making people less inclined to walk down such streets. This leads to inactive streets and it discourages small retailers from setting up businesses there (Montgomery, 1998). Permeability is often equated with connectivity. However, these concepts are not exactly the same. A neighbourhood can have a good street connectivity but lower permeability (Figure 3.1-A). In studies about the built environment and transport behaviour, street connectivity, instead of permeability, is often used as a measure of the built environment (e.g. Ewing and Cervero, 2010), as further described in Section 3.3.

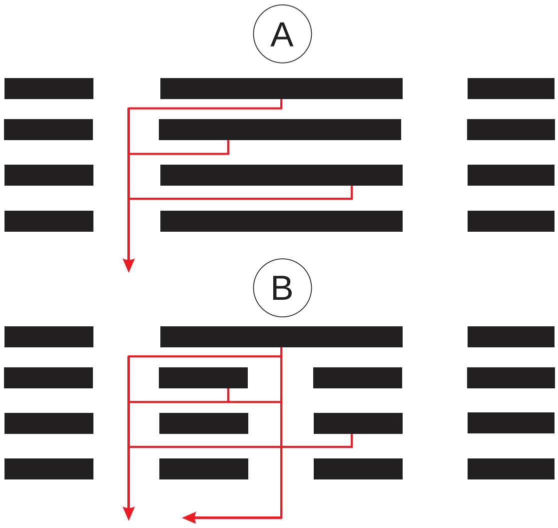


Figure 3.1 City blocks: long blocks hamper permeability (A) and short blocks facilitate permeability and street life (B) (Jacobs, 1961)

Furthermore, density refers to population or jobs per area unit (Ewing and Cervero, 2010) and it is intermingled with mixed-use and grain (Hoppenbrouwer and Louw, 2005). Thus, a mixed-use neighbourhood should have a fine grain, and high permeability, density and diversity (through multiple-use). Yet, those factors alone are not sufficient to create and maintain a sustainable, attractive and liveable mixed-use neighbourhood. For that to happen, social and cultural diversity should be a part of mixed-use (Grant, 2002). Nonetheless, higher income residents often consider social diversity within a neighbourhood unpleasant, as further discussed in Section 3.2.2.

Similarly, Grant (2002) suggests that mixed-use should have at least three conceptual levels: 1) high intensity of land use that can be accomplished, for instance, by mixing different types of tenancy; 2) high-diversity of use by encouraging a compatible mix; and 3) integration of uses to overcome regulatory barriers, for instance by incorporating functions (e.g. retailing) that can act as buffers between other functions (e.g. residential and industrial). Those levels are needed to obtain the full benefits of mixed-use development, namely: to create an attractive and vibrant urban environment; to give people an opportunity to own a property other than a house; to increase affordability and equity; to reduce car dependency and ownership; and to increase the use of more sustainable transport modes by enabling people to shop and work in the neighbourhood where they live in. Similarly, Coupland (1996) explains that mixed-use development encourages various activities to cluster together and therefore reduces the need to travel by car. At the same time, mixed-use increases the vitality of the place which results in a safer urban environment. These also give to inhabitants social, economic and environmental benefits (Figure 3.2). Besides those benefits, at a larger scale, governments seem to favour mixed-use development projects because they are considered a driver for stimulating economic growth and tax revenue (Boarnet and Crane, 1997; Grant and Perrott, 2010).

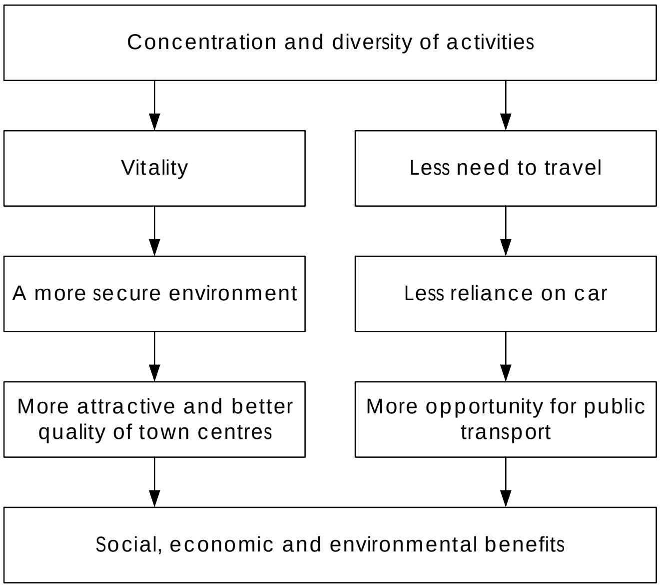


Figure 3.2 Benefits of mixed-use development (Coupland, 1996)

Adding more complexity to the concept of mixed-use, there are several other types of development with characteristics similar to those of mixed-use, such as new urbanism, transit-oriented development, smart growth and neo-traditional planning. Such development types typically include mixed-use as its central component, as stated by Grant and Perrott (2010, p.3): "*The philosophy of mixed use proves central to related theories of community design including new urbanism, smart growth and sustainable development.*"

Similar to mixed-use, those aforementioned development types are loosely defined. Their definition changes depending on the stakeholders involved in a development project. For instance, Cervero et al. (2004, p.6) list several definitions of transit-oriented development (TOD) used by planning authorities in the USA:

- Washington Metropolitan Area Transit Authority: *"Projects near transit stops which incorporate the following smart-growth principles: reduce automobile dependence; encourage high shares of pedestrian and bicycle access trips to transit; help to foster safe station environments; enhance physical connections to transit stations from surrounding areas; and provide a vibrant mix of land-use activities."*
- Bay Area Rapid Transit Authority: *"Moderate- to higher-density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment, and shopping opportunities designed for pedestrians without excluding the automobile. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use."*
- Maryland Transit Administration*: "A relatively high-density place with a mixture of residential, employment, shopping, and civic uses located within an easy walk of a bus or rail transit center. The development design gives preference to the pedestrian and bicyclist."*
- Central Florida Regional Transport Authority: *"A sustainable, economically viable, livable community with a balanced transportation system where walking, biking, and transit are as valued as the automobile."*
- Roaring Fork Transportation Authority: "*Land development pattern that provides a high level of mobility and accessibility by supporting travel by walking, bicycling, and public transit."*

It can clearly be seen that different planning authorities in the USA attach different meanings to TOD. Even though TOD clearly emphasizes the development around public transport facilities (e.g. bus, tram or train stops/stations), the remaining aspects of TOD largely overlap with those of mixed-use, e.g. with regard to permeability, density and diversity of use. Therefore, TOD neighbourhoods are mixed-use neighbourhoods located near public transport facilities (Cervero et al., 2004), as illustrated by Bertolini et al. (2009) and shown in Figure 3.3.

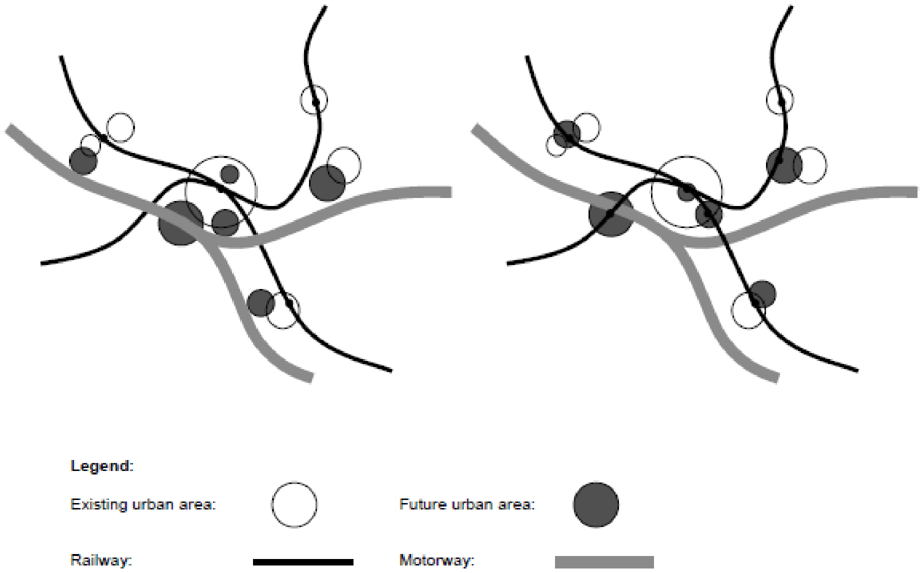


Figure 3.3 A compact mixed-use city and transit oriented development (Bertolini et al., 2009, p.7)

Another type of development frequently found in planning documents and research literature is new urbanism or neo-traditional planning. New urbanism typically refers to real-estate development in outer-urban areas that applies mixed-use development principals (Marcuse, 2000). Accordingly, its goals are similar to those of mixed-use, namely: having multiple-use; increasing diversity, density and permeability (through fully connected street systems); reducing car dependency; improving the quality of public areas (e.g. open spaces and pedestrian environment); and achieving housing affordability (Ellis, 2002; Gordon and Vipond, 2005; Grant and Bohdanow, 2008; Marcuse, 2000; Rodríguez et al., 2006; Villiers, 1997). In fact, new urbanism was born from the concept of mixed-used, as stated by Grant (2002, p.73): "*New Urbanism is probably the most important movement for entrenching mixed-use within North American planning in recent years. With roots in the neo-traditional town planning… and influenced by the transit-oriented development…*"

Moreover, vague definitions and overlapping goals of various development types, as described above, have created perplexing ideas on what can and should be achieved by such development. For instance, the results of a study done by Jepson Jr. and Edwards (2010) suggest that different planners have different perceptions about new urbanism, smart growth and ecological cities and what is feasible within such types of development. Supporting that view, literature search using mixed-use as the keyword produced many other publications related to new urbanism, smart growth and TOD. Thus, due to the close nature of those development types, we include reviewing those publications so that the characteristics and the potentials of mixed-use development can be identified fully.

3.1.2 The characteristics of mixed-use development projects

From the definitions of mixed-use presented in Section 3.1.1, several mixed-use characteristics can already be identified, namely: having a fine grain, high permeability, good pedestrian, cycling and public transport connectivity, multiple and compatible uses, social and cultural diversity and high density. However, those characteristics are by no means prescriptive. They trigger further questions, such as:

- What uses/activities can be considered compatible?
- In which geographical scales should mixed-use occur: in inner-suburban or in outer-urban areas?
- Can in-fill development projects be considered mixed-use?
- How important are architecture and other design-related aspects in determining the success of mixed-use neighbourhoods?

Accordingly, the results of the literature search are summarized below to address the questions above and to identify other dimensions of mixed-use.

a. Diversity of land use and social diversity

A major component of a mixed-use neighbourhood is a variety of functions/activities that it contains, for example working, commercial and living activities. A further distinction should be made between primary uses which generate a large number of trips, such as residential and major employment, and secondary uses which generate fewer trips, such as restaurants and other small services or facilities (Jacobs, 1961). Mixed-use should have a balanced mix of those functions to ensure that the vitality of urban environment can be reached. A mixture of different functions is linked to the first dimension of mixed-use, called diversity of use (Grant, 2002). Diversity does not only refer to accommodating a variety of functions inside a mixed-use neighbourhood but, it also concerns the ways to mix those dissimilar activities so that they can complement each other, thus generating synergies and avoiding conflicts. Van den Hoek (2008) further categorizes various functions as “mixable” and “un-mixable”. Non-residential functions, such as offices, shops, restaurants, bars, hotels and schools, are mixable with residential functions, such as houses and apartments. Nonetheless, other functions, such as airport, harbour, oil refinery, energy production and waste management, should not be included in any mixed-use development project. Similarly, the results of a study done by Angotti and Hanhardt (2001) suggest that industrial activities should be excluded from any mixed-use development project because they may impose serious health problems to residents living within their proximity.

The ULI further argues that those “mixable” functions, despite being compatible, can create different levels of synergy (Levitt and Schwanke, 2003). Table 3.1 shows the potential support of each use on others. For instance, offices and hotels very strongly support each other and offices are strongly supported by retailing. The intensity of synergy becomes stronger when mixing offices with restaurants (or other food services) due to the benefits that they give to office employees. Additionally, residential activities benefit strongly from cultural/civic/recreation activities and they are moderately supported by hotel activities. However, the intensity of synergy gets stronger when mixing high-end hotels with condominiums than when mixing mid-priced hotels with houses. Table 3.1 also shows that retail/entertainment activities seem to get most support from other types of activities, followed by cultural/civic/recreation activities.

Table 3.1 The synergy between mixed-use functions (Levitt and Schwanke, 2003, p.85)

Use	Degree of support for and synergy with other uses
Office	
Residential	• •
Hotel	• • • • •
Retail/entertainment[a]	• • • •
Cultural/civic/recreation	• • •
Residential	
Office	• • •
Hotel[b]	• • •
Retail/entertainment	• • • •
Cultural/civic/recreation	• • • • •
Hotel	
Office	• • • • •
Residential	• • •
Retail/entertainment	• • • •
Cultural/civic/recreation	• • • •
Retail/entertainment	
Office	• • • • •
Residential	• • • • •
Hotel	• • • • •
Cultural/civic/recreation	• • • •
Cultural/civic/recreation	
Office	• • • •
Residential	• • • • •
Hotel	• • • • •
Retail/entertainment	• • •

• = very weak or no synergy
• • = weak synergy
• • • = moderate synergy
• • • • = strong synergy
• • • • • = very strong synergy

[a] Restaurants and food services give benefits to offices.
[b] Synergy is strongest when mixing high-end hotels and condominiums and less when mixing mid-priced hotels with residences.

Nevertheless, diversity within mixed-use should not only be interpreted in terms of multiple-use but also in terms of social and cultural diversity (Grant, 2002). This means a mixed-use development project should offer different types of houses with various sizes and prices. In addition, a variety of property ownership and occupation arrangements (e.g. rent and shared ownership), must be made available (Rowley, 1996). Therefore, a range of people, with diverse socio-demographic and economic backgrounds, can be accommodated (Villiers, 1997). In terms of commercial use, mixed-use development projects should offer properties with several occupation arrangements (e.g. owning and leasing) to cover the needs of a range of business types.

Moreover, time is a dimension of mixed-use connected with diversity of land use. It represents temporal changes of functions over a certain period of time, e.g. 24-hours, a month, a year and so forth (Hoppenbrouwer and Louw, 2005; Rowley, 1996). For instance, in the evening, a school can serve a secondary function as a community centre. Additionally, a clinic, after being closed down, can be turned into a rest home (Figure 3.4). Time is linked to another mixed-use dimension called building sharing (Hoppenbrouwer and Louw, 2005; Montgomery, 1998).

Building sharing indicates that various activities can be accommodated within a single unit or building (Figure 3.4). For instance, as working from home becomes more popular in many developed countries, a house often accommodates both living and work activities.

b. Density of development

Density, as discussed in Section 3.1.1, is an important mixed-use dimension to create a more compact built environment. Together with diversity of use, high-density can reduce distance and travel time to reach local destinations. Therefore, it is believed that a high-density built environment supports walking, cycling and public transport use and moreover reduces car use and ownership. Whether or not these claims hold true in real-life situations will be discussed in Section 3.3.

Density of development and diversity of land use interact and share the same dimensions called horizontal and vertical mixing (Hoppenbrouwer and Louw, 2005; Montgomery, 1998). Horizontal mixing happens when buildings are located near to each other and they accommodate different activities (Figure 3.4). An example of this is having a corner shop, office building, café and restaurant next to each other. Additionally, in a multi-storey building, different functions can be accommodated at different floors, signifying the vertical dimension of mixed-use. For instance, one might use the basement for parking, the ground floor for commercial activities, the middle floors for offices and the upper floors for apartments. Thus, vertical, horizontal, time and building sharing dimensions can help accomplish a fine grain neighbourhood discussed in Section 3.1.1.

c. Design

Design is a dimension of mixed-use fundamentally related to place-making (Buchanan, 1988) and accordingly, it integrates a wide range of subjects: activities, physical forms and image (Montgomery, 1998), as shown in Figure 3.5. Furthermore, design is considered important to promote walkable communities (Cervero and Kockelman, 1997; Ewing and Handy, 2009; McIndoe et al., 2005). Accordingly, design is not only concerned with individual buildings and open spaces, but it also deals with ways to integrate individual designs into an overall neighbourhood design and plan. It is a crucial component needed to accommodate various activities, to strengthen synergies and to minimize conflicts. However, design qualities are difficult to measure because they can be fairly subjective. Thus, Ewing and Handy (2009) carried out a study to systematically and objectively measure the subjective qualities of urban environments. The results of their study suggest five categories of urban components that can be measured and that are important to create walkable neighbourhoods, namely: imageability, e.g. courtyard, plazas and parks; enclosure, e.g. proportion of street wall and sightlines; human scale, e.g. building height; transparency, e.g. proportion of windows on the ground floor; and complexity, e.g. building colours and public art.

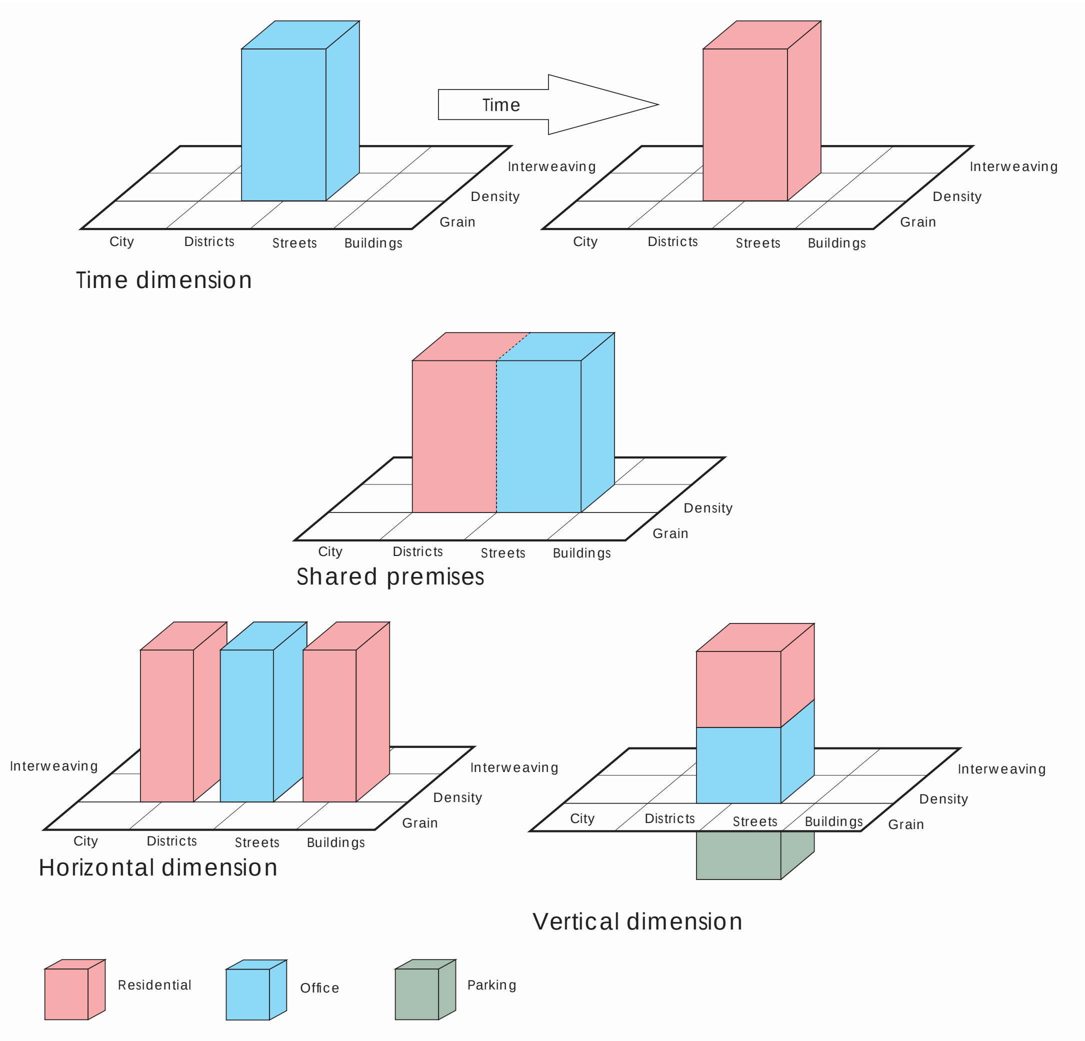


Figure 3.4 Mixed-use development model (Hoppenbrouwer and Louw, 2005, p.973)

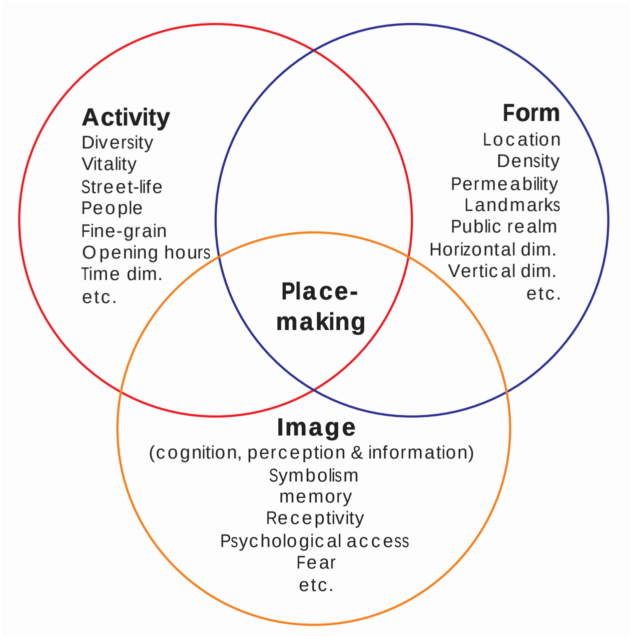


Figure 3.5 Design of the built environment in relation to place-making (Montgomery, 1998, p.98)

d. Destination accessibility and public transport accessibility

Two dimensions of the built environment and of mixed-use are linked to transportation, namely destination accessibility and distance to public transport facilities (Ewing and Cervero, 2010). Destination accessibility measures the ease of reaching local and regional destinations, such as the distance or travel time to the nearest local shop and to the central business district (Handy, 1993). In addition, parking supply, despite being considered an inaccurate indicator of trip generation, is often listed as a component of destination accessibility and it is used to determine an ‘internal capture rate’ of a mixed-use development project (Bochner et al., 2011). Internal capture rate signifies the percentage of trips made internally without the use of external roads. Additionally, distance to public transport facilities measures the shortest route from the home or workplace to the nearest bus stop. Besides, other measures are also used, such as route density, distance between stops to the nearest local shop, and the number of stops per area unit (Ewing and Cervero, 2010). As mixed-use aims to reduce car trips and to encourage the use of active transport and public transport, destination accessibility and distance to public transport facilities become two important dimensions of any mixed-use development project.

e. Geographical/spatial location

Geographical/spatial scale is another important dimension of mixed-use as it shows where mixed-use development projects can take place. Rowley (1996) points out that every urban environment, at a city scale, can always be considered mixed-use, even though its quality may vary from one city to another. However, at finer scales, mixed-use can appear within districts/neighbourhoods, streets/public spaces, street blocks, or individual buildings (Figure 3.6). Depending on where mixed-use is proposed, different mixtures of uses can be emphasized. For instance, within streets and street blocks, local grocery shops can be mixed with houses while within districts, a more complex mixture of use must be carefully planned. Furthermore, mixed-use development projects can take place at various locations (Rowley, 1996), such as in inner-suburban and outer-urban areas, in a city centre and in a ‘greenfield’ site. Those locations often determine the size of a mixed-use project and the suitable development approach. Three approaches have been identified, namely: 1) conserving the existing mixed-use settings; 2) gradually and incrementally revitalizing the existing city or town centres; and 3) systematically developing or redeveloping larger areas or plots (Rowley, 1996).

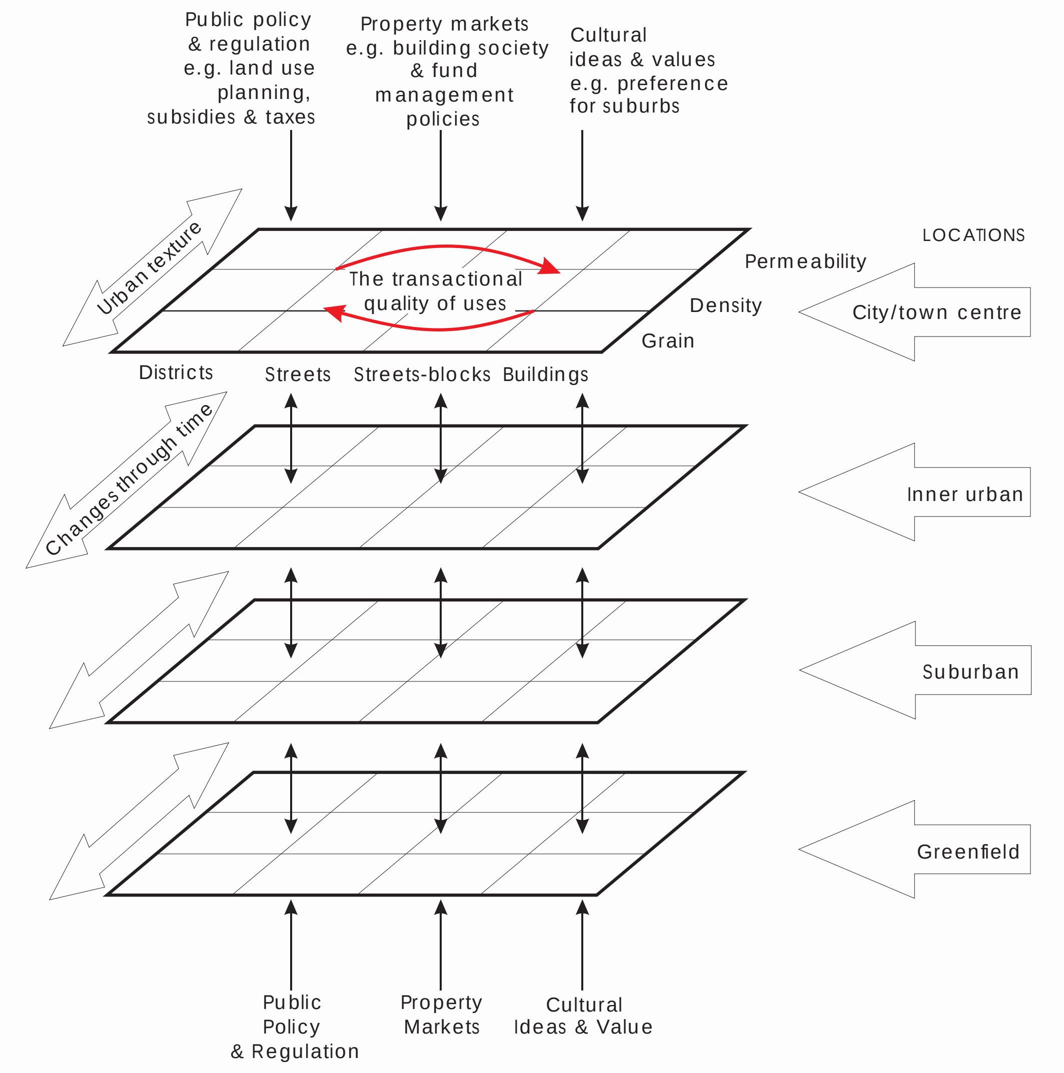


Figure 3.6 Mixed-use development (Rowley, 1996, p.86)

f. Stakeholders

In addition to the above dimensions, stakeholders involved in urban development projects play a very important role in shaping urban environments, including mixed-use. In general three main stakeholders are involved: private developers and investors; public authorities; and 'voluntary' organizations or groups of individuals (Ambrose, 1994). Each of them has their own main interests and motives that often contradict one another. They are also participants in land property development. For instance, the private and public sectors supply resources for development, public authorities and regulators decide on the rules governing development, and the general public, with their cultural ideas and values, decides on which house to buy, including where it is located (Healey and Barrett, 1990). These stakeholders affect each other in a complex and dynamic system. Moreover, they are influenced by other agencies involved in the development process. In a country where the private sector dominates the development process, such as in New Zealand, mixed-use development depends on the attitudes of landowners, investors and developers, who are driven by different influential markets (e.g. finance/investment, construction and land/property). A more detailed explanation about various development processes involved in mixed-use projects can be found in existing research publications (e.g. Rowley, 1996).

g. Summary

To sum up, Table 3.2 lists several dimensions of mixed-use identified during the literature study. Each of those dimensions is linked to particular mixed-use goals. Nonetheless, it should be noted that those dimensions are rather ambiguous. They have ill-defined and somewhat arbitrary boundaries and often overlap with each other. For instance, horizontal and vertical dimensions overlap with design and density dimensions; furthermore, building sharing overlaps with the time and diversity dimensions. Nevertheless, it is still beneficial to categorize those characteristics to provide insight into the structure of new and existing mixed-use development projects.

Table 3.2 A summary of mixed-use characteristics and goals

<table>
<tr><th>Mixed-use characteristics</th><th>Mixed-use goals</th></tr>
<tr><td>Diversity of use</td><td>To obtain synergy through having a balanced mixture of functions;
To create sustainable, liveable and attractive neighbourhoods;
To reduce car trips and increase the use of public transport and active transport.</td></tr>
<tr><td>Social and cultural diversity</td><td>To create sustainable, liveable and attractive neighbourhoods;
To increase housing affordability by giving people an opportunity to own a property other than a house;
To increase equity by accommodating people with different social, economic, ethnic and racial backgrounds.</td></tr>
<tr><td>Density</td><td>To reduce car trips and increase the use of public transport and active transport.</td></tr>
<tr><td>Design</td><td>To create pedestrian-friendly environments using designs of streetscape and neighbourhood (e.g. public parks and streets);
To create attractive and vibrant urban environments.</td></tr>
<tr><td>Destination accessibility</td><td rowspan="2">To reduce car trips and increase the use of public transport and active transport.</td></tr>
<tr><td>Distance to public transport facilities</td></tr>
<tr><td>Geographical scale</td><td rowspan="3">There are no particular targets set for these dimensions, but each of them contributes to the accomplishment of the other mixed-use dimensions. For instance, depending on geographical location (inner-suburban vs. outer-urban areas), density can be increased. It is difficult to introduce high-density when a development project is located in an outer-urban area. This issue will further be discussed in Section 3.2.</td></tr>
<tr><td>Time & building sharing</td></tr>
<tr><td>Horizontal and vertical dimension</td></tr>
</table>

3.2 The applications of mixed-use concepts

In this subsection, the applications of mixed-use concepts will be discussed. It should be noted that mixed-use development is very popular in the USA and Canada. Therefore, there are more research publications about it from those countries than from others, producing 'reporting bias'. Even though mixed-use has been an integral part of many old European cities, mixed-use concepts applied in those cities are fundamentally different from those applied in North America (Rowley, 1996). North American cities embrace mixed-use within mega real-estate development projects often located in the urban periphery. On the other hand, mixed-use in European cities has a tendency to be done gradually and incrementally, for instance, by adding more functions in already mixed-use neighbourhoods or districts in inner-cities.

In New Zealand, mixed-use development projects often adopt approaches similar to those used in North American cities. Few local studies have been done in the past years. An early study was done in 2001 in some inner-suburban and outer-urban areas of Auckland (Papatoetoe, New Lynn, Albany, Newton and Ponsonby) investigating residents' perceptions of mixed-use neighbourhoods there (Research Solution, 2001). In that study, several focus groups, involving a total of 35 residents and 31 businesses, were conducted. A recent follow-up study by Haarhoff et al. (2012) was carried out in similar locations, i.e. the Ambrico Place development area in New Lynn; The Ridge and Masons development areas in Albany; and Atrium on Main in Onehunga. The study investigated residents' preferences over medium-density neighbourhoods. The results of the latter study give further insight into important factors that New Zealanders consider when buying a property and they will be discussed in Section 3.4.

Furthermore, few studies have been done in NZ to examine the relations between the built environment and transport behaviour. A study done by Buchanan and Barnett (2006) explored travel patterns of people after relocating to the urban periphery of Christchurch. Afterwards, a study done by Badland et al. (2012) investigated associations between travel patterns of employed adults and the built environment factors. The results of these studies will be discussed in Section 3.3.

In addition, it should be noted at this point that mixed-use dimensions correlate with each other. For instance, a high-density neighbourhood tends to be located in a city centre and therefore also has high-diversity and permeability. This issue is called spatial multicolinearity (Saelens et al., 2003). The presence of spatial multicolinearity makes it harder to identify a specific dimension responsible for success and failure of mixed-use development projects. In order to properly assess the influence of each mixed-use dimension on the success or failure of a mixed-use development project, studies must be done in a strict and controlled environment. This can be done, for instance, by comparing, one at a time, two groups of mixed-use neighbourhoods that differ with regard to only one mixed-use dimension. Conducting such a study in real-life settings is extremely hard, or even impossible, as there are many overlapping mixed-use dimensions (see Section 3.1.2), confounding their effects.

Thus, the focus here will be on reviewing the applications of mixed-use development projects with regard to a group of dimensions, i.e. diversity of use (including the time and sharing dimensions), density (including vertical dimensions), design, location/geographical scale (including destination accessibility) and distance to public transport facilities. Moreover, we will separately discuss several practical issues related to social diversity. The influence of those dimensions on the reduction of car trips and the increase of walking, cycling and public transport trips will be discussed in Section 3.3.

3.2.1 Diversity, density, location and distance to a public transport facility

The results of a study about mixed-use practices in Canada (Grant and Perrott, 2010) suggest the difficulty in reaching and maintaining a proper and balanced mix between residential and commercial uses, confirming the results of a study done in the UK by Rowley (1996). For instance, in Vancouver, mixed-use neighbourhoods succeed in improving their vitality through having a balanced mixture of residences and retailing. However, in Toronto, such a combination often fails. This may happen because people's attitudes towards shopping at local shops have changed along with the increased number of shopping malls and large supermarket chains. Nowadays, people mainly consider going to locations that can offer one-stop shopping, with a wide variety of alternatives to choose from and competitive prices. This highlights the benefits offered by large retail outlets and supermarkets commonly located at large shopping centres. Consequently, many small local shops fail financially and are replaced with more specialist 'high-end' retailing activities.

Furthermore, it has been mentioned in Section 3.1.2 that there are multiple approaches to achieving mixed-use neighbourhoods and communities. One of them is developing large mixed-use projects (often called new urbanist neighbourhoods) in outer-urban areas and 'greenfield' sites where development regulations permit and land is low-priced. This implies 'second rate' locations or worse and make a property there a less favourable investment option in some countries, e.g. in the UK (Rowley, 1996). Similarly, the results of a study about the applications of mixed-use in Canada by Grant (2002) suggest that more problems are encountered by mixed-use developers who build in outer-urban areas than those in inner-cities. For instance, in Carma (Canada), developers face some difficulties in selling properties for commercial use. To solve this, they rent the properties out but the vacancy rate remains high. Besides, several developers must cancel their plan to rent out residential units above stores because the revenue from renting them out cannot cover the high building costs. Similarly, in Ontario, many mixed-use developers face difficulties in attracting commercial tenants. They manage to sell only a small number of commercial units because their properties are considered a risky investment. Therefore, developers tend to abandon commercial uses in newer development projects, making them the conventional single-use projects. In the several selected areas of Auckland, decent property sales for businesses in mixed-use neighbourhoods can be observed. Yet, businesses are still unhappy with the lower property values, limited market, increased traffic and noises from residents (Research Solution, 2001).

Besides problems related to low property sales for commercial use, mixed-use development projects in outer-urban areas fail to introduce high-density living. Developing a high-density neighbourhood in such areas is not feasible. When people relocate to outer-urban areas, they expect to live in a low-density neighbourhood. This, however, undermines the conceptual idea behind mixed-use: to build a compact neighbourhood. Moreover, residents living in neighbourhoods in outer-urban areas often express their concerns over the length of public transport trips to the city centre (Grant, 2002) and poorer level of service (Research Solution, 2001). On the other hand, from the point of view of the public transport provider, delivering a good level of service for public transport users living in outer-urban areas is deemed less cost-effective.

Another way to implement mixed-use is by gradually and incrementally revitalizing the existing urban areas, e.g. through in-fill development projects. The results of a study done by Grant (2002) suggest that this development type is more successful. Nevertheless, it still encounters some problems due to mixing different uses. For instance, proposing new functions within a well-established neighbourhood has often encountered opposition from the existing residents. Those residents are inclined to dislike mixing their neighbourhood with less popular functions, such as those that can increase density (e.g. school) and generate loud noises (e.g. bar, night club and restaurant) (Angotti and Hanhardt, 2001). Similarly, in Christchurch and New Lynn, existing residents feel that increased density in their neighbourhoods has invaded their privacy and made them less able to enjoy natural views. (Research Solution, 2001; Vallance et al., 2005). They feel hopeless and frustrated because they cannot do anything to prevent it from happening. Households in the CBD of Auckland find that a central location and the diversity of use give them the convenience that they look for, but this comes at the price of having to live in environments less suitable for raising children (Carroll et al., 2011). Additionally, established residents also have a tendency to hold the strong view of “not in my backyard” (Grant, 2002). Thus, they may even reject having new parks or playgrounds nearby their homes.

Nonetheless, despite the fact that inner-urban development projects are more successful, they remain less popular than their counterparts located in outer-urban areas. ‘Greenfield’ land remains cheap and there are powerful interests to promote development is those areas. Many people also prefer low-density living and want to remain attached to their cars (Grant, 2002). This highlights the importance of understanding people’s preferences for house location, as discussed in Section 3.4.

In addition, mixed-use development projects target different market segments, e.g. home buyers, retailers or business owners and renters. Those parties often have conflicting desires. For instance, it is more beneficial for retailers to buy or rent a property in a well-established residential community. This can reduce time lag before the business becomes profitable and as a result, decreases the risks of bankruptcy (Grant and Perrott, 2010). However, a well-established neighbourhood with operational local commercial centres is more attractive to home buyers, speeding up sales of houses in such a place. Additionally, the increasing popularity of working from home and internet purchasing in many developed countries around the world has a fundamental impact on the built environment. In terms of a mixed-use development project, this trend affects the sizes and the number of units of offices, shops and other facilities offered for sale (Rowley, 1996). The above examples show that a mixed-use development project requires careful planning with a complex development phasing and complicated calculations of probability of risks (Grant and Perrott, 2010). Furthermore, not every developer, builder and investor is prepared to be involved in such a project because each one of them is inclined to be specialized only in one particular type of development, e.g. residential or commercial only. Thus, to be successful, a mixed-use development project must be managed properly, making such a project subject to higher managerial costs (Rowley, 1996).

Moreover, in relation to diversity, wealthier communities are likely to have a greater control over the mixture of use than the poorer ones (Angotti and Hanhardt, 2001). This makes poor communities more vulnerable to being exposed to noxious uses that produce different kinds of pollution. Even activities that are seemingly safe, such as a shoe repair shop or a dry cleaner, may impose a health hazard on the neighbouring residents due to toxic fumes coming from chemical solvents used. Angotti and Hanhardt (2001) note that regulations cannot completely control the exposure to hazardous substances, as they often overlook the cumulative and interactive effects of different pollutants. A similar point is raised by Suddle (2006). He identified four dimensions of safety-related risks involved in a high-density mixed-use development project (Figure 3.7): risks coming from a building floor to the floor beneath it, e.g. fire [1] and to the floor above it, e.g. toxic gases [2]; risks from failing building structure [3]; and risks from/to other buildings nearby [4]. Hence, careful thought and consideration must be given to the design of a mixed-use neighbourhood, especially that with high-density and diversity, so that various safety- and health-related risks are kept within acceptable levels.

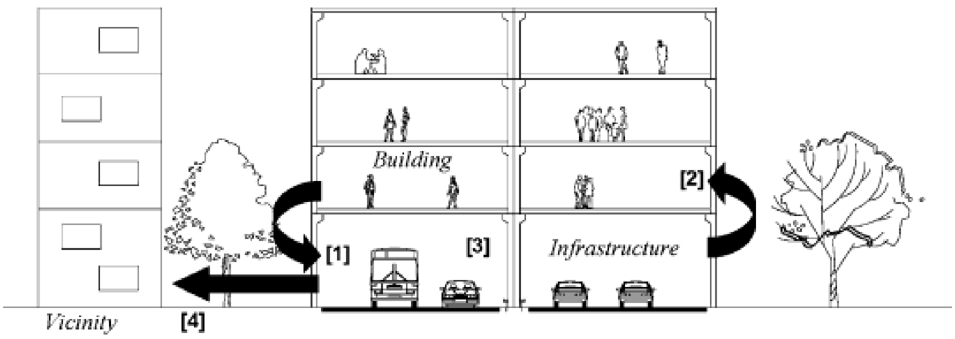


Figure 3.7 Risk dimensions in mixed-use neighbourhoods (Suddle, 2006, p.85)

Besides health- and safety-related issues, high-density and diversity generate some other concerns (Rowley, 1996). For instance, mixing uses within a single building requires separation of service facilities (e.g. stairs), and therefore may impose additional costs. Some companies are also worried that some tenants nearby may hurt their image. Mixing various functions within a single building may also imply mixing different types and lengths of tenancy. This means those properties may need to be refurbished at different time periods, and as a result, it may create some discomfort (e.g. smell of paint and noises). Some residents also fear that poorer quality covenants may decrease the values of their property. In several mixed-use neighbourhoods located in the inner-suburban and outer-urban areas of Auckland, residents complain about untidy businesses; the presence of neighbouring activities that produce noises, smells, smoke and steam; traffic congestion; and lack of parking (Research Solution, 2001). All of these issues must be considered by mixed-use developers and the City Council to ensure the attractiveness of mixed-use development projects.

The above discussion implies that the interaction between density and diversity of use requires innovative design solutions. Design can be used as a way to reduce those risks. Nevertheless, this requires integration of various components within a coherent design scheme so that a harmonious relationship can be created, despite different requirement specifications of various uses. Moreover, design must deliver efficient supporting facilities and services (e.g. mechanical, electrical and structural systems) that can accommodate different functions. Different activity cycles must also be considered and accommodated. For instance, several design solutions can be used to reduce noise coming from the neighbouring properties and to address security and privacy issues. Besides, to help generate synergies from various uses, design and placement of each use must be carefully considered. For instance, restaurants can be placed near offices, and local grocery shops near houses. Design can also be used to create a safe environment for children to play outdoors, as highlighted in the results of a NZ study by Haarhoff et al. (2012).

In addition, parking is a crucial component of most mixed-use development projects. However, it can impose a design challenge due to the difficulty in accommodating the parking needs of diverse uses (Levitt and Schwanke, 2003). For instance, residents prefer secure parking separated from commercial parking, employers prefer reserved parking and retailers prefer parking close to their store entrance. Due to the different activity cycles of those functions, calculating the total demand for parking in a mixed-use project is much more complex than for a single-use project. A similar point is raised by Haarhoff et al. (2012) based on the results of a study in selected areas of Auckland. Even though mixed-use neighbourhoods are located within close proximity of public transport facilities, many of the residents are not ready to give up their cars. This creates a major parking shortage problem, as developers did not anticipate such a high demand for parking. From the urban planning point of view, providing enough parking spaces that can satisfy the demand for parking spaces is undesirable, as this means that there is less incentive to reduce car ownership and use.

Furthermore, a mixed-use development project often requires more substantial public areas (e.g. plazas, squares, town greens, parks, gardens, promenades, courtyards, or streetscapes) than a single-use development project, due to a variety of functions that it contains. Open spaces are important to increase visual attractiveness of a mixed-use neighbourhood and to help integrate diverse functions within it (Levitt and Schwanke, 2003). Designs of buildings and open spaces can also help create a walkable neighbourhood and distinguish such a neighbourhood from a car-oriented one. Well-designed open spaces with a clear hierarchy (e.g. central plaza and major/secondary streets) are a key component of an effective pedestrian network because they facilitate spatial orientation and improve the appearance of the development.

3.2.2 Social diversity

Diversity within mixed-use is not only about having various uses within a neighbourhood but also related to social and cultural diversity (Grant, 2002). The results of a study done by Dale and Newman (2009) suggest that to be sustainable, mixed-use development should be made accessible to a diverse range of people with varying socio-economic characteristics. They argue that by doing that, issues related to social equity and liveable communities can be addressed. Furthermore, they also reason that both liveability and equity are needed because liveability without equity will lead to a shift to higher income residences and high-end stores.

Regulations often require a mixed-use development project to allocate a certain percentage of houses for lower income households. In spite of this, the specific needs of those households are rarely taken into account. For instance, the types and designs of houses do not match those people's needs and preferences. Moreover, there are no shops that suit them in the area. Thus, such a development project does not attract some of the 'intended' market groups (Newman and Wyly, 2006). Developers of several mixed-use development projects in Canada are also pushed to reduce the number of houses for lower income households as they encounter difficulties in selling high-priced houses in a neighbourhood where low-priced houses are also located.

Additionally, high-income residents resent having lower-income households in their neighbourhood and prefer being segregated from them (Dale and Newman, 2009). They often do anything, within their power, to push the lower-income households away from their neighbourhood. This shows the need for any mixed-use development project to include plans on how to keep their development project accessible to diverse groups of people. Furthermore, such a development project must place protections against displacement (Newman and Wyly, 2006). In many mixed-use projects, such as those in Canada and the USA, such a system is rarely put in place. As a consequence, resentment results in decreasing social diversity, which in turn increases housing prices and further forces low-income tenants and renters to move out of the development areas (Angotti and Hanhardt, 2001).

Therefore, real-estate mixed-use development projects are often criticized for further escalating social and cultural segregation. This was not the intention of planners who initiated the concept of mixed-use neighbourhoods, as stated by Dale and Newman (2009, p.679): *"A sustainable development paradigm that addresses the social imperative of sustainable community development in the form of equity and livability should not be building sustainable neighbourhoods for only the higher-income subsection of the population either passively or actively through the displacement of lower-income families. Sustainable development, if it is actually to be sustainable, should not be for some, but for all."*

3.3 Mixed-use development and travel behaviour

In studies about transportation and the built environment, five factors are commonly used to measure the built environment, namely: density, diversity, design, destination accessibility and distance to public transport facilities (commonly called the 5Ds). Density is a measure of population, house units, employment, or other variables of interest per gross/net area unit. Diversity, measured by entropy and/or job-house balance, represents the number of different land uses in a given area and accordingly it signifies land use intensity. Design represents the connectivity of the street network and the ability to distinguish a pedestrian-friendly neighbourhood from a car-oriented one. It is measured using several methods, such as the average block size, the average number of intersections per block size, the sidewalk coverage, the average building setback, the street width, the average number of pedestrian crossings and the street connectivity. Destination accessibility measures the ease of access, typically by using the travel times of car and public transport trips to several main trip attractions, such as a workplace, a central business district, a shopping centre and a local shop. Distance to a public transport facility signifies the average distances or travel times from home and from workplace to the nearest public transport stop or station. In addition, several other studies (e.g. Bhat and Eluru, 2009; Cao, 2010; Cervero, 2007; Khattak and Rodriguez, 2005; Shay and Khattak, 2005) use neighbourhood types (e.g. neo-traditional and TOD neighbourhoods) to represent the built environment, and therefore they avoid measuring the 5D factors described earlier.

From the above measures, it can clearly be seen that the 5Ds are only a fraction of dimensions discussed in Section 3.1.2. For instance, social diversity is excluded, and geographical scale/development locations are only partially represented through distance accessibility. Those excluded factors possibly obscure the effects of the 5D factors.

Many studies (e.g. Badoe and Miller, 2000; Crane, 2000; Næss, 2005) suggest that the influence of the built environment on travel behaviour is hard to estimate. This happens because their relationship is not straightforward and there are other intertwined factors, such as socio-demographic characteristics and residential self-selection. For instance, household incomes, structures and life-cycle stages tend to vary between inner-suburban and outer-urban areas. Therefore, the observed differences of travel behaviour may be attributed to those factors rather than residential location (Næss, 2005). For this reason, most studies carried out during the past decades have put more effort into controlling socio-demographic variables (e.g. Kitamura et al., 1997; Lu and Pas, 1999; Naess, 1995). However, less effort had been made to control residential self-selection. For instance, Ewing and Cervero (2010) note that more than 200 built environment and transport studies have been done between

2001 and 2010, but only 38 studies have attempted to control residential self-selection using various research approaches.

Residential self-selection refers to a tendency of households to live in a house location that matches their travel-related attitudes (e.g. travel preferences) and lifestyle (e.g. leisure interests and needs) (Bohte et al., 2009; Handy et al., 2006; Mokhtarian and Cao, 2008; Næss, 2009). For instance, people who enjoy walking and city life may choose to live in a mixed-use neighbourhood located in a city centre and near their workplace. They walk daily to their workplace and frequently shop at a local market. Accordingly, it is not mixed-use that influences their travel behaviour but instead, it is their travel attitudes and lifestyles, being represented by residential self-selection, that play an important role in their travel choices. The potential relationships between the built environment, travel attitudes and travel behaviour are shown in Figure 3.8.

Residential self-selection raises considerable doubt about the influence of built-environment on people's travel behaviour. Many researchers (e.g. Bhat and Eluru, 2009; Bohte et al., 2009; Cao et al., 2009b) argue that failure to take into account residential self-selection in a research study will result in a substantial bias and over-estimation of the influence of the built environment on travel behaviour. This means that, from the planning point of view, the influence of the built environment on people who are not motivated to walk/cycle, or to take public transport, may be limited (Handy et al., 2006).

Næss (2005) argues that self-selection in itself is a clear indication that the built environment is important, and states: *" The fact that people to some extent 'self-select' into areas matching their transport attitudes and car ownership is in itself a demonstration of the importance of urban structure to travel behaviour."* He further explains that if residential self-selection, along with travel attitudes and preferences, does not influence travel behaviour then public transport users may as well choose to live in an outer-urban area away from any public transport facility. Accordingly, residential location and other built environment characteristics are factors considered when making house purchase decision and they emerge prior to self-selection. Despite those remarks, he agrees that self-selection may still be a source of over-estimation of the influence of the built environment on travel behaviour.

Furthermore, as previously mentioned, a large number of studies about the effect of the built environment on transportation behaviour have been done in the past decades. As a result, many literature review papers, and even reviews of literature reviews, have been produced. As stated by Ewing and Cervero (2010, p.267): *"There are at least 12 surveys of the literature on the built environment and travel… There are 13 other surveys of the literature on the built environment and physical activity, including walking and bicycling… There is considerable overlap among these reviews, particularly where they share authorship. The literature is now so vast it has produced two reviews of the many reviews…"*

Thus, it is not intended to repeat those studies. Instead, the findings of several selected review papers are summarized, as many others echo similar messages. In addition, the findings are categorized based on specific travel behaviours: car trips (Section 3.3.1) and walking/cycling trips and public transport trips (Section 3.3.2).

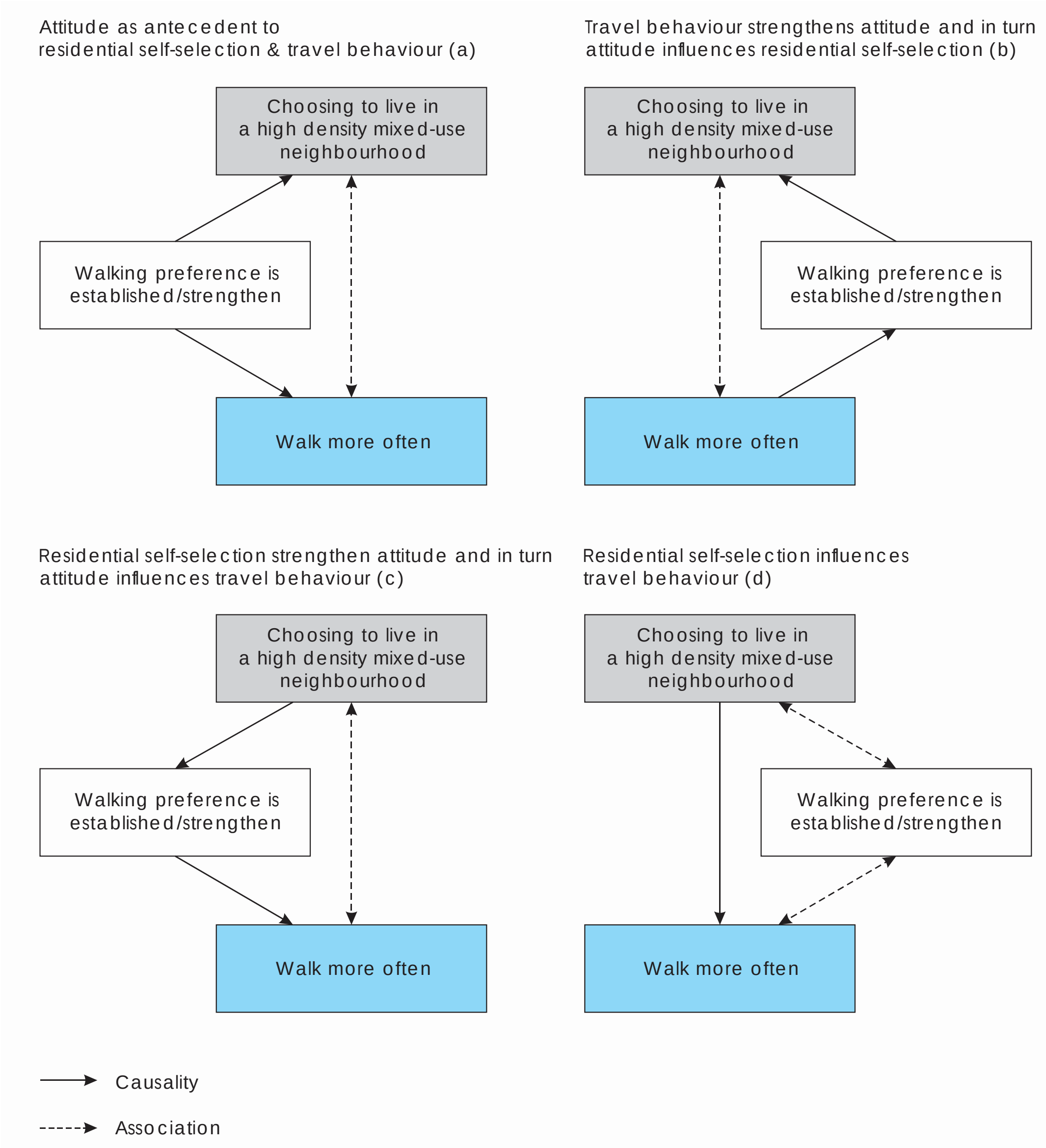


Figure 3.8 Potential relationships between the built environment, travel-related attitudes and travel behaviour (Mokhtarian and Cao, 2008, p.206)

3.3.1 Mixed-use – car trips

The results of existing literature review studies about mixed-use and car trips suggest inconclusive outcomes (Badoe and Miller, 2000; Cao et al., 2009b; Crane, 2000). For instance, a study, done by Badoe and Miller (2000), involved reviewing 18 empirical studies in North America. The results suggest that higher density, diversity and traditional neighbourhood design reduce car ownership and use, although their impact is merely marginal. Two main reasons for those vague outcomes were methodological weaknesses and data limitations. For instance, some studies use aggregate zone data and gross spatial units. As a result of this aggregation, the built environment with heterogeneous neighbourhoods (in terms of design, diversity and socio-demographic characteristics of residents) appears to be fairly homogeneous. In addition, parameter estimates of target variables were clouded by other uncontrolled factors. In other studies, factors related to the level of public transport service (e.g. frequency) were not taken into account, but authors of those studies simply concluded that the observed differences in travel behaviour are attributed to the built environment factors, instead of the excluded factors. To overcome this issue, Badoe and Miller (2000) suggest using an integrated approach, taking into account all major factors measuring the built environment and travel behaviour and their interactions. Without such an approach, estimates of the impact of the built environment on travel behaviour will likely be unreliable.

Besides, a review study done by Crane (2000) investigated the influence of the built environment, being represented by neighbourhood types (e.g. new urbanist and TOD neighbourhoods), on travel behaviour in the USA. Two main research methods were identified, namely: descriptive and multivariate statistical analyses. The latter commonly used ad hoc and demand models. In terms of research methodology, the results suggest that demand studies, involving trade-offs between travel costs and other attributes, seem to be more appealing than other standard approaches. With regard to the relationships between the built environment and car use, the results suggest that the current understanding of this issue remains unclear, as their relationships are more complex than they were initially believed to be. This happens because travel behaviour is a multifaceted concept and many built environment factors are difficult to separate. Furthermore, those factors tend to be correlated, adding some difficulties in identifying the effect of individual factors. On the other hand, when studies account for non-work trip purposes and geographical location in a city centre, there appears to be an association between a high-density, high-diversity and better-connectivity mixed-use neighbourhood and fewer car trips. A study done by Buchanan and Barnett (2006) in Christchurch compared people's travel behaviour before and after relocating to real-estate housing areas located inside urban areas but closer to the urban periphery (i.e. Northwood). The results suggest a very minimal change in car use and considerably longer travel distances after relocation, with some observed variations in travel distances by trip purpose, supporting the importance of trip purpose and geographical location.

Moreover, a study done by Cao et al. (2009b) involved reviewing 38 empirical studies that accounted for residential self-selection. Those studies used various analytical methods, namely: direct questioning, statistical control, instrumental variables, sample selection, propensity score, joint discrete choice models, structural equations models, mutually dependent discrete choice models and longitudinal designs. The results suggest that the built environment factors remain statistically significant even after accounting for residential self-selection, suggesting their direct influence on travel behaviour. However, the magnitudes of influence of the built environment factors reduce substantially once self-selection is taken into account. This means that when people who are not motivated to walk relocate to a pedestrian friendly neighbourhood, they will be expected to walk more, due to the influence of the built environment factors. However, it remains unclear how substantial such changes in behaviour will be.

Additionally, that study (Cao et al., 2009b) attempted to separately quantify and compare the strengths of influence of the built environment and residential self-selection on travel behaviour. The results of their study remain inconclusive, with the results of several studies suggesting a stronger influence of the built environment factors compared to self-selection and others suggesting the opposite. Studies using more sophisticated analytical methods are even more inconclusive about the magnitudes of the effects of the built environment factors and self-selection. Nevertheless, the results imply that socio-demographic and other unmeasured factors seem to have stronger influence on travel behaviour than those of the built environment and self-selection. Adding more complexity to the subject, the results changed depending on trip purpose and the built environment characteristics included in the analysis, echoing the same points made in other studies (e.g. Badoe and Miller, 2000; Handy, 1996).

The most recent meta-analysis study, done by Ewing and Cervero (2010), involved the calculation of elasticity of demand values of car trips, with respect to neighbourhood types and the 5D factors, based on the results of 62 studies. Vehicle miles travelled (VMT) was used to represent car trips. Overall, the results suggest inelastic relationships: each built environment factor has only a minor effect on the reduction of VMT (indicated by negative and small elasticity values). For instance, the highest elasticity values of VMT with regard to density were: -1.05 (at significance level 0.1) when using non-work VMT and population per road mile

(Chatman, 2008); -0.34 (at significance level 0.05) when using VMT per household and number of households per unit area (Bhatia, 2004); and -0.19 (at significance level 0.01) when using non-work VMT and the number of retail jobs per unit area (Chatman, 2008). Low negative elasticity values were also obtained for diversity, design, destination accessibility and destination to public transport facilities. The greatest absolute magnitude of the weighted average elasticity values was only 0.39 and most of the remaining elasticity values were considerably smaller.

Few studies have been done in NZ to investigate travel pattern of New Zealanders living in urban areas. One study by Badland et al. (2012) examined adults' travel behaviour using data collected from 1616 employees living in 48 neighbourhoods located in Waitakere, North Shore (Auckland), Wellington and Christchurch. The built environment characteristics were analysed using a geographic information system (GIS). The walkability of the neighbourhoods was assessed using a number of criteria: street connectivity, density and diversity. The results show that employed adults living in a car-oriented neighbourhood travel longer distances to work than their counterparts living in a pedestrian-friendly neighbourhood, and the difference is statistically significant. Additionally, those living in an outer-urban area commute a slightly further distance (i.e. 2.7 kilometres on average) than those living in an inner-urban area. Moreover, as the public transport stop density is lower in the outer-urban areas than that in the inner-urban areas, people who are living in an outer-area are more reliant on car travel than those living in an inner-area. On the other hand, the results of a qualitative study done by Bean et al. (2008) in Auckland suggest that even though respondents get attached to their car, they still find walking valuable for encouraging a healthier lifestyle and enhanced social activities. The results also suggest that if the public transport system in Auckland was better, respondents would have utilized it, together with walking more frequently. In spite of this, respondents complained about unpleasant and unsafe environments for walking in such a car-dominated city. Similar concerns were raised in a study done by Witten et al. (2013). They carried out a qualitative study to investigate the causes of the decline in walking and cycling amongst children aged 9-11 years old in Auckland. The results suggest that parents are concerned with their children's safety, as the built environments there are considered less favourable for walking and cycling. Consequently, they find chauffeuring their children an easy and convenient solution to avoid having to worry about their children's well-being.

3.3.2 Mixed-use – cycling, walking and public transport trips

Several literature review studies have been done to investigate the influence of the built environment on active transport, which includes physical activity (e.g. Handy, 2004). Similar to the above findings on car use, the results suggest mixed outcomes. The results changed depending on the specific travel behaviour being investigated (i.e. cycling or walking) and the built environment factors included in the analysis. Thus, an answer to a question about whether or not the built environment has any influence on active transport is, as stated by Handy (2004): "*it depends, sometimes it does and sometimes it doesn't.*" Nevertheless, there seems to be a distinct possibility that such causal relationships exist.

Similarly, the results of a literature study done by Badoe and Miller (2000) on various neighbourhood types suggest that there seems to be an increase in public transport and walking trips in mixed-use and neo-traditional neighbourhoods. In spite of this, the results of several other studies suggest that their impact is fairly weak. Badoe and Miller (2000) also reviewed several studies which investigated the impact of improving the accessibility of public transport on the values of properties in the areas. Again, the results were inconclusive.

The results of a review study done by Saelens et al. (2003) suggest that the built environment factors (i.e. population density, connectivity and diversity of use) are relevant to walking and cycling trips. Neighbourhoods with higher density and diversity and better street connectivity report higher rates of cycling and walking for utilitarian purposes (e.g. work trips) than their counterparts with lower density, diversity and connectivity. However, the results also suggest that the contribution of a specific built environment factor is difficult to measure, due to the presence of spatial multicolinearity. A similar concern about spatial multicolinearity is shared by Ewing and Cervero (2010). Based on the results of their meta-analysis study, density seems to have the least impact on travel behaviour than the other 4D factors. This smaller effect may be caused by the presence of multicolinearity within datasets used in various studies. Yet, research studies under their review often did not report the socio-demographic characteristics of people living in the study areas, hence clouding the research outcomes.

Furthermore, the results of a meta-analysis study done by Ewing and Cervero (2010) suggest that design (measured by intersection density), density (measured by job-housing balance), destination accessibility (measured by distances to local shops) are associated with walk trips and have the greatest elasticity values. The results also suggest that street connectivity is a less significant factor than intersection density, suggesting that permeability is hindered in a neighbourhood with long street blocks, as previously discussed in Section 3.1.1. Besides, the jobs-housing balance and population density seem to be better predictors for walking trips than land use diversity and job density.

When it comes to public transport trips, the results of a meta-analysis study done by Ewing and Cervero (2010) suggest that distance to public transport stops plays an important role in the likelihood of public transport trips. Design (measured by intersection density and street connectivity) and diversity are also relevant. Similar for walking trips, higher intersection density and better street connectivity increase permeability and therefore shorten the distance to public transport stops and increase routing options.

3.3.3 Altering travel behaviour via mixed-use development

Given the inconclusive research outcomes from many review studies, the exact strengths of influence of mixed-use factors on travel behaviour remain vague. There seems to be an indication that people who are living in a mixed-use urban neighbourhood walk, cycle and use public transport more often than those living in a single-use neighbourhood. This trend can still be observed even after controlling residential self-selection. This shows the potential of mixed-use development to alter people's travel behaviour. Nonetheless, extra care must be taken when interpreting the results of existing research studies. Those results do not necessarily suggest that every mixed-use development project will have the same desired influence on travel behaviour. Any development project located in a central location (e.g. CBD) is more likely to generate less car trips and more walking, cycling and public transport trips than that in a remote location, regardless of whether or not it implements sound mixed-use concepts (Ewing and Cervero, 2010).

Even though each built environment factor only has a marginal effect on travel behaviour, it does not necessarily mean that the built environment does not have a considerable influence on travel behaviour (Ewing and Cervero, 2010). The cumulative effect of the factors on car trips is much higher. In addition, synergy may be generated when the factors emerge simultaneously in a neighbourhood, intensifying their cumulative effect.

Besides, there are many other reasons for having mixed-use neighbourhoods, when they are properly planned, implemented and maintained, other than the reduction of car use. For instance, creating liveable neighbourhoods with affordable dwellings can still be very worthwhile (Handy et al., 2006).

3.4 House purchase decision

The next important question to address is whether or not mixed-use development reflects people's wishes or preferences. This issue has been discussed in many research publications. For instance, Rowley (1996) argues that city centre living is a minority taste and it is attractive to only certain groups of people, such as students and other young people. Most people, especially those with families, prefer to own a property with a garden in a peaceful and quiet location, which offers some degree of privacy. Some people do not prefer living in a neighbourhood with social and land use diversity and many of them prefer living closer to nature. Yet, there are only limited locations in a city that allow people to address their preferences. Because land price tends to be higher in the city, such properties become less affordable for many. Thus, people often seek a property further away from the city centre to acquire a desirable property, even at the price of an increase in commuting time, distance and cost.

A study done by Haarhoff et al. (2012) aimed to examine New Zealanders' housing preferences and views towards living in a medium density mixed-use neighbourhood. In this study, 84 respondents living in three development areas in the outer-urban areas of Auckland were interviewed. Those areas are: the Ambrico Place in New Lynn, located 12 kilometres to the south-west of Auckland (N=54); The Ridge and Masons in Albany, located16 kilometres to the north of Auckland (N=18); and Atrium on Main in Onehunga, located 10 kilometres to the south of Auckland (N=12). The results show that Aucklanders' preference to live in a (detached) house remains strong. However, residents do not mind medium density living and they support a diverse range of housing types and sizes in their neighbourhood. Additionally, residents are satisfied to be in close proximity to a town centre with many facilities and services, even though some of them are not easily accessible by modes other than car.

Several other research studies have also been done in recent years using stated and revealed preference methods to find the weights of factors that influence house location decisions (e.g. Burnley et al., 1997; Garcia and Hernandez, 2007; Hunt, 2010; Kim et al., 2005; Lee and Waddell, 2010; Molin and Timmermans, 2003). Several factors, discussed in Section 3.1.2, are used in the existing studies, such as diversity in house types and accessibility to the workplace and shops. However, other mixed-use factors are often treated as minor components and are not represented properly. For instance, density and location are often not included, and diversity of use is only considered in relation to local shops and (good quality) school. Moreover, social and cultural diversity are rarely taken into account. The results of several studies are summarized below.

A study done by Hunt (2010) investigated people's house location decision in Edmonton (Canada) using a wide range of factors, such as the built environment factors (e.g. density, type of street, air quality and traffic noise), transport-related attributes (e.g. travel times and costs by car and public transport, for shopping and commuting trips), funding sources (e.g. taxes) and house types. The results suggest that house type is the most important factor that people consider. It is followed by traffic noise, air quality, municipal taxes and type of street in front of the dwelling. Transport-related factors, despite being statistically significant, are less important than the other factors. On the other hand, the results of a study in Oxfordshire (UK), done by Kim et al., (2005), suggest that commuting cost is one of the most important factors that people consider when buying a property. Findings also suggest that the increase in residential density negatively affect people's decision to move, implying that people prefer to live in a lower density neighbourhood than in a higher density one. This supports findings of other studies about the applications of mixed-use, discussed in Section 3.2.

Furthermore, a study done by Cooper et al. (2001) in Belfast (UK) used factors such as walking to a local public transport stop and waiting time, travel cost, the number of bedrooms and housing price. The results show that housing price appears to be statistically significant and more important compared to the other factors. Similarly, the results of a study done by Molin et al. (1996) on housing preferences of middle class families in Meerhoven (Netherlands) suggest that house price is the most important factor that people consider, raising issues related to housing affordability. In addition, tenancy type (rent vs. own) is as important as house-related factors (i.e. the number of bedrooms and the size of the living room). On the other hand, neighbourhood-related attributes (related to density, diversity and accessibility) do not appear to be as important as the aforementioned factors.

A study done by Earnhart (2002) on housing choices in Kansas (USA) included the attribute of house price and other house-related variables (e.g. lot size, the number of bedrooms and bathrooms, size, style and age of the house). Besides, it also incorporated other location-related factors, such as the chance of flooding and a natural view. The results suggest that people prefer to buy a house located in an area that has a good natural view, with views towards water being considered more important than views towards land. Additionally, house and lot sizes appear to be more important than other factors.

Moreover, the results of a study done by Burnley et al. (1997) on people's reasons for relocating to outer-areas of Sydney (Australia) suggest that people relocate mainly to get home ownership, a better place to raise a family, lower housing costs and a better quality house. In addition, changes in marital status (e.g. married, divorced, etc.) and other personal reasons also play an important role in the decision to relocate. The results also suggest that the residential location choice is strongly affected by house affordability, design quality of the environment and proximity to friends/relatives.

A revealed preference study by Garcia and Hernandez (2007) investigated factors influencing the decision to purchase a house in Spain, taking into account the following alternatives: high-quality property ownership in an urban area, average-quality property ownership in an urban area, property ownership in a rural area and renting. Furthermore, house attributes (e.g. price and location) and socio-demographic characteristics (e.g. income, savings, household size and education level) were used as the explanatory variables. The results suggest that income is the most important factor that influences property decisions. Thus, an increase in income indicates a higher probability of owning a property in urban areas and a lower probability of owning a property in rural areas or renting a property.

A study done in Seattle (USA) by Lee and Waddell (2010) investigated households' decisions to relocate or stay at a current house location by using house and location factors (e.g. house price, house type and work accessibility) and socio-demographic characteristics. The results suggest that older households, households with children and home owners are less likely to move compared to renters or young households with no children. Moreover, accessibility, house price and house type are statistically significant. When an alternative property offers lower commuting cost and better accessibility to a workplace, people find relocating a more attractive option. Additionally, households with children prefer to live in a house located in a neighbourhood that has many other young families with children.

A study done by Næss (2009) investigated factors considered by people when selecting a new house in Copenhagen (Denmark). The results suggest that a private garden, low price, proximity to recreational areas, proximity to friends and relatives, proximity to shopping facilities and traffic conditions are deemed important by 26-39 % of the participants (N=1907–1910). Fewer participants regarded distance to the workplace and accessibility to a public transport facility as important factors.

From the above summary of the previous studies, it can be seen that the results are again inconclusive. Several factors, such as housing price, appear to be most influential in one study but not in others. This implies that the residential location decision depends greatly on the local contexts and the factors included in the study. Thus, the results of overseas studies may not be applicable in NZ. This further highlights the importance of conducting a local study to investigate the relative importance of factors that influence New Zealanders' decisions when selecting residential location, especially in relation to mixed-use development projects.

Moreover, through the literature review, the attributes used in the existing research are identified and they are listed in Table 3.3. These attributes, along with other mixed-use characteristics (Table 3.2), were considered in the design of the stated preference survey.

Table 3.3 List of factors that influence residential choice decision

Factors	Remarks
The built environment and mixed-use attributes	
Density	This variable was included in a small number of studies (e.g. Cooper et al., 2001; Kim et al., 2005).

School quality	This variable can be used to capture the diversity within a mixed-use neighbourhood and it was included in a small number of studies (e.g. Kim et al., 2005).
Children's playground	This variable can be used to capture the diversity within a mixed-use neighbourhood and it was included in a small number of studies (e.g. Molin and Timmermans, 2003).
Natural view	This variable captures the natural view surrounding a house, e.g. river, lake, beach and mountain, and it is an attribute of residential location.
Neighbourhood type	This variable was included in a small number of studies (e.g. Molin and Timmermans, 2003).
Socio-economic status/social environment	This variable can be used to capture the social and economic diversity within a mixed-use neighbourhood and it was rarely included in the existing studies.
Location (inner-suburban vs. outer-urban areas)	This variable was rarely included in the existing studies.
Flooding	These variables are relevant to explaining the differences in house locations but they were rarely included in the existing studies.
Quietness and privacy	
Residential environment /amount of traffic	Other indicators, such as air quality and types of street in front of dwellings, were used in several other studies (e.g. Hunt, 2010).
Air quality	Bad air quality can be caused by the amount of traffic nearby but it can also be caused by other factors, such as the concentration of log burners in the area.
Travel time/accessibility to work	In the existing studies (e.g. Cooper et al., 2001; Earnhart, 2002; Garcia and Hernandez, 2007; Hunt, 2010; Kim et al., 2005; Molin and Timmermans, 2003), attributes related to transportation were often included. However, they were often portrayed differently. For instance, a study done by Molin and Timmermans (2003) treated commuting time as two separate factors: commuting time for husband and wife. Furthermore, a study by Hunt (2010) used commuting times by different modes. Various treatments can also be found for travel time to shops and travel costs.
Travel cost to work	
Walking time/accessibility to public transport stop	
Waiting time at a bus stop/bus frequency	
Travel time/accessibility to friends and relatives	
Travel time/accessibility to local shops	
Travel time/accessibility to city centre/shopping centre	
Travel time/accessibility to children's school	
Distance to parking facilities	
Parking cost	
Previous place of residence	This variable was included in a small number of studies (e.g. Molin and Timmermans, 2003).
House-related attributes	
Lot size	Existing studies (e.g. Cooper et al., 2001; Earnhart, 2002; Garcia and Hernandez, 2007; Hunt, 2010; Kim et al., 2005; Molin and Timmermans, 2003) always included house-related attributes, with several attributes (e.g. price, house types, size and number of rooms) being used more often than others (e.g. taxes and maintenance).
House size/interior space	
Size of garden	
Interior space	
House price/mortgage/rent	
House types/styles (e.g. house, town house/flat and apartment)	
Number of rooms/bedrooms	
Size of rooms/bedrooms	
Number of bathrooms	
Building age	
Garage	
Maintenance cost	
Taxes	

Socio-demographic attributes	
Age (average age of adults in a household)	Socio-demographic characteristics were often included as explanatory variables to explain residential location decisions.
Household income	
Number of children living together	

4 Choice modelling

One of the objectives of this project was to investigate New Zealanders' choice of residential location when purchasing a property as this might influence their travel behaviour considerably. Accordingly, we sought to find the weight that New Zealanders' place on the cost of house purchase, the commuting time, and other important and relevant attributes discussed in Section 3. To address this objective, we applied choice modelling, which included designing surveys, using stated preference method, and specifying and estimating choice models. The surveys were implemented using Qualtrics survey software, and were administered online, making it accessible to all New Zealanders having access to the Internet.

It has been noted in the literature (e.g. Bethlehem, 2010) that an online survey may cause sampling bias due to the exclusion of people who have limited access to the Internet (e.g. elderly people). However, given that this study intended to investigate New Zealanders' decision-making when deciding upon housing location, the target population were those aged 20 to 40. The majority of New Zealanders in that age range, who are also living in major NZ cities, have good access to the Internet, either at work, at home, or both. Therefore, sampling bias due to online surveying was not considered a major problem. The analysis method used in this project, namely choice modelling, is described briefly below.

Choice modelling is an analytical method which attempts to identify the sources of preferences or the underlying influences or reasons behind individuals' choice behaviour (Hensher et al., 2005). This is done by asking individuals to assess a number of choice situations. Choice modelling typically comprises several components, and they will be described using a simplified example. Consider an individual buying a house and facing two alternative locations: a higher density mixed-use inner-urban neighbourhood or a lower density single-use outer-urban neighbourhood. These alternatives differ in a number of aspects (or attributes), such as house prices, commuting costs, and commuting time. Each attribute is explained by its levels. For instance, commuting time might be 30 – 50 minutes and 20 – 30 minutes for the outer-urban single-use and the inner-urban mixed-use neighbourhoods respectively. Choice modelling involves evaluating the trade-offs that are made, as reflected in the choices of residential location, for each combination of attribute levels associated with the alternatives. To make a finite number of choice situations (hereafter will be referred to as treatment combinations/choice tasks), the attribute levels have to be treated as discrete rather than continuous. Choice models assume a rational decision-making process, with the location with the highest utility being chosen.

It should be noted that choice modelling, as with any other modelling approach, is a simplification of reality. In this regard, choice models simplify individuals' choice behaviour. Moreover, a choice study typically involves two parties: researchers who want to explain individuals' choice behaviour by developing models, and individuals whose behaviour is of interest to the researchers. Accordingly, the overall utility associated with alternative *i* (U_i) has also two components. The first component (denoted by V_i) is the utility associated with the attributes and levels of alternative *i* that can be observed by researchers, such as commuting time and cost, and is also referred to as the representative utility. The second component (denoted by ε_i) is the utility associated with the factors unobserved by researchers, such as variations in taste amongst individuals, and is often referred to as the random error component. It also reflects researchers' inability to fully identify and include all relevant variables in the utility function. Therefore, the overall utility associated with alternative *i* can be written as:

$$U_i = V_i + \varepsilon_i \qquad \text{Eq. 4.1}$$

while the representative utility can be written as:

$$V_i = \beta_{0i} + \beta_{1i} f(X_{1i}) + \beta_{2i} f(X_{2i}) + \cdots + \beta_{Ki} f(X_{Ki}) \qquad \text{Eq. 4.2}$$

where β_{0i} is an alternative-specific constant (ASC), which represents the average role of all unobserved components of utility, and β_{Ki} is the estimated parameter (or the weight) associated with attribute X_K of alternative *i*.

Equation 4.2 shows that choice modelling provides an estimate of the weight for each attribute, giving the relative importance of the attributes affecting the representative utility. The statistical significance of each weight is also identified.

Because researchers have limited information on individuals' choice behaviour, they cannot be absolutely certain that an individual will choose one alternative over the others. They can only estimate the probability of alternative *i* being chosen by an individual as the probability that the overall utility associated with alternative *i* is larger than or equal to the overall utility of another alternative (alternative *j*). This can be written as:

$$Prob_i = Prob\left(U_i \geq U_j \;\forall\; i \neq j\right) \qquad \text{Eq. 4.3}$$

$$Prob_i = Prob\left[(V_i + \varepsilon_i) \geq \left(V_j + \varepsilon_j\right) \;\forall\; i \neq j\right] \qquad \text{Eq. 4.4}$$

$$Prob_i = Prob\left[\left(\varepsilon_j - \varepsilon_i\right) \leq \left(V_i - V_j\right) \;\forall\; i \neq j\right] \qquad \text{Eq. 4.5}$$

Different choice models are obtained from different assumptions about the distribution of the error term. The most popular logit model is the multinomial logit (MNL). More recent logit models are the mixed logit (ML), scale heterogeneity logit (S-MNL) and generalized multinomial logit (G-MNL) models, allowing modelling of taste heterogeneity.

The multinomial logit (MNL) model assumes that all of the unobserved factors are independent and identically distributed (IID), and the error is distributed according to the extreme value type-1 (EV1) distribution. The IID assumption allows us to calculate analytically the values of probability using the following equation:

$$Prob_i = \frac{expV_i}{\sum_{j=1}^{J} exp\, V_j} \qquad \text{Eq. 4.6}$$

The probabilities of choosing an option are easily computed with the MNL model, but the MNL model is behaviourally more restrictive due to its "independence from irrelevant alternatives" (IIA) property. This property has been illustrated in the well-known red bus/blue bus example of Debreu (1960). Imagine that there are two transport mode alternatives for a trip (e.g. using a car or a red bus), and imagine that these modes have equal probability of being chosen (i.e. 50% each, or equal odds). Imagine that a new bus service is introduced, operating on the same routes with the same fares and travel time. The only difference is that the new buses are blue rather than red. With the additional new alternative, the expected probabilities will be 50% for the car, 25% for the red bus and 25% for the blue bus. The IIA property requires, however, that the odds ratio between the car and the red bus has to be preserved, so the MNL model will give estimated new probabilities equal to 33.3% for each mode. To relax this restriction, the mixed logit (ML) model was developed. ML adds more flexibility in the treatment of the random component, allowing pairs of alternatives to be correlated to varying degrees. This gives greater behavioural realism, but at the expense of computational complexity. There are several other types of choice models, other than ML, which also relax the IIA property, such as the scale heterogeneity model and the generalized mixed logit model (for details of these models see Ben-Akiva and Lerman, 1985; Fiebig et al., 2010; Hensher et al., 2005; Louviere et al., 2000; Train, 2009).

5 Stated preference method

Stated preference (SP) and revealed preference (RP) are widely used methods to obtain data needed in choice modelling. The former uses hypothetical scenarios and asks individuals to indicate or state their preferences (or choices) whereas the latter uses the revealed or observed behaviour and data. The advantages and disadvantages of both techniques have been widely discussed in research literature (e.g. Hensher et al., 2005; Louviere et al., 2000). To summarize, because SP elicits choices that individuals made given hypothetical scenarios, it can be used to investigate options which are not currently available. However, an SP survey has to be designed carefully to ensure realistic scenarios. In addition, in an SP study the levels of the attributes have to be pre-specified by researchers, whereas in an RP study the levels can be derived from the data provided by individuals. The most prominent difference between the two methods is that in an SP study, respondents are usually shown multiple choice sets with varying attribute levels, leading to multiple observations per respondent. On the other hand, RP data typically contain information about a single choice made by each respondent. Hence, in RP studies, attributes' levels of non-chosen alternative(s) are often not available. For instance, there are two transport mode alternatives to go to work: car and bus. These alternatives are different with regard to travel time and cost. A respondent who has never used bus before may not be able to give correct indications of travel time and cost by bus. Considering the advantages and disadvantages of both methods and the purpose of this study, the SP method was considered the most appropriate method to use. However, several RP questions were asked in the survey. A study done by Hensher and Bradley (1993) show that both types of data can be combined and used to estimate model parameters.

The fundamental component of any SP study is the experimental design. The term experimental design is used due to the nature of an SP study, which involves multiple observations of the response (or dependent) variable, given the manipulation of the levels of the attributes (or independent variables). For example, there are two choices of housing location, each having three attributes (housing price, travel time and direct travel cost). Thus, assuming that each attribute has three levels, there will be 729 ($3^3 \times 3^3 = 729$) possible treatment combinations. It is certainly infeasible to ask each participant to respond to all those combinations. Therefore, a specialized form of statistics (experimental design) is used to determine the manipulation of levels of attributes. In this project, we examined several SP design approaches, such as orthogonal design, optimal design and efficient design (Goupy and Creighton, 2007; Hensher et al., 2005; Louviere et al., 2000; Montgomery, 2000; Street et al., 2005). The fundamental differences between these designs will be summarized in Sections 5.1 to 5.3 below and the results were used as the basis for selecting the design for the survey.

Moreover, any SP study requires a comprehensive experimental design process, involving multiple steps: (1) problem refinement; (2) stimuli refinement (identifying alternatives, attributes and levels); (3) experimental design conceptualization (deciding upon the choice modelling approach, specifying utility functions, and deciding upon the SP design); (4) experimental design generation (including treatment combination and choice set generation); and (5) survey generation. We followed those steps to prepare the SP survey. Moreover, the specialized NGENE software was used in step #4 to generate experimental designs. This software allowed us to evaluate the performance of multiple SP designs before selecting the final one. The Qualtrics software was used in step #5.

After the data were collected, checked, cleaned and re-formatted, they were analysed using NLOGIT, which is specialized software for estimating choice models and is an extension of the statistical data analysis software package LIMDEP. This analysis produced estimates of the weight of each attribute which influences the house location decision, along with statistics indicating the statistical significance of those estimates.

5.1 Orthogonal design

Orthogonal design is a design approach used in the experimental design conceptualization (step #3 above) and it is probably the mainstream design approach used in the stated preference studies. An experimental design is typically generated by creating a matrix, with each column representing levels of an attribute and each row signifying a treatment combination (Hensher et al., 2005). In that matrix, levels are coded with either design coding or orthogonal coding. For instance, three levels are coded {0, 1, 2} when using design coding and {-1, 0, 1} when using orthogonal coding.

A design is said to be orthogonal when 1) all attribute levels are balanced, or they appear the same number of times, and 2) all attributes can be estimated independently (Hedayat et al., 1999; Hensher, 2005; Louviere et al., 2000). The latter implies that attribute levels in every attribute column cannot be correlated with one another. When orthogonal coding is used, orthogonality is reached when the sum of the inner product of any two attributes is zero, as shown below:

$$\sum_{s=1}^{S} x_{j_1 k_1 s} x_{j_2 k_2 s} = 0 \; \forall (j_1, k_1) \neq (j_2, k_2) \qquad \text{Eq. 5.1}$$

where j is an alternative; X_k is attributes; and s is treatment combinations.

Once an orthogonal design has been found, removing any row will disrupt orthogonality but removing any column will not. This means users can randomly select columns and re-arrange it to generate a survey design. In addition, orthogonal design offers some flexibility in how to attach attribute labels to coded levels. For instance, if travel time has three levels: 20, 25 and 30 minutes, signifying labelled attribute levels, and orthogonal coding is used, travel time can be coded as {-1, 0, 1} for {20, 25, 30}, {25, 20, 30} or {30, 25, 20} without affecting design orthogonality.

However, despite the benefits described above, finding an orthogonal design is not a straightforward task. Several tables of orthogonal arrays have been mathematically derived for a number of attributes and levels but they are fairly limited to models with small number of variables (Addelman, 1962; Eccleston and John, 1996; Hedayat et al., 1999). Mixing attributes with different numbers of levels can also create difficulties in finding an orthogonal design. In addition, orthogonal designs are available only for a certain number of treatment combinations. This implies that to satisfy orthogonality, one must use a larger number of treatment combinations than is required by the degrees of freedom alone, adding more burden for respondents, who must assess the treatment combinations. Blocking design is often used to reduce the number of treatment combinations that must be assessed by each respondent, but it may jeopardize the orthogonality of the design (Hensher et al., 2005).

Many researchers believe that the popularity of orthogonal design in choice modelling is merely due to historical impetus and inertia (e.g. Bliemer et al., 2009; Huber and Zwerina, 1996; Kessels et al., 2011; Sándor and Wedel, 2002). In the past, experimental design was mainly dominated by linear regression models. Thus, orthogonality is considered important to minimize the variances of the parameter estimates of such models and to produce non-confounded estimates.

However, discrete choice models are not the same as linear regression models. Being able to maintain orthogonality in a dataset used to derive parameter estimates in a choice study is considered a mere exception rather than the norm. Without going into theoretical details on how parameters are estimated in choice models and thus, why orthogonal design is not suitable, we will briefly describe several practical reasons. Firstly, data on the socio-demographic characteristics of participants are typically collected in choice studies. These non-design data are combined with experimental design data and are analysed together. Thus, they are likely to produce some correlations. Secondly, when blocking design is used to reduce the burden of respondents, design orthogonality can also be lost. Finally, enforcing orthogonality may produce treatment combinations which are behaviourally implausible (e.g. a big house in a city centre at a low price) or give no information. The latter happens when one alternative noticeably dominates other alternatives. In this case, no information will be gained in terms of trade-offs among attributes.

Given the above, even a carefully generated orthogonal design will most likely produce non-orthogonal data. Therefore, better designs should be used in a choice study, such as optimal and efficient designs, despite their lower popularity.

5.2 Optimal design

Optimal design is a special type of a sequential orthogonal design proposed by Street et al. (2005). They suggest that an experimental design should be constructed in such a way that it forces respondents to make the trade-offs among attributes. As a consequence, common attributes across alternatives cannot take identical levels throughout the experiment, so that attribute level differences can be maximized. Detailed descriptions on how to construct an optimal design can be found in the literature (e.g. Street et al., 2005; Street and Burgess, 2007).

Optimal design is better than orthogonal design as it maximizes information gain with a smaller number of treatment combinations. However, it suffers from a number of issues (Rose and Bliemer, 2009). Firstly, it is not suitable for a labelled experiment where alternatives do not share any common attribute or where levels of common attributes are different across alternatives. It is also not suitable for an unlabelled experiment. A choice experiment is called unlabelled when alternatives are not given any identification. For instance, two house alternatives to buy are called “option A” and “option B”. In a labelled experiment, those alternatives are given some descriptions, such as “city apartment” and “country house”. Secondly, optimal design is argued to promote certain behavioural responses, such as lexicographic decision rules. Lexicographic choice happens when individual decision makers make a choice based on only one attribute (e.g. price) and disregard the other attributes entirely. Only when two alternatives share the same level for that dominating attribute does the decision maker start to consider other attributes (Tversky and Kahneman, 1974). Thus, as optimal design forces common attributes to be different across alternatives, trade-offs may be based on the changes of levels of only one particular dominating attribute. Moreover, optimal design is considered suitable only for MNL (Bliemer and Rose, 2009a).

The issues described above, with regard to orthogonal and optimal designs, led us to consider efficient design to generate the survey design.

5.3 Efficient design

Unlike orthogonal design that seeks to minimize correlation across attributes, efficient design aims to obtain data that can minimize the standard errors of parameter estimates, implying more reliable estimates. Such a design comes with the price of losing design orthogonality. Nevertheless, this should not be a major concern as orthogonality within a dataset will likely be lost in any case, as discussed in Section 5.1. To reduce standard errors, efficient design requires some prior information about estimates of attributes. These prior estimates can be obtained in a number of ways, such as using the results from previous or pilot studies. Subsequently, the prior estimates are used to determine an asymptotic variance-covariance (AVC) matrix, through which the asymptotic standard errors can be obtained. Further theoretical explanation on how to obtain an AVC matrix can be found in the literature (e.g. Bliemer and Rose, 2009).

The results of a study done by Huber and Zwerina (1996) suggest that designs that minimize asymptotic standard errors of parameter estimates are able to produce more reliable estimates with smaller sample sizes, as shown in Figure 5.1. The figure shows two designs: one with higher standard errors and thus lower efficiency (X^{I}), such as orthogonal design, and the other one with lower standard errors and thus higher efficiency (X^{II}). It can clearly be seen in the figure that the standard error of an estimate improves as the sample size gets larger. The reduction of the standard error caused by the increase in sample size (* in Figure 5.1) is still much smaller than its reduction caused by using a more efficient design (**) (Bliemer and Rose, 2009a).

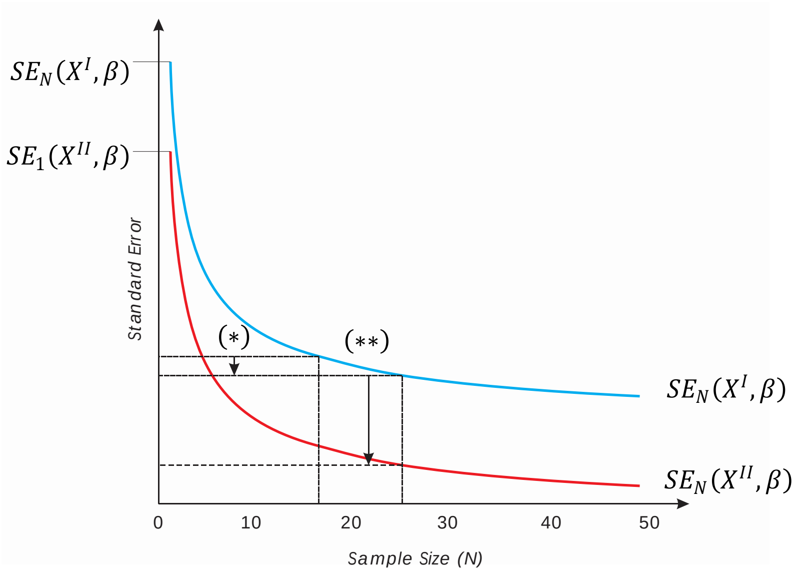


Figure 5.1 Relation between asymptotic standard error (*y*) and sample size (*x*) (Bliemer and Rose, 2009, p.516)

Efficiency, or more precisely inefficiency, is measured using the efficiency 'error' index, derived from an AVC matrix. The most well-known measure is D-error and a design with the lowest D-error value is called D-optimal. In reality, a D-optimal design is hard to find. Therefore, having a design with a sufficiently low D-error value is considered adequate. Such a design is called D-efficient design. Based on prior estimates, several types of D-error are proposed, namely D_z-error, D_p-error and D_b-error. D_z-error ('z' comes from zero) is used when there is no prior information available. When prior estimates are relatively accurate and are assumed to be correct, D_p-error is used ('p' comes from prior). Furthermore, when there is some uncertainty surrounding prior estimates and when those estimates are assumed to be random, following a certain probability distribution, then D_b-error is used ('b' comes from Bayesian). Different types of D-error are calculated using the following formulas:

$$D_z - error = det(\Omega_1(X,0))^{1/H} \qquad \text{Eq. 5.2}$$

$$D_p - error = det\left(\Omega_1(X,\tilde{\beta})\right)^{1/H} \qquad \text{Eq. 5.3}$$

$$D_b - error = \int_{\tilde{\beta}} det\left(\Omega_1(X,\tilde{\beta})\right)^{1/H} \phi(\tilde{\beta}|\theta)d\tilde{\beta} \qquad \text{Eq. 5.4}$$

where Ω_1 is an AVC matrix assuming a single respondent; *H* is the number of parameters to be estimated; and $\tilde{\beta}$ (Equation 5.3) is the set of prior estimates. $\tilde{\beta}$ (Equation 5.4) is a set of random variables with joint probability distribution $\phi(.)$ (e.g. a normal or uniform distribution) and given θ parameters.

Another inefficiency measures have been proposed, such as A-error and S-optimality. A-error uses the trace of an AVC matrix, instead of its determinant. Similar to D-error, there are three different types of A-error: A_z-error, A_p-error and A_b-error. A_p-error is calculated using the formula below.

$$A_p - error = \frac{tr\left(\Omega_1(X,\tilde{\beta})\right)}{H} \qquad \text{Eq. 5.5}$$

S-optimality is a measure of efficiency in relation to sample sizes and it has been introduced by Bliemer and Rose (2009b). It gives an indication of the sample size required to obtain significant parameter estimates. However, it should be interpreted with caution as the calculated minimum sample size depends on the type of logit model, the model specification, and the parameter estimates (de Bekker-Grob et al., 2015). Thus, the S-estimate can be used as a measure to compare different designs, similar to other efficiency criteria, such as D-error (Kessels et al., 2006).

The lower bound of the sample size (*N*), or S-optimality, is calculated using the following formula:

$$N \geq \left(\frac{SE_{1,k}(X,\tilde{\beta})t_{\alpha}}{\tilde{\beta}_k}\right)^2 \qquad \text{Eq. 5.6}$$

where t_{α} is the t-value corresponding to the chosen confidence interval (e.g. 95%); $\tilde{\beta}$ is the set of prior estimates of attributes (X_k).

Accordingly, the goal of researchers is to obtain a design that can minimize those error indices. However, D-error must be preferred over A-error, as the latter may yield some scaling problems (Bliemer and Rose, 2009a).

To sum up, considering the benefits of efficient design over the other types of experimental design (i.e. orthogonal and optimal designs), efficient design was used in this study. Furthermore, a pilot survey (discussed in Section 6.1) was conducted to obtain prior estimates required to generate the final design that can minimize D_p-error.

6 Pilot and main surveys for Christchurch

It has been mentioned in Section 5 that the SP method (i.e. efficient design) was used to obtain data needed to estimate choice models. The efficient design method requires prior parameter estimates to generate experimental design (a basis for making choice tasks). In this study, the prior estimates were calculated from data of a pilot survey. To design the pilot survey (and subsequently the main survey), alternatives, attributes and levels had to be assessed and selected. The processes involved in designing the pilot and main surveys are described in Sections 6.1 and Section 6.2 subsequently.

6.1 The pilot survey

The first stage in the SP design process was to decide on the alternatives (Section 6.1.1), the attributes (Section 6.1.2), the attribute levels and the labels of levels (Section 6.1.3). Subsequently, the utility functions of the MNL model were specified (Section 6.1.4) and used to generate the experimental designs for the pilot survey. Furthermore, pilot survey data were collected (Section 6.1.5) and analysed, resulting in prior estimates used to generate the main survey design (Section 6.1.6).

6.1.1 Alternatives

There are two general types of SP study: unlabelled and labelled. In an unlabelled study, generic titles are used for alternatives (e.g. Property-1 vs. Property-2), whereas in a labelled study, alternative-specific titles are used (e.g. inner-suburban vs. outer-suburban property). In an SP study, the decision whether or not to carry out an unlabelled or labelled study is crucial, because it influences the model specification (i.e. generic vs. alternative specific models), the number of choice tasks that needs to be assessed by respondents, and the types of results that can be obtained. These are further explained below.

In an unlabelled study, the differences between alternatives can only be explained by the preselected factors. For instance, Property-1 is located in a high density neighbourhood whereas Property-2 is in a low-density one. The levels (i.e. low and high) of the density factor describe the alternatives. An unlabelled experimental design is sufficient to obtain data needed to develop a generic model and thus, to study the relative importance of one factor or attribute (e.g. density) on others (e.g. diversity), such as shown in the example below. In a generic model, a parameter estimate (e.g. β_1) signifies the weight of an attribute (e.g. density) and it remains constant across all alternatives. The representative utilities are thus:

$$V_{Property1} = ASC_1 + \beta_1 \times Density + \beta_2 \times Diversity \ldots + \beta_x \times Attribute_x$$

$$V_{Property2} = \beta_1 \times Density + \beta_2 \times Diversity \ldots + \beta_x \times Attribute_x$$

A labelled study allows us to obtain the estimates of alternative-specific parameters in the expressions for the representative utilities, as follows:

$$V_{Inner-suburban\,property} = ASC_1 + \beta_{i1} \times Density + \beta_{i2} \times Diversity + \cdots + \beta_{ix} \times Attribute_x$$

$$V_{Outer-suburban\,property} = \beta_{o1} \times Density + \beta_{o2} \times Diversity + \cdots + \beta_{ox} \times Attribute_x$$

where $\beta_{ix} \neq \beta_{ox}$.

The model specification above shows that different weights are given to the density attribute when a property is located in an inner-suburban area (β_{i1}) and an outer-suburban area (β_{o1}). This creates a more realistic modelling interpretation, as people may value the increase of density in inner-suburban and outer-suburban areas differently. Thus, the results would be richer and more beneficial in helping to formulate actions to support mixed-use development.

However, there are several disadvantages of using a labelled study. Because a labelled study can be used to estimate alternative-specific parameters, it requires more degrees of freedom. This implies more treatment combinations to be assessed by respondents and accordingly, more time is needed to complete the survey. A degree of freedom can be seen as an independent piece of information obtained from respondents' answers to each treatment combination. It is needed to estimate a parameter. Accordingly, the more parameters that need to be estimated, the more treatment combinations are required. Note that the number of treatment combinations also depends on other aspects, such as the types of experimental design (i.e. an orthogonal design vs. an efficient design), and the numbers of alternatives, attributes and levels. An orthogonal design typically contains more treatment combinations compared with an efficient design (see Section 5).

Weighting the pros and cons above, it was decided to use a labelled study. Furthermore, several issues were considered when deciding upon the number and 'labels' of the alternatives. These are described in the subsequent paragraphs.

Considering the objectives of this study, 'location' should be used as the alternatives. In a broader sense, a city can be categorized into urban, inner city and suburban areas (Figure 6.1). This shows that there were several possible 'labels' of the alternatives that could be used.

In the Christchurch City Plan (2012), the urban area consists of the core, frame and fringe which together constitute the centre business district (CBD). The inner city is the area immediately located outside the CBD (Figure 6.1). Compared to the CBD, the inner city has a lower intensity of development and it often acts as a buffer between the CBD and the suburban area. With regard to the built environment, the inner city is more urban-oriented, with a higher ratio of built form to open space compared to the suburban area. The inner city often accommodates a wide range of activities, such as residential use (e.g. occasional high rise apartment buildings, two or three storey apartments and single storey detached dwellings), tourist accommodation (e.g. hotels, motels and hostels), institutional and community buildings (e.g. hospitals, schools, clubrooms, and medical centres), and retailing. Medium and higher densities are often encouraged/promoted in residential areas in the inner city whereas lower density living is expected in the suburban areas.

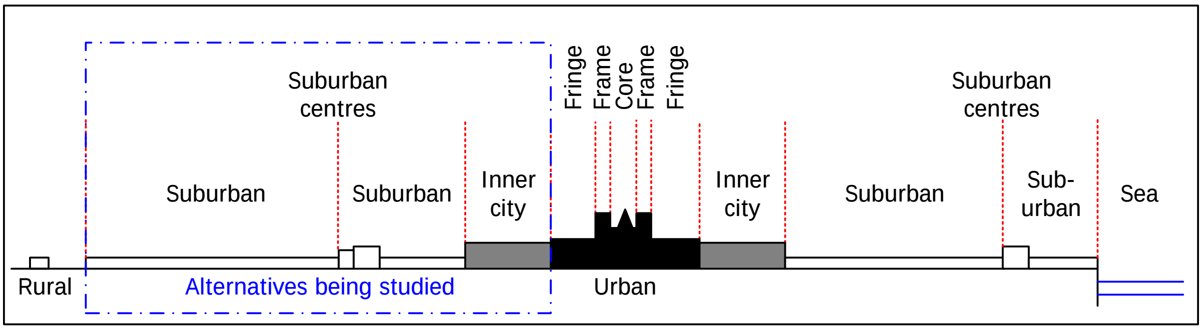


Figure 6.1 Profile of the city (Christchurch City Plan, 2012)

To decide on the alternatives, several aspects were considered. The CBD of all NZ large cities, including Christchurch, tends to already implement mixed-use development principles, such as having high density and diversity. Therefore, the levels of the neighbourhood factors in the CBD were difficult to vary. It would have been unrealistic to ask the respondents to imagine a property in the CBD to be located in a neighbourhood with low-density and diversity. Besides, people who prefer living in the CBD tend to be more tolerant to increasing density and diversity in their neighbourhood. Accordingly, it was decided to exclude the CBD from the list of alternatives being studied.

The inner city and suburbs tend to accommodate a wide range of neighbourhood types, from high to low densities and from residential only neighbourhoods to neighbourhoods with a mixture of uses. Besides, there are an increasing number of housing development projects in those areas, such as in Riccarton (an inner city of Christchurch) and Wigram (a suburban area of Christchurch). This will be discussed further in Section 6.1.3.

Based on the above considerations, it was decided to use the inner city and suburban areas as the alternatives. However, as the boundaries of an inner city area are often less distinct, it was decided to combine the inner city and parts of suburbs and to 'label' them as 'inner-suburban'. The remaining parts were regarded as 'outer-suburban'. Accordingly, residential properties in inner-suburban and outer-suburban areas were the two alternatives in this study.

A more practical reason to use only two alternatives was to keep the response burden within a reasonable limit, ensuring more reliable information is obtained. Including more alternatives within the SP design would have considerably increased the number of treatment combinations, producing a higher burden for respondents and possibly affecting the reliability of the data gathered.

6.1.2 Attributes

During the literature study, a large number of factors were identified (see Section 3). These factors were categorized into two groups, i.e. neighbourhood-related factors (linked to mixed-use characteristics/dimensions) and house-related factors. Given the research objectives and the necessity of limiting the number of factors (as it reduces the number of treatment combinations), it was decided to focus on the mixed-use dimensions only (Table 6.1) and to carefully select, amongst those dimensions, the ones to be included in the SP study.

A backward-reasoning approach was used: before selecting the factors, their number must firstly be decided. As the number of factors influences the number of treatment combinations, it became crucial to determine a sensible number of treatment combinations to be assessed by the respondents. Increasing the number of treatment combinations would lead to an increase in time and effort (e.g. to maintain concentration) to fill in the survey. On the other hand, reducing the number of treatment combinations might lead to insufficient information (degrees of freedom) needed to estimate all parameters in the model. Thus, it was decided that the number of treatment combinations should be kept below 20. For reasons detailed in Section 6.1.3, it was decided that two and three level factors/attributes were to be used in this study. Therefore, to have a balanced design, it was decided to use 18 treatment combinations.

If six (two level) factors were assigned to every alternative, a minimum number of 13 treatment combinations would be required to estimate a basic MNL model. If three levels were assigned to the attributes and MNL models with non-linear effects were to be estimated, a larger design would be required. A larger design would also be necessary to estimate the parameters of ML models. Accordingly, it was decided to investigate only five factors (having two and three levels).

Based on the above considerations, each mixed-use dimension was evaluated based on its degree of relevancy to the research objectives and the ease of translating that dimension into the SP surveys. The result of the evaluation can be seen in Table 6.1 and from that, it was decided to include the following attributes: (1) diversity of use, (2) density, (3) travel time to the CBD, and (4) travel time to the workplace.

Besides the above mixed-use factors, several house-related factors were also considered important to be included in the surveys, namely house price and type. The type of residential property was also considered an important factor. The results of a NZ study (Haarhoff et al., 2013) suggest that New Zealanders have a very strong preference towards detached houses. However, it was regarded as unnecessary to include 'house type' as a separate factor as it is not considered as a mixed-use development factor and it also correlates with other factors (e.g. density and price).

Given the considerations above, the final factors used in this study were: (1) diversity of use, (2) density, (3) travel time to the CBD, (4) travel time to workplace, and (5) property price.

Table 6.1 Mixed-use dimensions and consideration

Mixed-use dimension	R	E	Note
Diversity of use	H	H	It is important to include diversity and density in the study because both are two important characteristics of mixed-use development. In relation to New Zealand, it is important to study how New Zealanders value the increase of diversity and density in their neighbourhood.
Density	H	H	
Destination accessibility (to CBD and to workplace)	H	H	The possible factors related to this dimension are commuting times to work and to the CBD (e.g. in free-flow condition by car). It is important to include these factors because the recent trends of residential property development in the suburban areas of many NZ large cities will likely result in the increase in travel time to both trip destinations.
Distance to public transport facilities	M	H	Distance to a main public transport facility (e.g. tram and bus) is important. However, it is more related to mode choice behaviour. For instance, people living closer to a major bus stop may use buses more often than those living further away from it. Thus, this factor was not considered having as high priority as the aforementioned factors.
Social (and cultural) diversity	H	L	There is difficulty in investigating the effects of social and cultural diversity because it is regarded as a sensitive matter. Respondents may feel uncomfortable responding to the hypothetical scenarios. They may even feel offended with the scenarios. Thus, it was decided to omit this dimension from the SP design.
Design	H	L	There is difficulty in including this factor in the SP design because it covers a wide range of design-related aspects (e.g. neighbourhood design, streetscape design, etc.) that can be fairly subjective.
Time and building sharing	L	M	Both dimensions are not that crucial to be included in the SP survey because they correlate with other factors. For instance vertical and horizontal dimensions correlate with density; time and building sharing correlate with diversity.
Horizontal and vertical dimension	L	M	
Relevance to the research objectives (R) = high (H); medium (M); low (L). Ease of adoption in the SP survey (E) = high (H); medium (M); low (L).			

6.1.3 Attribute levels and labels

After deciding on the factors, the next stage was to determine the number of levels and their labels. To be able to estimate the non-linear effects, a factor must have at least three levels. The diversity of land use was considered to have three levels. The increase of diversity may have non-linear effects on the utility. Some people may enjoy living in a neighbourhood with some degree of diversity but they may dislike living in a neighbourhood where the degree of diversity is either too high or too low (Figure 6.2, left-hand side). Similar to the diversity of land use, the increase of density from low to medium may influence the (representative) utility differently than its increase from medium to high (Figure 6.2, right-hand side).

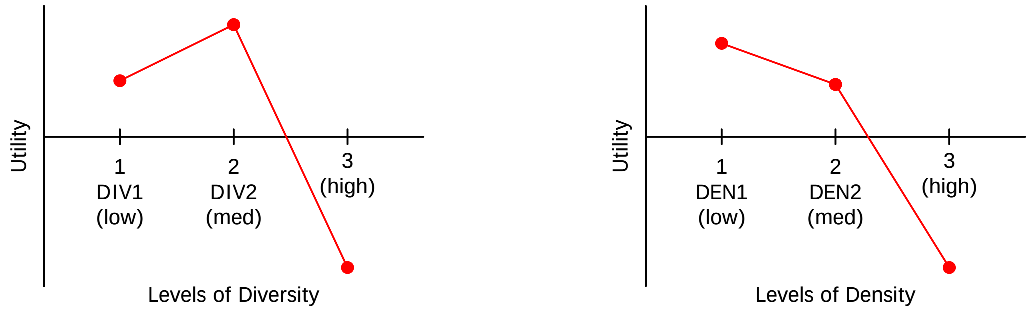


Figure 6.2 Possible non-linear effects of levels of diversity of use (left-hand side) and density (right-hand side) on the utility

If diversity of land use was the only factor relevant in explaining people's decisions to purchase an inner-suburban residential property and this factor was to have three levels (i.e. low, medium and high diversity), which effects on the utility were non-linear (see Figure 6.2, left-hand side), the representative utility function could be written as:

$$V_{Inner-suburban\ property} = ASC_1 + \beta_{i1} \times DIV1 + \beta_{i2} \times DIV2$$

where ASC_1 is the alternative specific constant of the inner-suburban alternative, $DIV1$ is the attribute associated with the low level of density of development (see further explanation in the subsequent paragraph), $DIV2$ is the attribute associated with the medium level of density of development, and β_{ix}s are the estimated parameters .

Two coding schemes are used to code attribute levels when estimating non-linear effects: dummy and effects coding. Given the above example, if a residential neighbourhood has low-density of development, $DIV1 = 1$ and $DIV1 = 0$ and therefore, $DIV1$ is associated with the low level of density of development. If a residential neighbourhood has medium density of development, $DIV1 = 0$ and $DIV1 = 1$ and accordingly, $DIV2$ is associated with the medium level of density of development. If a neighbourhood has high-density of development and dummy coding is used, $DIV1 = 0$ and $DIV1 = 0$, or else, if effects coding is used, $DIV1 = -1$ and $DIV1 = -1$ (see Table 6.2).

Table 6.2 Using dummy an effects coding to code 'diversity of land use'

Diversity of land use		Dummy coding		Effects coding	
		DIV1	DIV2	DIV1	DIV2
Level 1	Low diversity	1	0	1	0
Level 2	Medium diversity	0	1	0	1
Level 3	High diversity	0	0	-1	-1

For the density and diversity factors, a 'neighbourhood' must be properly defined. After consulting with the members of the panel, a 500 metre radius around the property, or 7 to 8 minute walking distance from the property, was set as the limit.

Two levels were assigned to the travel time factors, assuming that the effect of an increase in travel time on the utility is linear. Two or three levels were assigned to the price factor depending on the ranges of land values found. This will further be explained below.

For the purpose of this study, the areas within the city of Christchurch were categorized into two, the inner-suburban and outer-suburban areas, to represent the two alternatives of property locations (see Section 6.1.1). The inner-suburban areas of Christchurch are located within a close proximity to the CBD, such as Riccarton, Addington, Merivale, Fendalton, Ilam, Woolston, St. Albans, Sydenham, Richmond, etc. The outer-suburban areas include the areas of Avonhead, Burnside, Sockburn, Halswell, Hornby, Hoon Hay, Cashmere, Huntsbury, Hillsborough, Heathcote, Mt. Pleasant, Sumner, New Brighton, etc.

In the District Plan of Christchurch, the residential areas outside the CBD are categorized into three living zones, allowing certain densities (Figure 6.3). Only low-density development is permitted in Living Zone 1 whereas medium density development is permitted in Living Zone 2 and medium density town-house type development is permitted in Living Zone 3.

Each residential unit in Living Zone 1 shall be contained within a minimum net area of 420 sq. metres per section (Christchurch City Council, 2010a), implying a maximum number of around 23 houses per hectare. Furthermore, the maximum building coverage is 35% of the net area (including garage). Residential buildings within this zone should maintain landscape plantings and a considerable amount of open space.

Each residential unit in Living Zone 2 shall be contained within a minimum net area of 330 sq. metres per section (Christchurch City Council, 2010b), implying a maximum number of around 30 houses per hectare. The maximum building coverage is 40% of the net area. If the height of all buildings in the site does not exceed 5.5 metres, the maximum permitted coverage increases to 45%.

In Living Zone 3, it is allowed to erect new buildings or to alter the existing ones on a site smaller than 300 sq. metres (gross site area) or to have the total residential floor area of one or two residential units greater than 500 sq. metres (Christchurch City Council, 2010c). Additionally, the permitted height ranges between 8 and 20 metres, depending on the specific development location. The minimum sizes of a unit are 35 sq. metres for a studio; 45 sq. metres for a one bedroom unit; 70 sq. metres for a two bedroom unit; and 90 sq. metres for a three (or more) bedroom unit. Furthermore, the maximum residential floor area ratio per site is 0.8, making Living Zone 3 higher density living compared to Living Zone 2.

The Living Zone 1 neighbourhoods are generally located in the outer-suburban areas of Christchurch, such as Wigram, Halswell, Burwood, Redwood and Northwood. The Living Zone 2 neighbourhoods are typically located in the suburban centres or areas closer to the CBD, such as Merivale, St. Albans, Richmond, Linwood, Waltham and Spreydon. The Living Zone 3 neighbourhoods are typically located in areas closer to the central city, such as Woolston and Riccarton. However, there are several exceptions to this rule. For instance, Fendalton, located in close proximity to the CBD of Christchurch, is regarded as Living Zone 1 whereas Sumner and New Brighton, located further away from the CBD, are regarded as Living Zone 3.

Given the descriptions of the living zones and the areas regarded as inner-suburban and outer-suburban, the inner-suburban alternative (e.g. Riccarton, Merivale, Fendalton, Ilam and St. Albans) was assigned two levels: medium and high. The outer-suburban alternative (e.g. Avonhead, Burnside, Halswell, Hornby, Cashmere, Mt. Pleasant and Sumner) was assigned two levels: low and medium.

In the survey, density was explained using four parameters, namely the average section size, the average percentages of building coverage, the number of residential units per site and the average height (using the number of storeys of buildings) in the neighbourhood. A low-density neighbourhood was defined as "*a neighbourhood where a 1 or 2 storey single-unit building is typically located on a site, the average section size is 500 sq. metres and the average building coverage is 35%."* A medium density neighbourhood was defined as "*a neighbourhood where a 1 or 2 storey single-unit building is typically located on a site, the average section size is 350 sq. metres and the average building coverage is 40%."* A medium-high neighbourhood was defined as "*a neighbourhood where 2 or 3 storey multi-unit buildings are typically located on a site, the average section size is 300 sq. metres and the average building coverage is 50%."*

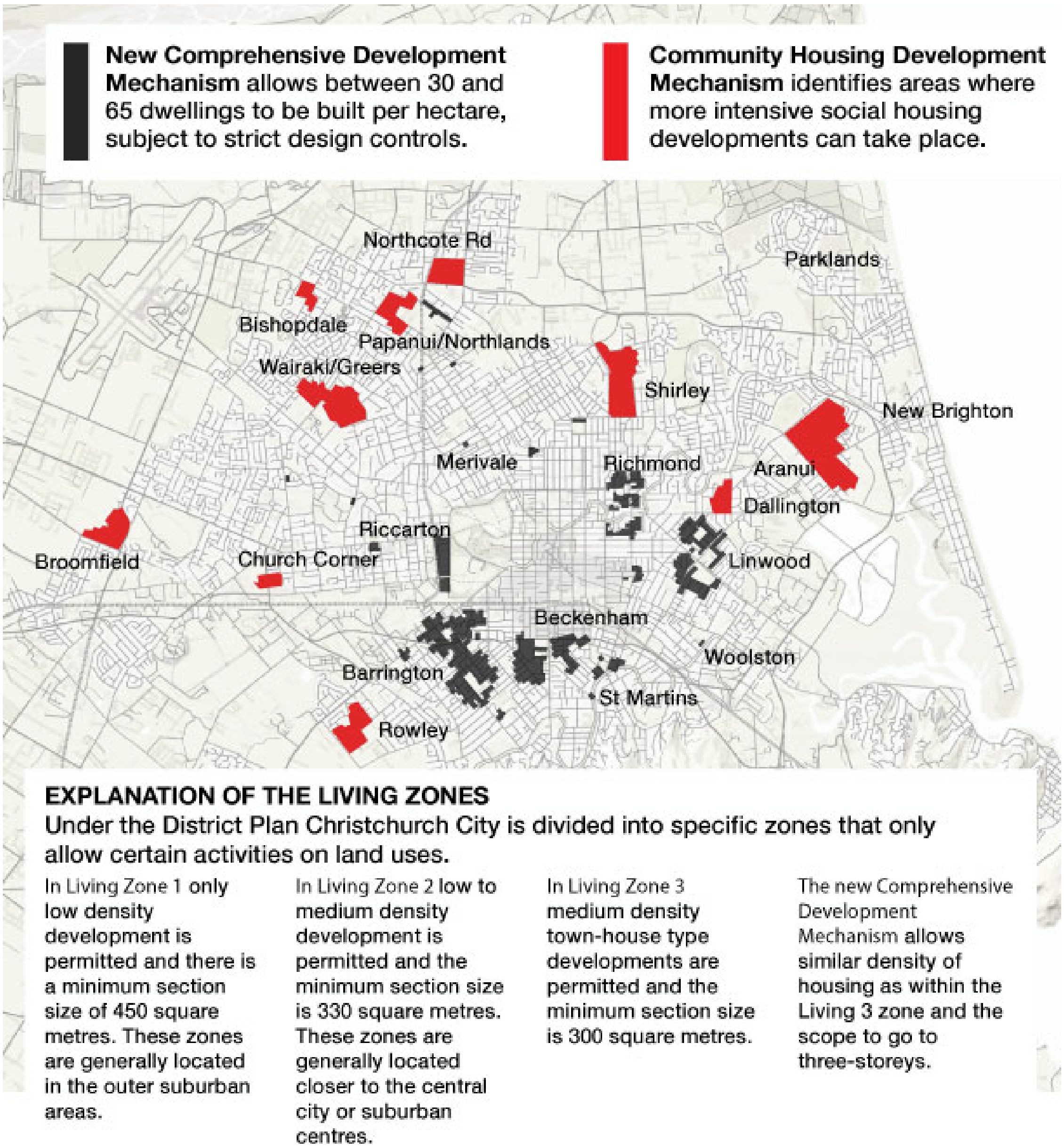


Figure 6.3 Permitted density in the living zones of Christchurch (Cairns, 2013)

The level labels of the diversity factor were decided based on the percentages of non-residential activities in the neighbourhood where the property is located. For the inner-suburban alternative, the low level of this attribute represented a ‘pure’ residential neighbourhood; the middle level represented a neighbourhood where 80% of the activities were residential and the remaining 20% were office, retailing, entertainment, cultural and recreational activities; and the high level represented a neighbourhood where 60% of the activities were residential, indicating ‘mixed-use’ neighbourhoods. For the outer-suburban alternatives, only the ‘pure’ residential neighbourhood and the 80% residential neighbourhood were used.

Google Maps was used to decide on the labels of (free-flow) travel time to the CBD by car. Travel times to the CBD for the inner-suburban and outer-suburban alternatives were set to 5-15 minutes and 15-25 minutes respectively. Similar labels were assigned to the factor of travel time to the workplace.

After conducting research on property prices, it was considered more sensible to use the land price instead. In this way, the study does not need to take into account variations in the buildings' quality and age, which result in dispersion of property prices. Material cost and construction cost to build residential properties with specified type, size and quality, will be fairly similar across various locations. The final property prices will then be determined based on the land values, which tend to increase as land sections get closer to the CBD. This trend is supported, to some extent, by the results of a 'rates and valuation' search, using the website of the Christchurch City Council (www.ccc.govt.nz/services/rates-and-valuations/rates-information/). Several randomly selected residential addresses in inner-suburban (N=85) and outer-suburban areas (N=150) were input to the search function of the website. Note that this analysis was done to give an approximate estimate of the land values in Christchurch. It is by no means ideal but it gave a sufficient indication of the land values needed to determine the labels. The resulting land values and land sizes were marked down and used to calculate the land values per sq. metre.

The resulting histograms can be seen in Figure 6.4 (for the inner-suburban areas) and Figure 6.5 (for the outer-suburban areas). The results show that the land values in the inner-suburban areas of Christchurch varied between \$200 and \$1000 per sq. metre while the land values in the outer-suburban areas varied between \$100 and \$600 per sq. metre. However, the land value that appeared most often in the datasets (i.e. the mode), for the inner-suburban and outer-suburban areas, was similar: around \$400 per sq. metre in the inner-suburban areas and \$300/\$400 per sq. metre in the outer-suburban areas. Given the above and the need to maintain a constant spacing for the labels of the levels, the labels for the inner-suburban alternatives were \$250, \$500 and \$750 per sq. metre and for the outer-suburban alternatives were \$250 and \$500 per sq. metre.

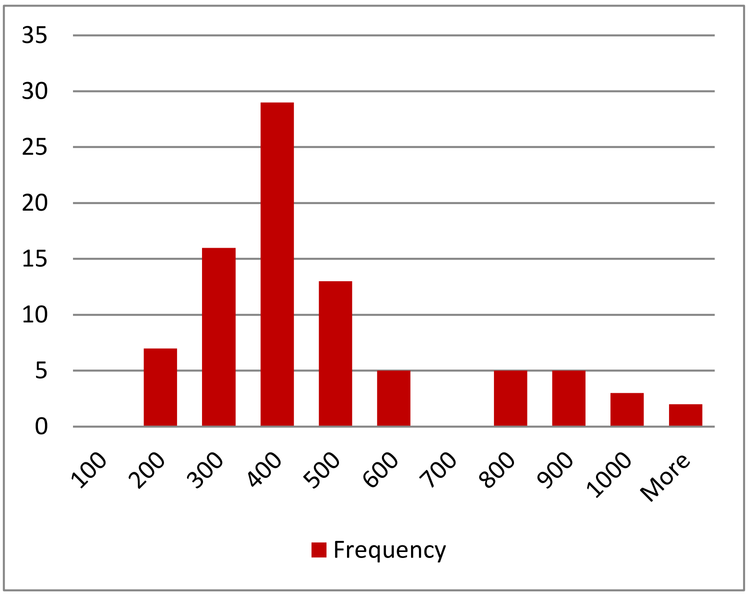


Figure 6.4 The land values (per sq. metre) of randomly selected sections (N=85) in the inner-suburban areas of Christchurch

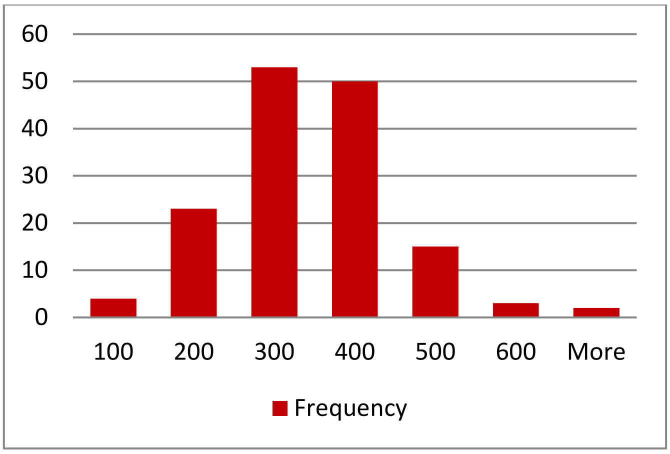


Figure 6.5 The land values (per sq. metre) of randomly selected sections (N=150) in the outer-suburban areas of Christchurch

6.1.4 Utility specification

Given the above alternatives, attributes and levels, the representative utility functions of the MNL model for Christchurch were:

$$V_{ic} = ASC_i + \beta_{iDEN}DEN + \beta_{iDIV1}DIV1 + \beta_{iDIV2}DIV2 + \beta_{iTTC}TTC + \beta_{iTTW}TTW + \beta_{iPRC}PRC$$

$$V_{oc} = \beta_{oDEN}DEN + \beta_{oDIV}DIV + \beta_{oTTC}TTC + \beta_{oTTW}TTW + \beta_{oPRC}PRC$$

where: ASC_i= alternative specific constant of the inner-suburban alternative (relative to the outer-suburban alternative); DIV= diversity; $DIV1$ and $DIV2$= new variables associated with diversity, coded using effects coding ($DIV1 = 1$ and $DIV2 = 0$ for no diversity, $DIV1 = 0$ and $DIV2 = 1$ for low diversity, and $DIV1 = -1$ and $DIV2 = -1$ for medium diversity); DEN= density; $DEN1$ and $DEN2$= new variables associated with density, coded using effects coding ($DEN1 = 1$ and $DEN2 = 0$ for low-density, $DEN1 = 0$ and $DEN2 = 1$ for medium density, and $DEN1 = -1$ and $DEN2 = -1$ for high-density); TTC= travel time to the CBD; TTW= travel time to workplace; PRC= land price; $\beta_{ix}s$= parameters to be estimated for the inner-suburban alternative; and $\beta_{ox}s$= parameters to be estimated for the inner-suburban/outer-suburban alternatives.

6.1.5 Data collection

As the pilot survey was designed using the efficient design method, and due to the absence of the prior estimates to generate the pilot surveys, small values were set as the prior estimates (e.g. 0.01). The signs were initially decided based on common sense. For instance, the increase of travel time to a workplace was expected to reduce the utility and hence, the sign of the ‘prior’ estimate of this factor was set to be negative (i.e. -0.01).

The initial efficient design of Christchurch was generated using the NGENE software. The design, obtained after around 24 hours of computer running time, was transformed into a pilot survey using the Qualtrics platform. Note that because the main purpose of the pilot surveys was to obtain the prior estimates, a small sample size of around 10 respondents was targeted. To compensate for this small sample size, the number of choice tasks was set to thirty six.

Before asking the respondents to assess each of the 36 hypothetical choice tasks (see Figure 6.6 for an example of a choice situation), the respondents were asked to imagine a particular setting (Figure 6.7). The descriptions of factors and levels were given in the pilot survey, as shown in Figure 6.8.

Choice situation 1

	Option 1 Inner-suburban property	Option 2 Outer-suburban property
Density of development	High	Medium
Diversity of land use	80% residential & 20% other activities	80% residential & 20% other activities
Travel time to the CBD	15 minutes	25 minutes
Travel time to the workplace	5 minutes	25 minutes
Land price/value per sq. metre	$250	$250
Given the above, which property would you choose?	☐	☐

Figure 6.6 An example of hypothetical choice tasks/situations in the Christchurch pilot survey

Please imagine the following setting when answering the 36 choice situations
Imagine that you are planning to buy a property in Christchurch. You are considering two locatio alternatives: a property in an inner-suburban (e.g. South St. Albans) area or in an outer-suburba area (e.g. Avonhead). The properties in both location alternatives are identical (e.g. in terms of th size, the numbers of bedrooms and bathrooms, orientation, etc.). Therefore, the values of th buildings in both alternatives are identical and only the values of the land per square metre ar different.

Imagine that the following five factors are important in your decision making: density of developmen diversity of land use, travel time to the CBD, travel time to your workplace and the land price (pe square metre). The two alternatives are different only with regard to these factors Please indicate your choice in each of the thirty six choice situations, which contain variou combinations of the five factors mentioned above.

Figure 6.7 Hypothetical setting in the pilot survey

Description of the factors

- **Density of development**: density (i.e. the number of residential units and storeys permitte per section, the average section size and the average building coverage) within a 500 metr radius around the property or a 7-8 minute walk from the property.
  - **Low**: a 1 or 2 storey single-unit building is typically located on a section; the averag section size is 500m^2; the average building coverage is 35%.
  - **Medium**: a 1 or 2 storey single-unit building is typically located on a section; th average section size is 350m^2; the average building coverage is 40%.
  - **High**: 2 or 3 storey multi-unit buildings are typically located on a section; the averag section size is 300m^2; the average building coverage is 50%.

- **Diversity of land use**: percentages of types of activities, i.e. residential & other activitie (non-residential and non-industrial activities, e.g. office, retailing, entertainment, cultura allowed within a 500 metre radius around the property or a 7-8 minute walk from the property

- **Travel time to the CBD**: travel time in minutes to the CBD by car (free-flow speed).

- **Travel time to the workplace**: travel time to the workplace in minutes by car (free-flo speed).

- **Land price/value per square metre**: for instance, someone is buying a residential propert on 500m^2 land in a low density neighbourhood. If the price of land is $500 per square metre the total land price (excluding building cost) is $250.000.

Figure 6.8 Description of factors (and levels) in the pilot survey

The Christchurch pilot survey was from December 2015 to January/February 2016 using a combination of methods: the online survey (using the Qualtrics online surveying platform) and the paper-and-pencil survey. The snowball sampling technique was used. The data from 14 respondents were collected, leading to the total number 508 observations (i.e. 14 respondents x 36 choice situations).

6.1.6 Results

The data obtained from the pilot survey were used to estimate the multinomial logit model parameters, using the NLOGIT software, which is specialized software for estimating choice models. The results (Figure 6.9) were used as prior estimates required to generate the experimental design for the main survey.

```
---------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -287.08254
Estimation based on N =    504, K =  10
Inf.Cr.AIC  =    594.2 AIC/N =    1.179
Model estimated: Apr 21, 2016, 20:33:24
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only must be computed directly
               Use NLOGIT ;...;RHS=ONE$
Chi-squared[ 9]         =    115.32464
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   504, skipped    0 obs
--------+------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+------------------------------------------------------------------
    ASCI|    -.33021***      .10274    -3.21  .0013     -.53157   -.12885
    IDEN|    -.33995***      .10201    -3.33  .0009     -.53989   -.14001
    DIV1|    -.16796         .14568    -1.15  .2489     -.45349    .11757
    DIV2|     .25682*        .14636     1.75  .0793     -.03005    .54368
    ITTC|    -.18054*        .10267    -1.76  .0787     -.38176    .02069
    ITTW|    -.15326         .10235    -1.50  .1343     -.35387    .04735
    IPRC|   -1.00860***      .12912    -7.81  .0000    -1.26167   -.75554
    ODEN|    -.29973***      .10244    -2.93  .0034     -.50050   -.09895
    OTTW|    -.15503         .10202    -1.52  .1286     -.35500    .04493
    OPRC|    -.42941***      .10287    -4.17  .0000     -.63104   -.22779
--------+------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

Where *ASCI*= alternative specific constant of the inner-suburban alternative (relative to the outer-suburban alternative); *IDEN*= density of development (inner-suburban); *DIV1*= low level of diversity (inner-suburban); *DIV2*= medium level of diversity (inner-suburban); *ITTC*= travel time to the CBD (inner-suburban); *ITTW*= travel time to workplace (inner-suburban); *IPRC*= land price per sq. metre (inner-suburban); *ODEN*= density of development (outer-suburban); *OTTW*= travel time to workplace (outer-suburban); and *OPRC*= land price per sq. metre (outer-suburban).

Figure 6.9 Prior estimates used to generate the final design

Note that the results presented in Figure 6.9 correspond to the utility specification described in Section 6.1.4. However, the outer-suburban factors of land use diversity and travel time to the CBD were removed from the model specification and the model was re-estimated without them because the parameters of these factors did not turn out to be statistically significant, with very low z-values (i.e. 0.27 and -0.62 in turn).

The model was re-estimated, and even though the parameters of several attributes (i.e. DIV1, ITTW and OTTW) did not appear to be statistically significant, they were kept in the model specification to generate the experimental design for the main survey. The attribute of DIV1 was kept because the attribute of DIV2 turned out to be statistically significant and both attributes were used to represent the factor of land use diversity (for the inner-suburban alternative). The factors of travel time to workplace for both inner-suburban and outer-suburban alternatives were kept because their associated z-values (i.e. -1.50 and -1.52, in turn) were very close to the critical z-value for the 90% confidence level (+/-1.64). Thus, they might appear to be significant once a bigger sample size was to be used.

6.2 The main survey

The results of the pilot survey were used to refine the attribute levels (Section 6.2.1). In addition, they were also used to generate the experimental designs for the main surveys (Section 6.2.2). Several additional questions (e.g. socio-demographic characteristics) were added into the main surveys (Section 6.2.3), and data collection was conducted (Section 7).

6.2.1 Refining attributes and/or levels

Several respondents of the Christchurch pilot survey raised their concerns regarding the description of the land use diversity factor. Initially, this factor was represented using percentages, e.g. “80% residential and 20% other activities”. However, some participants indicated difficulty in thinking in terms of percentages and accordingly, in the main survey, the description of this factor was changed. For the example above, it became “8 residential units and 2 units for other activities in every 10 property units”.

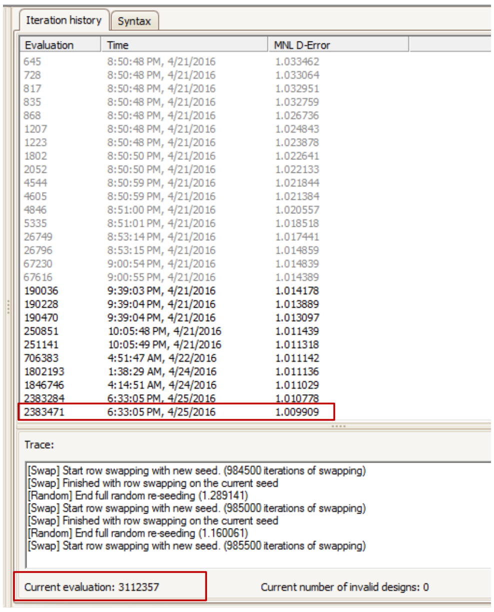
As described in Section 6.1.6, the factors of land use diversity and travel time to the CBD of the outer-suburban alternative were removed from the list of attributes/levels. This resulted in the final attributes and levels for the main survey, as shown in Table 6.3b.

Table 6.3 Comparison of the attribute levels used in the pilot survey (left-hand side) and main survey (right-hand side)

Attributes	(a) Pilot survey		(b) Main Survey	
	Inner-suburban	Outer- suburban	Inner-suburban	Outer-suburban
Density	Medium High	Low Medium	Medium High	Low Medium
Diversity of use	100% residential 80% residential 60% residential	100% residential 80% residential	All residential units 8 residential units in every 10 property units 6 residential units in every 10 property units	NA
Travel time to the CBD by car	5 minutes 15 minutes	15 minutes 25 minutes	5 minutes 15 minutes	NA
Travel time to the workplace by car	5 minutes 15 minutes	15 minutes 25 minutes	5 minutes 15 minutes	15 minutes 25 minutes
Land price per sq. metre	$250 $500 $750	$250 $500	$250 $500 $750	$250 $500

6.2.2 Experimental designs for the main survey

The attributes/levels (Table 6.3b) and prior estimates (Figure 6.9) were used to generate the mail experimental designs, again by employing the NGENE software. The experimental design for the main survey contained 18 choice situations/tasks. To obtain the ‘best’ design, the NGENE software was used to assess over 3 million designs, taking around 7 days of computer running time to complete (Figure 6.10 left-hand side). This was done to ensure that the likelihood of finding a better design than the ones assessed could be kept low. The selected design (Figure 6.10 right-hand side) was transformed into choice tasks in the online survey (Figure 6.11), generated and administered using the Qualtrics platform.



MNL efficiency measures									
D error	1.009909								
A error	1.124877								
B estimate	69.50236								
S estimate	215.703305								
Prior	deni	divi(e0)	divi(e1)	ttci	ttwi	prci	deno	ttwo	prco
Fixed prior value	-0.33995	-0.16796	0.25682	-0.18054	-0.15326	-1.0086	-0.29973	-0.15503	-0.42
Sp estimates	46.748214	91.284353	39.594433	156.062135	215.703305	2.679217	57.08045	211.525727	28.265
Sp t-ratios	0.286664	0.205144	0.311486	0.156894	0.133453	1.197436	0.259425	0.134764	0.368
Design									
Choice situation	i.iden	i.idiv	i.ittc	i.ittw	i.iprc	o.oden	o.ottw	o.oprc	
1	1	0	1	1	2	0	0	0	
2	0	0	0	1	1	0	1	1	
3	0	1	0	1	1	1	0	1	
4	0	1	1	0	1	1	0	0	
5	0	1	1	0	1	0	1	1	
6	0	0	1	0	1	0	0	1	
7	1	1	0	1	0	0	1	0	
8	1	0	0	0	1	0	1	0	
9	0	2	0	1	2	1	1	1	
10	1	2	1	0	0	1	1	1	
11	1	2	1	1	2	0	0	0	
12	1	1	0	0	2	1	1	1	
13	0	2	0	0	2	1	1	0	
14	0	2	0	0	0	0	0	0	
15	0	0	1	1	0	1	1	0	
16	1	2	1	1	0	0	0	1	
17	1	1	1	1	2	1	0	0	
18	1	0	0	0	0	1	0	1	

Figure 6.10 Generating the experimental design (left-hand side) and the selected design for the main survey (right-hand side)

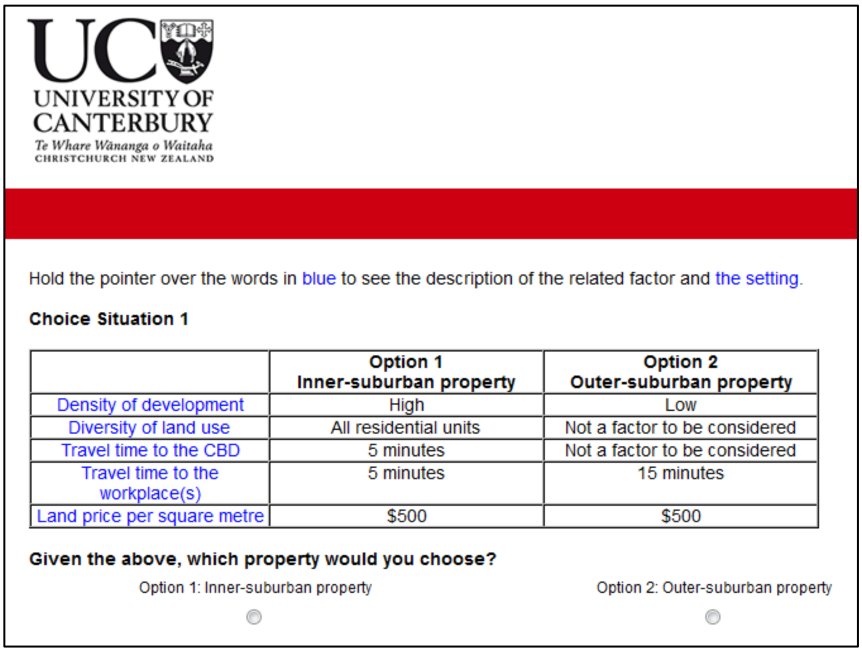


Figure 6.11 A choice situation in the main survey

6.2.3 Additional questions

To get better insights into how the residents of Christchurch and its surrounding districts evaluate various neighbourhood-related and house-related factors, and their liking for living near various activities commonly associated with mixed-use development, the survey asked the respondents to rate the importance of 24 neighbourhood and 23 house-related factors (found in the literature review), and to rate their liking for living close to each of 12 'land uses' (e.g. parks, shops, restaurants, bars, bus/train stations), as shown in Figure 6.12, Figure 6.13 and Figure 6.14. Additionally, several questions were asked to identify the respondents' socio-demographic characteristics (e.g. gender, age and household income). Besides being for modelling purposes, socio-demographic characteristics were required to check the representativeness of the sample.

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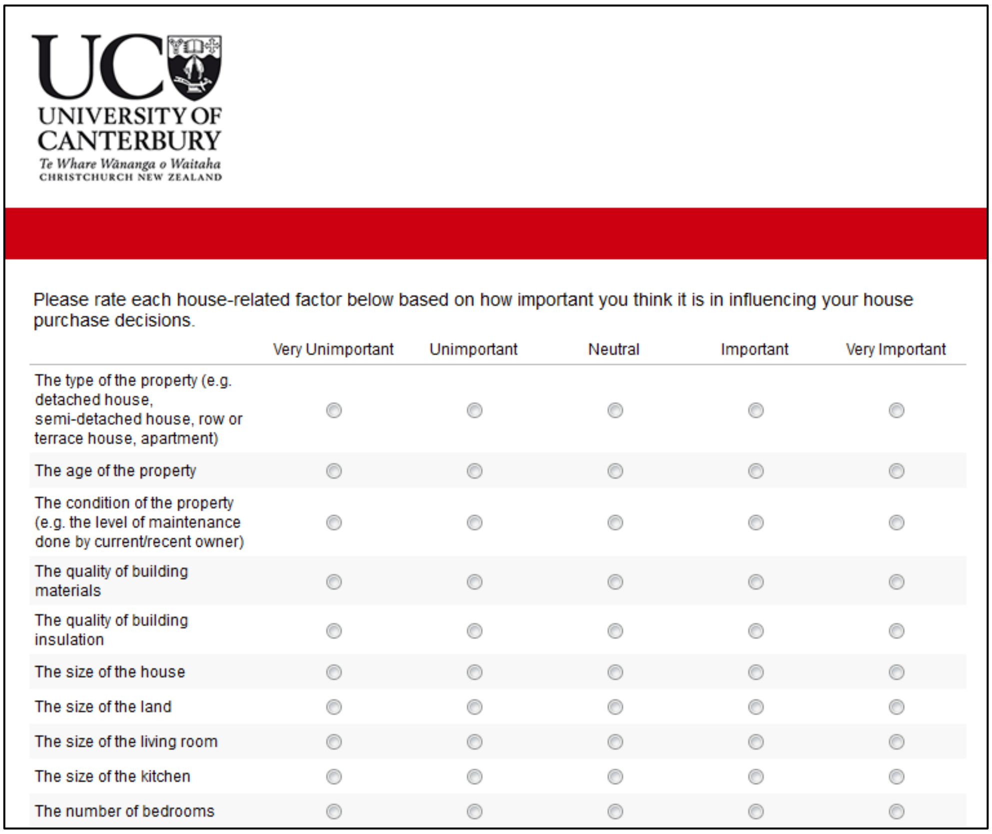
Please rate each neighbourhood-related factor below based on how important you think it is in influencing your house purchase decisions.
Hold the mouse pointer over the words in blue to see the description of each factor.

	Very Unimportant	Unimportant	Neutral	Important	Very Important
Neighbourhood density					
Neighbourhood diversity					
School quality					
Natural views					
The type of neighbourhood					
Perceived neighbourhood safety					
Socio demographic and economic status of the neighbours					
Presence of properties having much lower value than your own property					
Presence of properties having much higher value than your own property					
Location (e.g. inner-suburban or outer-suburban areas)					
Proneness to flooding					
Quietness and privacy					
The amount of traffic in the neighbourhood					
The type of road in front of the property (e.g. main urban roads, etc.)					

Figure 6.12 Screenshot of the main survey: Rating of neighbourhood factors



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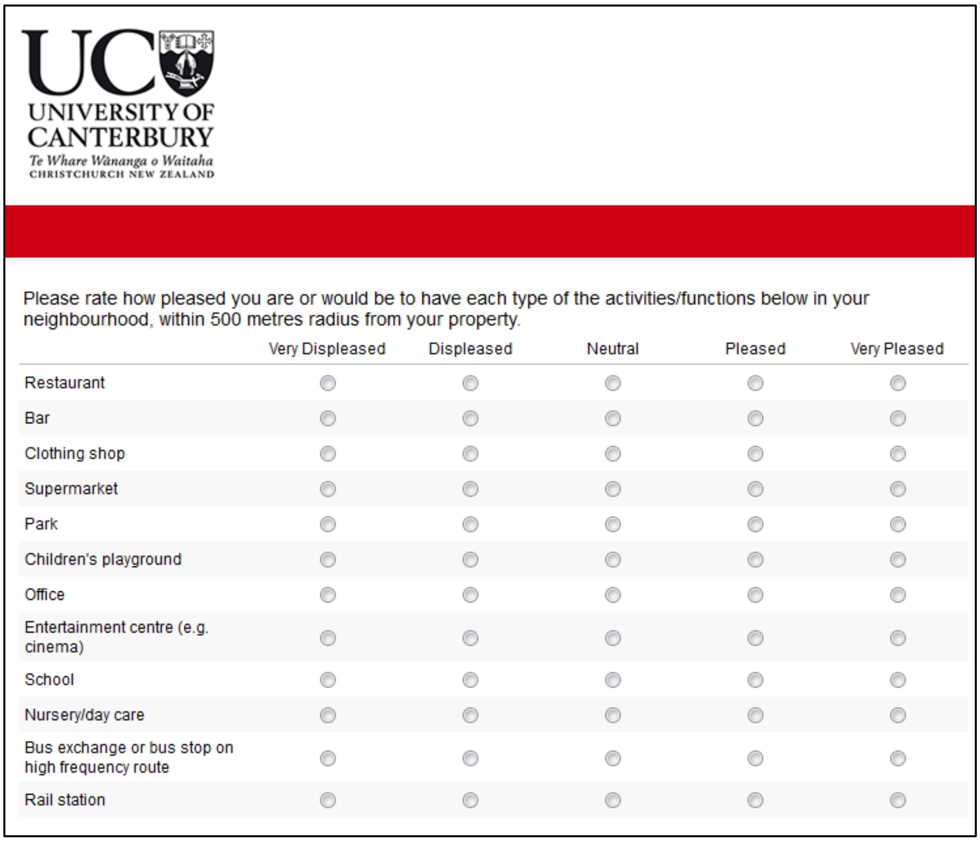
Please rate each house-related factor below based on how important you think it is in influencing your house purchase decisions.

	Very Unimportant	Unimportant	Neutral	Important	Very Important
The type of the property (e.g. detached house, semi-detached house, row or terrace house, apartment)					
The age of the property					
The condition of the property (e.g. the level of maintenance done by current/recent owner)					
The quality of building materials					
The quality of building insulation					
The size of the house					
The size of the land					
The size of the living room					
The size of the kitchen					
The number of bedrooms					

Figure 6.13 Screenshot of the main survey: Rating of house-related factors



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CHRISTCHURCH NEW ZEALAND

Please rate how pleased you are or would be to have each type of the activities/functions below in your neighbourhood, within 500 metres radius from your property.

	Very Displeased	Displeased	Neutral	Pleased	Very Pleased
Restaurant					
Bar					
Clothing shop					
Supermarket					
Park					
Children's playground					
Office					
Entertainment centre (e.g. cinema)					
School					
Nursery/day care					
Bus exchange or bus stop on high frequency route					
Rail station					

Figure 6.14 Screenshot of the main survey: Rating of neighbourhood factors

7 Data collection

Considering the objectives of this research study (see Section 1), the target population was the residents of Christchurch and its surrounding districts. To have more sound research outcomes, people who were looking to purchase residential property were targeted to complete the survey. Such people have already considered the trade-offs between the various influencing factors included in the survey. To get access to those people, the Chief Executives of Trademe and Realestate.co.nz (two major residential property websites in NZ) were asked about putting a link to the online survey on their websites, but they were not interested in assisting. A large real estate firm was asked to assist with distribution of flyers, containing a short description of the research study and the link to access the online survey, to people viewing residential properties for sale in Christchurch, but there was considerable scepticism regarding whether staff would be willing and able to assist.

Several market research companies were then contacted and asked to distribute the link to the online surveys, but all but one declined to help, as they use only telephone and face-to-face interviewing techniques. One company based in Auckland finally agreed to send out a brief description of the research (with a link to the online surveys) to their panel members in Christchurch. On 16 May 2016, the link to access the Christchurch survey was distributed to about 2000 people in Christchurch. Between May and June 2016, 298 people undertook the survey.

Because this study involves two different types of analysis, i.e. (a) logit modelling and (b) analysis of the rating tasks, the sample sizes varied accordingly. 141 people completed the choice tasks and there were more respondents (i.e. 247 people) who completed the rating tasks of the survey. Thus, the characteristics of these respondents are described in Section 7.1 (for the choice modelling tasks) and Section 7.2 (for the rating tasks).

7.1 Description of the samples for the choice modelling tasks

Out of 214 people who completed the choice tasks, only data from 141 respondents were considered appropriate for estimating logit models. 73 consistently selected one particular alternative throughout the 18 choice tasks, and therefore, their data could not be used for estimating logit models. Trading-off between varied attribute levels is crucial for model estimation. When trading-off is not made by a respondent (indicated by invariant choices), information to estimate logit models could not be gained (Hensher et al., 2005). Among those 73 respondents, 61 respondents selected the outer-suburban alternative. The characteristics of the omitted respondents are presented in Table 7.1a, and are discussed below.

Whenever possible, the representativeness of the sample was checked by comparing the figures of the sample (Table 7.1b) with those of the NZ latest (2013) census data (Table 7.1c), focusing on the Canterbury region. Note that the socio-demographic questions in the survey were optional, resulting in varied sample sizes (Ns).

Table 7.1 Description of the sample (choice modelling)

	a. Respondents removed from the sample (total 73 respondents)	b. Sample description (total 141 respondents)	c. NZ census 2013 for Canterbury Region
Gender	Male: 19 (35.2%); female: 35 (64.8%). [N=54]	Male: 20 (24.4%); female: 62 (75.6%). [N=82]	Male: 51%; female: 49%. [N=539,436]
Living condition	Living alone: 15 (20.5%); living with a partner: 58 (79.5%) [N=73]	Living alone: 42 (29.8%); living with a partner: 99 (70.2%) [N=141]	NA.
Number of dependent children	0 child: 33 (56.9%); 1 child: 8 (13.8%); 2 children: 10 (17.2%); ≥3 children: 6 (12.1%). [N=58]	0 child: 43 (43.4%); 1 child: 14 (14.1%); 2 children: 27 (27.3%); ≥3 children: 13 (15.2%). [N=99]	0 child: 52.2%; 1 child: 18.2%; 2 children: 19.7%; ≥3 children: 9.5%. [N=124,732]
Couple with & without (dependent) children	0 child: 33 (56.9%); 1 child: 8 (13.8%); 2 children: 10 (17.2%); ≥3 children: 6 (12.1%). [N=58]	0 child: 43 (43.4%); 1 child: 14 (14.1%); 2 children: 27 (27.3%); ≥3 children: 13 (15.2%). [N=99]	0 child: 52.2%; 1 child: 18.2%; 2 children: 19.7%; ≥3 children: 9.5%. [N=124,732]
One parent with (dependent) children	1 child: 3 (75%); 2 children: 1 (25%); ≥3 children: 0 (0%). [N=4]	1 child: 3 (33.3%); 2 children: 3 (33.3%); ≥3 children: 3 (33.3%). [N=9]	1 child: 59.7%; 2 children: 29.2%; ≥3 children: 11.1%. [N=21,630]
Age	20-24 yrs: 0 (0%); 25-29 yrs: 4 (5.6%); 30-34 yrs: 9 (12.7%); 35-39 yrs: 8 (11.3%); 40-44 yrs: 3 (4.2%); 45-49 yrs: 9 (12.7%); 50-54 yrs: 8 (11.3%); 55-59 yrs: 9 (12.7%); 60-64 yrs: 5 (7%); >64 yrs: 16 (22.5%). [N=71]	20-24 yrs: 4 (2.9%); 25-29 yrs: 12 (8.6%); 30-34 yrs: 23 (16.4%); 35-39 yrs: 16 (11.4%); 40-44 yrs: 16 (11.4%); 45-49 yrs: 15 (10.7%); 50-54 yrs: 11 (7.9%); 55-59 yrs: 14 (10%); 60-64 yrs: 12 (8.6%); >64 yrs: 17 (12.1%). [N=140]	20-24 yrs: 9.8%; 25-29 yrs: 8.5%; 30-34 yrs: 8.2%; 35-39 yrs: 8.8%; 40-44 yrs: 10.3%; 45-49 yrs: 10.1%; 50-54 yrs: 10.3%; 55-59 yrs: 9.1%; 60-64 yrs: 8.4%; >64 yrs: 16.5%. [N=393,882]
Household income	Below $29,999: 4 (5.8%); $30,000-$49,999: 12 (16.7%); $50,000-$69,999: 13 (18.1%); $70,000-$89,999: 12 (16.7%); ≥$90,000: 31 (43.1%). [N=72]	Below $29,999: 11 (7.8%); $30,000-$49,999: 28 (19.9%); $50,000-$69,999: 20 (14.2%); $70,000-$89,999: 29 (20.6%); ≥$90,000: 53 (37.6%). [N=141]	NA. Statistics New Zealand reports the average weekly salary, which was $1,802 based on the 2013 census data (or equivalent to around $93,962 per year).
Ownership of & intention to buy a residential property	Second-home buyers[1]: 35 (47.9%); owning & not buying[2]: 26 (35.6%); first-home buyers[3]: 6 (8.2%); not owning & not buying[4]: 6 (8.2%). [N=73]	Second-home buyers[1]: 40 (28.4%); owning & not buying[2]: 60 (42.6%); first-home buyers[3]: 20 (14.2%); not owning & not buying[4]: 21 (14.9%). [N=141]	NA.
Home location	CBD: 2 (2.7%); inner-suburban areas: 10 (13.7%); outer-suburban areas: 46 (63%); other towns: 15 (20.5%). [N=73]	CBD: 0 (0%); inner-suburban areas: 28 (19.9%); outer-suburban areas: 90 (63.8%); other towns: 23 (16.3%). [N=141]	NA.
Work location	CBD: 9 (12.3%); inner suburbs: 15 (20.5%); outer suburbs: 28	CBD: 24 (17.1%); inner-suburbs: 32 (22.9%); outer-suburbs: 58	NA.

	(38.4%); other towns: 9 (12.3%); anywhere in Christchurch: 2 (2.7%); work at home: 2 (2.7%); not working/retired: 8 (11%). [N=73]	(41.4%); other towns: 11 (7.9%); anywhere in Christchurch: 2 (1.4%); work at home: 5 (3.6%); not working/retired: 8 (5.7%). [N=140]	
Spouse work location	CBD: 9 (12.3%); inner suburbs: 6 (8.2%); outer suburbs: 23 (31.5%); other towns: 8 (11%); anywhere in Christchurch: 2 (2.7%); work at home: 1 (1.4%); not working/retired: 6 (8.2%). [N=55]	CBD: 13 (17.1%); inner suburbs: 16 (21.1%); outer suburbs: 29 (38.2%); other towns: 11 (14.5%); anywhere in Christchurch: 4 (5.3%); work at home: 0 (0%); not working/retired: 3 (3.9%). [N=76]	NA.

Note:
[1]Second-home buyers: owning a residential property & considering buying another one
[2]Owning & not buying: owning a residential property & not considering buying another one
[3]First-home buyers: not owning a residential property & considering buying one
[4]Not owning & not buying: not owning a residential property & not considering buying one

Table 7.1 shows that females were over-represented in the sample, while single parents were substantially under represented. 70.2% of the respondents indicated that they live together with a partner/spouse, and 56.6% of the respondents who were living with a partner indicated that they have at least one child living with them. The categories of the respondents with dependent children were to some extent similar to those of the population, suggesting the representativeness of the sample with regard to this aspect.

The respondents were asked to indicate their age category and, where applicable, their spouse's age category. Compared with the census data, the age categories of 20-24 years old and ≥65 years old were underrepresented while the age category of 30-34 years old was overrepresented. The remaining age categories were relatively comparable in sizes.

A question was asked to identify the respondents' annual (gross) household income. However, it was considered difficult to check the representativeness of the sample with regard to this factor. Statistics New Zealand reports the average weekly salary in the Canterbury region, which was $1,802 based on the 2013 census data (or equivalent to around $93,962 per year). The Christchurch SP survey collected information on household income categories, making a direct comparison with the census data unfeasible.

A question was asked to identify the respondents' ownership of a residential property and their intention to buy one. The results show that 14.2% of the respondents were 'first-home buyers' while 28.4% were 'second-home buyers'. 42.6% have already owned a residential property and were not considering buying another one while 14.9% did not own nor intend to buy a property.

Furthermore, in the survey, the respondents were asked to select the areas where they lived. Their indicated areas were then sorted into five area categories: the CBD (0% respondents), inner-suburban areas, e.g. St. Albans (19.9% respondents); outer-suburban areas, e.g. Avonhead (63.8% respondents); and other towns, e.g. Lincoln (16.3% respondents). It can be seen that more than half of the respondents lived in the outer suburbs, while none of them lived in the CBD of Christchurch. Note that outer-suburban areas cover around half of the entire city area.

With regard to work location, substantial proportions of the respondents and their spouse worked in the outer-suburban areas (41.4% for the respondents and 38.2% for their spouse), the inner-suburban areas (22.9% for the respondents and 21.1% for their spouse), the CBD (17.1% for both the respondents and their spouse), and other towns (7.9% for the respondents and 14.5% for their spouse). Extra categories were added for 'work location' as few respondents indicated that they/their spouse worked at home (3.6% for the respondents and 0% for their spouse), worked anywhere in Christchurch (1.4% for the respondents and 5.3% for their spouse), and were retired/not working (5.7% for the respondents and 3.9% for their spouse).

Comparing the characteristics of the respondents in the sample (N=141) with the excluded respondents (N=73), it can be seen that socio-demographic characteristics of the respondents in these two groups were mostly similar (Table 7.1a and Table 7.1b). The most obvious differences can be seen in the sub-categories of 'ownership and intention to buy a residential property'. The proportion of 'second-home buyers' was substantially higher in the excluded group and the proportion of 'first-home buyers' was substantially lower.

7.2 Description of the sample of the rating tasks

As mentioned earlier, 247 respondents completed the rating tasks. Similar to the sample description above, females were still over-represented. In general, the characteristics of this sample are fairly similar to the one described above.

Table 7.2 Description of the sample (rating tasks)

	Sample description	New Zealand Census for Canterbury Region
Gender	Male: 28.7%; female: 70.7%; other: 0.5% [N=188]	Male: 51%; female: 49%. [N=539,436]
Living condition	Living alone: 27.1%; living with a partner: 72.9% [N=247]	NA.
Number of dependent children	1 child: 29.5%; 2 children: 44.2%; 3 children or more: 26.3%. [N=95]	**Couple with and without (dependent) children** 0 child: 52.2%; 1 child: 18.2%; 2 children: 19.7%; 3 children and more: 9.5%. [N=124,732] **One parent with (dependent) children** 1 child: 59.7%; 2 children: 29.2%; 3 children and more: 11.1%. [N=21,630]
Age	20-24 yrs: 1.9%; 25-29 yrs: 7.5%; 30-34 yrs: 15.1%; 35-39 yrs: 11.3%; 40-44 yrs: 9.0%; 45-49 yrs: 11.3%; 50-54 yrs: 9.4%; 55-59 yrs: 10.8%; 60-64 yrs: 8%; >64 yrs: 15.6%. [N=212]	20-24 yrs: 9.8%; 25-29 yrs: 8.5%; 30-34 yrs: 8.2%; 35-39 yrs: 8.8%; 40-44 yrs: 10.3%; 45-49 yrs: 10.1%; 50-54 yrs: 10.3%; 55-59 yrs: 9.1%; 60-64 yrs: 8.4%; >64 yrs: 16.5%. [N=393,882]
Household income	Below $29999: 7.0%; $30000-$49999: 18.7%; $50000-$69999: 15.4%; $70000-$89999: 19.6%; >$90000 and above: 39.3%. [N=214]	NA. Statistics New Zealand reports the average weekly salary, which was $1802 based on the 2013 census data (or equivalent to around $93962 per year).

8 The choice modelling results

The resulted multinomial logit and mixed logit models are presented in Sections 8.1 and 8.2, and marginal effects were calculated and are presented in Section 8.3.

8.1 Multinomial logit model

Logit modes were developed to identify the weights attached to each of the selected factors, implying the relative importance of each factor to people when purchasing a residential property in an inner-suburban or outer-suburban area. The SP data, containing 2,538 observations from 141 respondents (each respondent answered 18 hypothetical choice tasks, resulting in 18x141 observations), were used to estimate MNL models using the NLOGIT software.

The data were coded using the coding scheme shown in Table 8.1. The resulting coefficients have the correct/logical signs (Table 8.2a). For example, an increase in land price (OPRC or outer-price) and longer commuting time from an outer-suburban area (OTTW or outer-commuting-time) are expected to reduce the probability of choosing the outer-suburban property alternative, and hence, their coefficients should have a negative sign. Similarly, an increase in density in the inner-suburban areas (IDEN or inner-density) is expected to reduce the probability of choosing the inner-suburban property, and thus, its coefficient should have a negative sign. Note that the alternative specific constant of the inner-suburban property (ASCI) is statistically significant with a relatively large (negative) value. This means that relative to the outer-suburban property, the inner-suburban property is inheritably less attractive. This result also implies that there were other factors, not included in the model specification, that influenced the choice probabilities for the inner-suburban and outer-suburban properties.

Note that the attributes of inner-commuting-time, inner-travel-time-CBD, and outer-density were omitted and the model was estimated without them because their coefficients are not statistically significant. This result seems to be logical. The CBD of Christchurch is still under re-development after a series of major earthquakes in 2010 and 2011, making the CBD a less desired destination in the city. Additionally, commuting time (in free-flow conditions, by car) from the inner-suburban areas was rather short, between 5 and 15 minutes, making it rather negligible to many people. However, attaching different levels to this attribute was not desirable as it might not reflect the real-life situation of Christchurch, and thus, it might make it harder for the respondents to assess the hypothetical choice tasks. Density of development in the outer-suburban areas is not statistically significant and this might be due to the relatively homogeneous low-density neighbourhoods in the outer-suburban areas of Christchurch.

Table 8.1 Coding scheme

Linear effects (2 levels)	Non-linear effects (3 levels)	Covariates
▪ IDEN (or inner-density): Density of development for the inner-suburban alternative; 2 levels: medium (=-1) and high (=1) ▪ ODEN (or outer-density): Density of development for the outer-suburban alternative; 2 levels: low (=-1) and medium (=1) ▪ OPRC (or outer-price): Land price per square metre for the outer-suburban alternative; 2 levels: $250 (=-1) and $500 (=1) ▪ ITTW (or inner-commuting time): Travel time to the workplace for the inner-suburban alternative; 2 levels: 5 minutes (=-1) and 15 minutes (=1) ▪ ITTC (or inner-travel-time-CBD): Travel time to the CBD for the inner-suburban alternative; 2 levels: 5 minutes (=-1) and 15 minutes (=1) ▪ OTTW (or outer-commuting-time): Travel time to the workplace for the outer-suburban alternative; 2 levels: 15 minutes (=-1) and 25 minutes (=1)	▪ IDIV (or inner-diversity): Diversity of land use for the inner-suburban alternative; 3 levels: • No diversity of land use/all residential neighbourhood: IDIV1 (or inner-diversity1)=1 and IDIV2 (or inner-diversity-2)=0; • Low level of diversity of land use: IDIV1=0 and IDIV2=1; • Medium level of diversity of land use: IDIV1=-1 and IDIV2=-1. ▪ IPRC (or inner-price): Land price per square metre for the outer-suburban alternative; 3 levels: • $250: IPRC1 (or inner-price1)=1 and IPRC2 (or inner-price2)=0; • $500: IPRC1=0 and IPRC2=1; • $750: IPRC1=-1 and IPRC2=-1.	House ownership and intention to buy a house; 4 levels/categories: ▪ OB: Owning a house and wanting to buy another one (OB=1; ONB=0; NOB=0); ▪ ONB: Owning a house and not wanting to buy another one (OB=0; ONB=1; NOB=0); ▪ NOB: Not owning and wanting to buy a house (OB=0; ONB=1; NOB=0); ▪ NONB: Not owning and not wanting to buy a house (OB=-1; ONB=-1; NOB=-1).

To improve the log-likelihood of the MNL model, MNL models with two-way interactions were estimated (Table 8.2b). Two variables interact if the effect of one of these variables is subject to the level of the other variable. The results of a study done by Dawes and Corrigan (1974) suggest that 70-90% of variance may be explained by main effects while 5-15% of it may be explained by two-way interactions. Thus a model that includes all main and two-way interaction effects may explain 75-100% of the variation observed.

The coefficients of three 2-way interaction parameters are highlighted in the table: IDEN*IDIV1, IDEN*IPRC1 and IDEN*IPRC2, and they were statistically significant, at least at α=10%. Note that 2-way interactions, other than those presented in Table 8.2b, were also estimated. However, their coefficients are not statistically significant and thus were omitted from the model specification.

The results also show that the coefficients of the MNL-interaction model (Table 8.2b) are fairly similar to the coefficients of the MNL model (Table 8.2a), except for IDIV2 and OTTW. The sign of the coefficient of IDIV2 is negative in the MNL model, but it is positive in the MNL-interaction model. However, both coefficients are very small and not statistically significant. The magnitude of the coefficient of OTTW is reduced considerably and lost its statistical significance in the MNL-interaction model.

Table 8.2 The coefficients and standard errors of the MNL model

Alt.	Parameters	(a) MNL		(b) MNL-interaction	
		Coefficient	Std. error	Coefficient	Std. error
IN	ASCI	-0.76198 ***	0.04778	-0.65341***	0.06983
	IDEN	-0.26322 ***	0.05359	-0.24753***	0.05710
	IDIV1	0.35854 ***	0.06628	0.31346***	0.07085
	IDIV2	-0.05048	0.06976	0.09211	0.10395
	IPRC1	0.82036***	0.07221	0.77659***	0.07786
	IPRC2	-0.05650	0.09026	-0.04534	0.09331
	IDEN*IDIV1	NA	NA	-0.19618**	0.08669
	IDEN*IPRC1	NA	NA	-0.18395*	0.09432
	IDEN*IPRC2	NA	NA	0.32199**	0.16347
OUT	OTTW	-0.15712***	0.04530	-0.07982	0.06235
	OPRC	-0.36120***	0.04774	-0.43025***	0.06560
LL		-1460.65006		-1456.80156	
***Estimated coefficient is significant at the 1% significance level; **Estimated coefficient is significant at the 5% significance level; *Estimated coefficient is significant at the 10% significance level.					

8.2 Mixed logit model

The models previously described were estimated using the MNL approach. The MNL approach, despite its increasing popularity, is constrained by the condition that error components ε_i are independent and identically distributed (IID) across individuals, alternatives and choice tasks. Those error components are distributed according to the extreme value type-1 distribution (or Gumbel distribution). This means, the error components of different alternatives cannot be correlated. To relax this restriction, the mixed logit (ML) approach (or also known as the random parameter logit model) allows for stochastic elements, that may be correlated across alternatives and heteroskedastic, to be introduced through model coefficients (β_s). This implies that instead of having a parameter coefficient(s) that is 'fixed' across all individuals, this parameter(s) is treated as 'random' according to a certain type of distribution (e.g. normal, uniform, triangular and lognormal).

In this study, additional models were estimated using the mixed-logit approach, varying (1) the model specifications; (2) the parameters to be treated as 'fixed' and 'random'; (3) the types of distribution used for the random parameters (i.e. normal, uniform, triangular and lognormal); (4) the number of draws required to obtain a stable set of parameter estimates; and (5) the types of intelligent draws (i.e. Halton and Shuffled sequences). This process was very time consuming, considering the number of combinations available. Thus, to reduce the amount of time required, not all the combinations were tested. Later on in the process, the number of draws was set at 100 and the Shuffled sequence was employed. Further information related to the Halton and Shuffled intelligent draws can be found in Bhat (2003) and Daly et al. (2003) in turn.

The coefficients of the 'best' ML model can be found in Table 8.3. The results show that the coefficient of inner-diversity1 (IDIV1) is statistically significant at the 99% confidence level. Similar to the MNL model (Table 8.2a), the coefficient of inner-diversity2 (IDIV2) is not statistically significant. The coefficient of inner-price1 (IPRC1) is statistically significant at the 99% confidence level. As in the MNL model, the coefficient of inner-price2 (IPRC2) in the ML model remains not significant. Note also that all the coefficients of the standard deviations were statistically significant at the 99% confidence level.

Two random parameters of the outer-suburban alternative were estimated in the ML model. The coefficient of outer-commuting-time (OTTW) is not statistically significant in the MNL model but it becomes significant (at the 99% confidence level) in the ML model. The coefficient of its standard deviation is significant at the 99% confidence level. The coefficients of mean and standard deviation of outer-price (OPRC) are both statistically significant at the 99% confidence level.

The ML model shows the presence of heterogeneity around the means of the random parameters, indicated by significant standard deviation parameter coefficients. One of the appeals of using the ML approach is its ability to reveal the possible sources of preference heterogeneity. This is done by interacting a random parameter with another variable (typically a covariate such as gender, income, age, number of children, and the respondents' house ownership/intention to buy a house). After testing each of those covariates, the results show that interacting random parameters with 'house ownership/intention to buy a house' seems to produce the most desirable model. The interactions for people who owned a house and considered buying another one (OB) are statistically significant for the inner-density (IDEN*OB) and outer-price (OPRC*OB) random parameters, but not for inner-diversity1 (IDIV1*OB), inner-price1 (IPRC1*OB), inner-price2 (IPRC2*OB) and outer-commuting-time (OTTW*OB) random parameters. This suggests that people in this group have different marginal utility for increasing density in inner-suburban areas and land price in outer-suburban areas. The negative coefficient of the interaction between inner-density and OB (IDEN*OB coefficient of -7.772) and the positive coefficient of the interaction between outer-price and OB (OPRC*OB coefficient of 6.229) might suggest that people in this group are less sensitive to increases of land price in outer-suburban areas than increases of density in inner-suburban areas. It is also interesting to note that even though the coefficients of the OB interactions with inner-price1 (IPRC1*OB), inner-price2 (IPRC2*OB) and outer-commuting-time (OTTW*OB) are not statistically significant, all of their coefficients have a negative sign. This suggests that people in this group are more sensitive to increases of land price in inner-suburban areas than in outer-suburban areas and are more sensitive to increases of travel time from outer-suburban areas.

Furthermore, the interactions for people who owned a house and did not consider buying another one (ONB) are statistically significant for inner-price1 (IPRC1*ONB) and outer-price (OPRC*ONB). This shows that similar to people in the OB group, people in the ONB group are more concerned with increases of land price in inner-suburban areas than in outer-suburban areas. Additionally, similar to OB, the coefficient of the interaction between ONB and OTTW (OTTW*ONB), despite being not statistically significant, has a negative sign, suggesting that people in this group are more sensitive to increases of travel time from outer-suburban areas. The main difference between people in the OB group and those in the ONB group is related to density of development. People in the OB group seem to be more sensitive to increases of density in the inner-suburban areas than those in the ONB group.

Contrary to the people in the OB and ONB groups, people who did not own a house and considered buying one (NOB) seem to be more sensitive to increases of land price in outer-suburban areas than in inner-suburban areas. Similar to those in the ONB group, they are less sensitive to increases of density in inner-suburban areas and longer commuting time from outer-suburban areas. Despite the lack of statistical significance, people in this group seem to be more sensitive to an increase of diversity in outer-suburban areas.

Table 8.3 The coefficients, standard errors and LL value of the selected ML model

Attributes	Coefficient	Standard Error
Random Parameters		
IDIV1	16.4278***	3.84551
IPRC1	50.0013***	8.74397
IPRC2	-5.99968	5.02594
OPRC	-23.5836***	4.64493
IDEN	-15.6071***	3.65514
OTTW	-7.38459***	2.44137
Non-Random Parameters		
ASCI	-42.8473***	7.03727
IDIV2	-2.82112	3.15126
ITTW	-.59545	2.09495
Diagonal values in Cholesky matrix		
NsIDIV1	14.3791***	5.06118
TsIPRC1	84.8283***	19.02548
TsIPRC2	21.0541	13.42029
TsOPRC	48.4922***	11.12746
NsIDEN	7.56929**	3.52507
TsOTTW	26.9534***	9.42025
Below diagonal values in Cholesky matrix		
IPRC1*IDIV1	-22.3267***	7.02118
IPRC2*IDIV1	60.9011***	11.76704
IPRC2*IPRC1	-59.2018***	18.09818
OPRC*IDIV1	11.9650**	4.68212
OPRC*IPRC1	15.1332	9.32577
OPR0*IPRC2	-28.6648***	10.83018
IDEN*IDIV1	-17.9995***	4.48493
IDEN*IPRC1	32.0932***	9.98803
IDEN*IPRC2	36.3636***	11.36265
IDEN*OPRC	64.5194***	12.29858
OTTW*IDIV1	-9.71184**	4.70416
OTTW*IPRC1	37.0973***	10.40593
OTTW*IPRC2	6.01556	8.93018
OTTW*OPRC	-33.7219***	9.85953
OTTW*IDEN	9.13971**	3.80050
Heterogeneity in mean		
IDIV1*OB	5.67556	4.06295
IDIV1*ONB	0.63588	3.42549
IDIV1*NOB	-2.97079	4.75260
IPRC1*OB	-5.32964	3.99712
IPRC1*ONB	-13.5918***	4.20932
IPRC1*NOB	19.1116***	5.92635
IPRC2*OB	-2.82946	5.70403
IPRC2*ONB	2.58299	5.02863
IPRC2*NOB	1.84440	7.13252
OPRC*OB	6.22850*	3.45453
OPRC*ONB	5.55878*	3.05737
OPRC*NOB	-8.01541*	4.25780
IDEN*OB	-7.77208**	3.20855
IDEN*ONB	2.19083	2.75945
IDEN*NOB	9.86236***	3.61050
OTTW*OB	-2.51162	3.10891
OTTW*ONB	-2.68059	2.82923
OTTW*NOB	7.21109*	4.08210
Standard deviations of random parameter distributions		
sdIDIV1	14.3791***	5.06118

sdIPRC1	87.7173***	19.17584
sdIPRC2	87.5047***	12.29712
sdOPRC	59.5428***	9.80317
sdIDEN	83.0441***	13.93052
sdOTTW	58.7699***	9.33307

***, **, *Estimated coefficient is significant at 1%, 5% and 10% levels in turn.

Ns = Distributed according to a normal distribution; Ts = Distributed according to a triangular distribution.

8.3 Marginal effects

Given the coefficients of the ML model in Table 8.3, the marginal effects for each attribute were calculated to evaluate how the probabilities of choosing the inner-suburban and outer-suburban properties changed due to a unit change in an attribute level, other things being equal. Direct marginal effects represent a change in the choice probability of an alternative given 1-unit change of an attribute belonging to the same alternative. It is calculated by differentiating P_{iq} with respect to X_{ikq} (Eq. 8.1). Cross marginal effects represent a change in the choice probability of an alternative given 1-unit change of an attribute of other alternative(s), and it is calculated by differentiating P_{iq} with respect to X_{jkq} (Eq. 8.2).

$$M_{X_{ikq}}^{P_{iq}} = \frac{\partial P_{iq}}{\partial X_{ikq}} = [1 - P_{iq}]\beta_{ik} \quad \text{Eq. 8.1}$$

$$M_{X_{jkq}}^{P_{iq}} = \frac{\partial P_{iq}}{\partial X_{jkq}} = -\beta_{jk}P_{jq} \quad \text{Eq. 8.2}$$

where $M_{X_{ikq}}^{P_{iq}}$ and $M_{X_{jkq}}^{P_{iq}}$ are direct and cross marginal effects in turn; P_{iq} is the probability of choosing alternative *i* by individual *q*; X_{ikq} is attribute X_k of alternative *i* considered by individual *q*; and X_{ikq} is attribute X_k of alternative *j* considered by individual *q*.

Marginal effects were calculated using the simulation and scenario commands of the NLOGIT software. The results are presented in Table 8.4 and discussed in Section 9.

Table 8.4 The marginal effects

	Scenarios	[Probability of choosing an inner-suburban property; Probability of choosing an outer-suburban property]
Scenario 1	Density of development in the inner-suburban neighbourhood is increased from a low level to a medium level	[-16.66%; 16.66%]
Scenario 2	Diversity of land use in the inner-suburban neighbourhood is increased from no diversity (i.e. a residential only neighbourhood) to a medium level of diversity	[-7.84%; 7.84%]
Scenario 3	Diversity of land use in the inner-suburban neighbourhood is increased from a medium level to a higher level of diversity	[-9.697%; 9.697%]
Scenario 4	Diversity of land use in the inner-suburban neighbourhood is increased from no diversity to a higher level of diversity	[-17.585%; 17.585%]
Scenario 5	Land price per square metre in the inner-suburban neighbourhood is increased from $250 to $500	[-24.243%; 24.243%]
Scenario 6	Land price per square metre in the inner-suburban neighbourhood is increased from $500 to $750	[-11.466%; 11.466%]
Scenario 9	Land price per square metre in the inner-suburban neighbourhood is increased from $250 to $750	[-35.79%; 35.79%]
Scenario 8	Land price per square metre in the outer-suburban neighbourhood is increased from $250 to $500	[15.528%; -15.528%]
Scenario 9	Travel time to the workplace from the outer-suburban neighbourhood is increased from 15 minutes to 25 minutes	[3.344%; -3.344%]

9 The results of the rating tasks and discussions of all results

Before discussing the results, it should be noted that due to some bias in the participants' socio-demographic characteristics (discussed in Section 7), the results presented here might be able to capture only the 'behaviour' of people who make trade-offs between the attributes' levels.

In this section, the results related to land price and house affordability are described first in Section 9.1. Subsequently, in Section 9.2, the results related to mixed-use development characteristics (i.e. density of development, diversity of land use, social diversity, destination accessibility and public transport accessibility, and geographic location) are presented and discussed. The results of other neighbourhood factors considered important when making house purchase decisions are presented and discussed in Section 9.3. At last, the results of the house-related factors are presented and discussed in Section 9.4.

9.1 Land price and housing affordability

The results of marginal effects (Table 8.4) show that land price seems to be the most important factor influencing people's decisions on where to buy a residential property. This result is also consistent with the results of the rating task of house factors (presented and discussed in Section 9.4). 86.6% and 87.4% of the respondents considered property price (or weekly rent) and mortgage repayment very important or important. The resulting marginal effects suggest that an increase in land price in the inner-suburban areas from $250 to $500 would reduce the probability of choosing an inner-suburban property by 24.2% while an increase from $250 to $500 in the outer-suburban areas would reduce the probability of choosing an outer-suburban property by 15.5%. A further increase in land price in the inner-suburban areas from $500 to $750 would reduce the probability of choosing an inner-suburban property by a further 11.5%.

The result of the interaction between the random parameter of inner-price1 and NOB, as presented in Table 8.3, suggest that first-home buyers seem to be more sensitive to increases of land price in the outer-suburban areas than in the inner-suburban areas. This might be because they are more inclined to buy a property in an outer suburb. On the other hand, those considering buying their second home seem to be more sensitive to increases in density in the inner-suburban areas than increases in land price in the outer-suburban areas. This might be because they are more attracted to buying a property in an inner-suburban area. The results above are in-line with the results of other studies (i.e. Burgess and Skeltys, 1992; Burnley et al., 1997), suggesting that first-home buyers seem to prefer outer suburbs because houses there tend to be more affordable for them. Similarly, it was reported that median house prices in many outer-suburban areas of Christchurch (e.g. Aranui, Bromley, Linwood, Waltham and New Brighton) are the lowest in the city (McDonald, 2017). Note that house prices in Christchurch had increased by around 30% since the earthquakes, as shown in sales figures from the Real Estate Institute of New Zealand (McDonald, 2015). This means houses have become less affordable for many first-home buyers.

The results of many existing studies (e.g. Levine, 1998; Reed and Mills, 2007) have indicated that house affordability is an important factor determining decisions to buy a house. It is acknowledged that house affordability is a complex issue, involving many parameters (e.g. income and willingness-to-spend), as discussed in many existing studies (e.g. Stone, 2006). However, it is worth noting that most of the existing studies (e.g. Beer et al., 2007; Thalmann, 1999) tend to include property prices as a component to measure affordability.

9.2 Mixed-use factors

9.2.1 Density of development

The results (Figure 9.1) show that 59.1% of the respondents considered density of development very important or important, and only 9.3% of them considered it very unimportant or unimportant. Similarly, the calculated marginal effects (Table 8.4) show the importance of this factor on choice probability. An increase in density of development from a low level to a medium level would reduce the probability of choosing an inner-suburban property by 16.7%.

Some respondents highlighted the importance of density in the commentary section at the end of the survey, as shown below. Note that the respondents were not compelled to leave a comment. However, those who left a comment related to density of development seem to prefer low-density development. Also note that grammatical errors have been corrected in the quotes.

> *"…We are really concerned with the increasing density appearing in new housing developments… We resent the attitude of developers that 'in other countries they are happy to live in apartments' and take a dim view of inner city residential intensification. It's not producing more affordable property for first-home buyers, just more profit for developers."*

> *"…Dense housing development takes the character away from an area."*

> *"I am living in a high-density area and it can be challenging with absentee owners not trimming trees so you can end up with the sun being blocked out... Most of my garden maintenance is now cutting back the neighbours' trees..."*

> *"I live in a medium-density area but overlook a park so do not feel closed in. I prefer low-density as I enjoy working in the garden, and having some space from neighbours…"*

To address issues related to sustainability and to increase housing stock after the major earthquakes in 2010 and 2011, the Christchurch City Council has been enlarging the areas in outer suburbs (e.g. Hornby, Linwood and north Papanui) rezoned to allow higher-density development (e.g. townhouses/terraced houses and apartments) (Cairns, 2013). This attempt has met opposition from residents of the areas, as many of them dislike higher-density living in their neighbourhood and are concerned that their communities would turn into 'ghettos' (Law, 2016). Furthermore, developers are often forced to reduce property prices in suburbs (e.g. Halswell, Wigram, Prestons, Kaiapoi, Rolleston, and Pegasus in North Canterbury), especially prices of terraced houses, because of a decline in people's interests in purchasing such a type of property.

The trend above seems to be in line with the results of the literature study. A high-density neighbourhood in outer suburbs is often considered undesirable, especially because people who relocate to such areas tend to expect to live in a low-density neighbourhood. This, however, undermines the purpose of mixed-use (i.e. to build a compact neighbourhood). The results of a study in Canada by Grant (2002) suggest that mixed-use development projects in inner suburbs or the CBD (typically done by gradually and incrementally revitalizing the existing urban areas) seem to be more successful than their counterparts in outer suburbs. However, they remain less popular because 'Greenfield' land is cheaper.

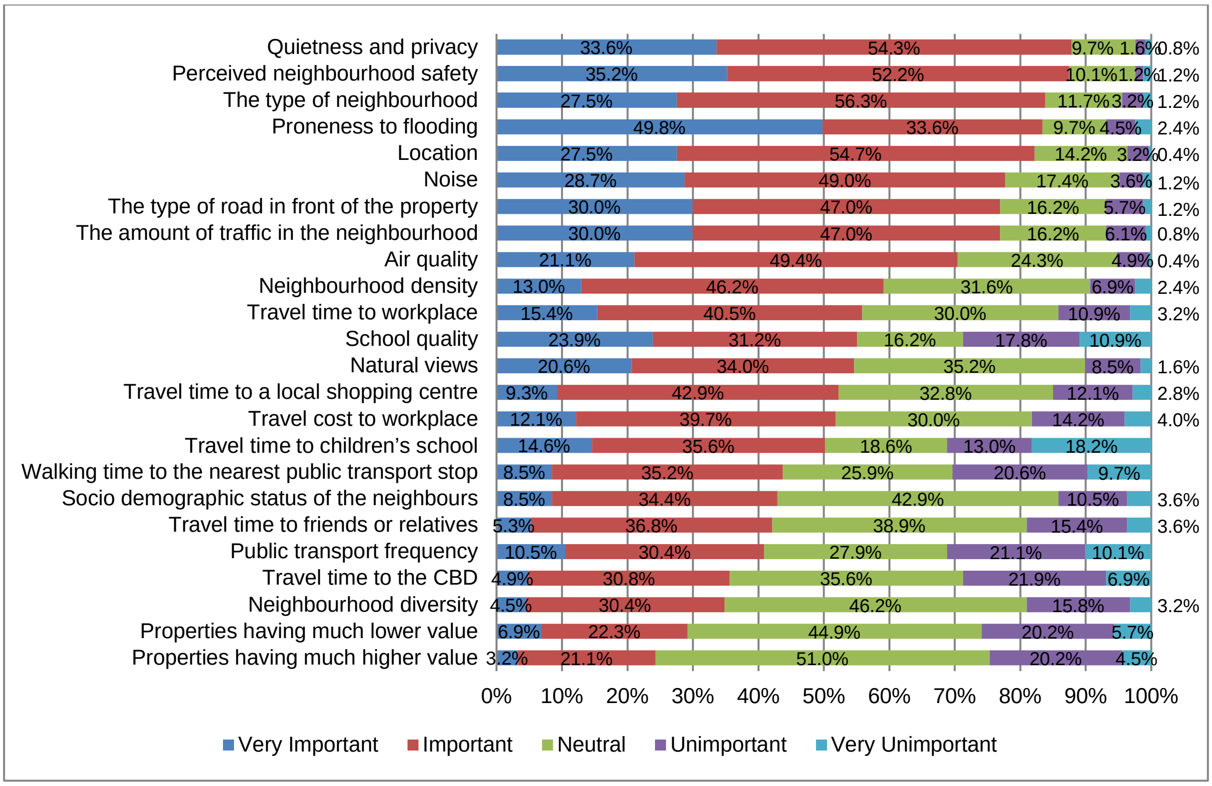


Figure 9.1 The rating results of mixed-use and other neighbourhood factors (N=247)

9.2.2 Diversity of land-use

Diversity of land-use was considered very important or important by only 34.8% of the respondents, and 46.2% indicated neutrality. However, through the calculated marginal effects, the influence of diversity of land use on people's property choices should not be taken lightly. An increase in diversity of land use from a purely residential neighbourhood to a neighbourhood that contains 20% other activities would reduce the probability of choosing an inner-suburban property by 7.8%, while an increase in diversity from a purely residential neighbourhood to a neighbourhood that contains 40% other activities would reduce the probability of choosing an inner-suburban property by 17.6%.

Additionally, the results of rating different land uses (Figure 9.2) show that the respondents have strong preferences for particular types of facilities (e.g. park and playground) than others (e.g. offices and a rail station). This is also highlighted by one of the respondents in the commentary section:

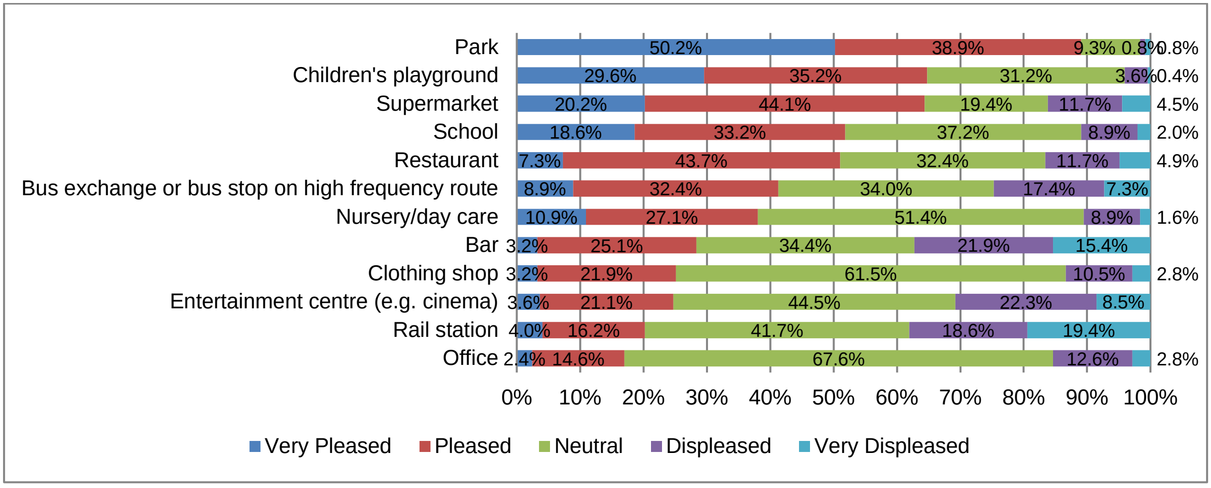
> *"The affordability of the housing is important but the livability of the area is also important i.e. noisy, dirty or smelly businesses nearby would detract from daily wellbeing."*

Most of the respondents indicated that they would be very pleased or pleased to live near a park (89.1%), a playground (64.8%), a supermarket (64.4%), a school (51.8%), and a restaurant (51%). On the other hand, only few respondents indicated that they would be very pleased or pleased to live near offices (17%), and most of them (67.6%) indicated neutrality. Similarly, only a few respondents indicated that they would be very pleased or pleased to live near a rail station (38.1%). Interestingly, a substantial number of them do not seem to mind living near a bus exchange or a bus stop on a high frequency route, as 41.3% indicated that they would be very pleased or pleased and 34% indicated neutrality.

These results, to some extent, are in line with the framework of synergy (Levitt and Schwanke, 2003). Table 3.1 shows that residential activities are moderately supported by offices, strongly supported by retail/entertainment, and very strongly supported by cultural/civic/recreation. However, substantial numbers of the respondents remained neutral about living near offices

(67.6%), clothing shops (61.5%) and an entertainment centre (44.5%), although, a supermarket (64.4%) and restaurant (51%) seem to be desirable functions in a neighbourhood. The results also show that most functions associated with cultural/civic/recreation (e.g. park, playground, and school) were found to be desirable, supporting the work done by Levitt and Schwanke (2003).

Figure 9.2 The rating results of land uses (N=247)



The results of the literature review suggest that extra care must be taken when diversity of land-use is combined with density of development. Activities that are seemingly safe (e.g. a shoe repair shop or dry cleaner) may impose a health hazard on the neighbouring residents (e.g. toxic fumes from chemical solvents) (Angotti and Hanhardt, 2001). Unfortunately, regulations cannot completely control the exposure to hazardous substances because of difficulties in estimating the cumulative and interactive effects of different pollutants. In several mixed-use neighbourhoods located in the outer suburbs of Auckland, residents complain about untidy businesses; the presence of neighbouring activities that produce noises, smells, smoke and steam; traffic congestion; and lack of parking (Research Solution, 2001). Hence, careful thought and consideration must be given by the City Council of Christchurch, city planners and architects when designing a mixed-use neighbourhood, especially that with high-density and diversity, so that various safety and health related risks are kept within acceptable levels, and the attractiveness of mixed-use development projects can be assured.

9.2.3 Social diversity

Social diversity was represented in the survey using socio-demographic and economic status of the neighbours, and presence of properties having higher and lower values than the respondents' properties. The results show that most respondents do not seem to mind having higher or lower value properties in their neighbourhoods (i.e. more than 40% indicated neutrality and less than 30% considered each factor as very important/important or very unimportant/unimportant). The socio-demographic and economic status of the neighbours was considered very important or important by more respondents (i.e. 42.9%). In the commentary section of the survey, a respondent indicated a strong correlation between high-density living and social economic diversity:

> *"I would prefer a property that has higher spec with less density. When housing units are more closely packed, they tend to be of less quality and that of the inhabitants* [sic]*."*

Regulations often require a mixed-use development project to allocate a certain percentage of houses for lower-income households. However, high-income residents often resent having lower-income households in their neighbourhood and prefer being segregated from them, as observed by Dale and Newman (2009). Resentment results in decreasing social diversity, which in turn increases housing prices and further forces low-income tenants and renters to move out of the neighbourhoods (Angotti and Hanhardt, 2001) While the results of the survey show that a substantial portion of the respondents considered social diversity factors very unimportant/unimportant, or remained neutral about this, it is still important to include plans on how to keep a mixed-use development project accessible to diverse groups of people (Newman and Wyly, 2006).

9.2.4 Destination accessibility and public transport accessibility

In the survey, destination accessibility was represented by travel times to the CBD, a workplace, children's schools, friends' and relatives' houses, and a local shopping centre. In addition, walking time to the nearest public transport facility and public transport frequency were included as the components of accessibility by public transport.

Travel time to a workplace is rated as very important or important by 55.9% of the respondents, and only 14.2% indicated that the factor was either very unimportant nor unimportant. These results are in line with the results of a study by Levine (1998). He, through estimation of a discrete choice model of residential location in Minneapolis (USA), suggested that commuting time is an important factor determining residential location decisions at the regional scale. On the other hand, based on the calculated marginal effects, this factor seems to have the least influence on choice probability. An increase from 15 minutes to 25 minutes would reduce the probability of choosing an outer-suburban property by only 3.3%. Although the small influence of accessibility-related factors (such as commuting time) on residential purchase decisions was also found in the results of other study (e.g. Hunt, 2010), further studies need to be done to address this issue.

52.2% and 50.2% of the respondents subsequently considered travel time to a local shopping centre and children's schools very important and important. 42.1% and 35.6% respectively considered travel times to friends and relatives and to the CBD very important or important. Walking time to the nearest public transport stop and public transport frequency were considered very important or important by 43.7% and 40.9% of the respondents respectively.

The results above show that travel times to several destinations (e.g. workplace, local shops and children's school) appear to be important factors. Hence, further analysis should be done to identify the amount of time that people are willing to spend to travel to each of those destinations, especially by foot, bicycle and public transport. It should also be noted that re-building of the CBD of Christchurch after the earthquakes had not been completed. Many commercial activities were relocated from the CBD and they remained in the suburbs (Harper, 2012), creating many small suburban centres and making the CBD a less important location compared to before 2011.

In Canada, residents living in neighbourhoods in outer-suburban areas often express their concerns over the length of public transport trips to the city centre (Grant, 2002). Additionally, residents living in mixed-use neighbourhoods in the outer suburbs of Auckland complain about the poorer level of service of public transport (Research Solution, 2001). From the point of view of the public transport provider, delivering a good level of service for public transport users living in outer-urban areas is considered not economically viable.

9.2.5 Location and type of development

Location (e.g. inner or outer suburbs) and type of neighbourhood (e.g. mixed-use or single-use) were included in the rating task, as they are related to mixed-use development. The results (Figure 9.1) show that 82.2% and 83.8% of the respondents considered both factors very important or important, and less than 5% considered each of these factors very unimportant or unimportant.

Geographical location shows where mixed-use development projects can take place, such as in inner-urban and outer-urban areas, in a city centre and in a 'greenfield' site. Those locations often determine the size of a mixed-use project and the suitable development approach (e.g. conserving the existing mixed-use settings, gradually and incrementally revitalizing the existing city or town centres, and systematically developing or redeveloping larger areas or plots) (Rowley, 1996). It has also been noted above that location can play an important role in people's acceptance of higher-density living (Grant, 2002). Furthermore, at a city scale, urban environment can always be considered mixed-use, although its quality may vary from one city to another (Rowley, 1996). Depending on which level of mixed-use is proposed, different mixtures of uses can be emphasized. For instance, within streets and street blocks, local grocery shops can be mixed with houses, while within districts, a more complex mixture of use must be carefully planned.

9.3 Other neighbourhood factors

The results show that neighbourhood factors, other than mixed-use factors, such as quietness and privacy (87.9%), neighbourhood safety (87.4%) and proneness to flooding (83.4%), were considered very important or important by most respondents. In fact, these factors were perceived to be important by more respondents than the mixed-use factors. Furthermore, noise, the type of road in front of the property, the amount of traffic in the neighbourhood and air quality were considered very important or important by at least 70% of the respondents.

The results above suggest that to be successful, mixed-use development should address people's need to have quietness and privacy and to feel safe. This would provide a challenge, as higher-density is often associated with less privacy and noisier neighbourhoods. Innovative design (and material) solutions might be used to reduce noise coming from the neighbouring properties and to address security and privacy issues. Design might also help generate synergies from various uses (e.g. placing restaurants near offices), and create a safe environment for children to play outdoors (Haarhoff et al., 2012).

9.4 House-related factors

The results of the rating of house-related factors (Figure 9.3) show that compared to the neighbourhood factors (Figure 9.1), there were more house-related factors considered important by the respondents. Besides factors associated with house affordability discussed in Section 9.1, i.e. affordability of mortgage repayment (87.4%) and the price of the property or the weekly rental price (86.6%), other factors were rated as very important or important by at least 80% of the respondents. These factors are: quality of building materials (91.1%), number of bedrooms (87.9%), condition of the property (87.9%), type of property (87.4%), quality of building insulation (87.1%), presence of garaging (86.2%), size of the house (85.4%), type of land (85%), and orientation of the property (80.6%). Note that there is strong correlation between the factors of affordability of mortgage repayment and the price of the property. Both factors were considered important, neutral and unimportant by fairly similar numbers of the respondents, showing some consistency in the respondents' answers. The only factor considered very important or important by the smallest number of the respondents (i.e. 17.8%) was the presence of balcony. This was also the only factor considered very unimportant or unimportant by the highest number of respondents (i.e. nearly 40%).

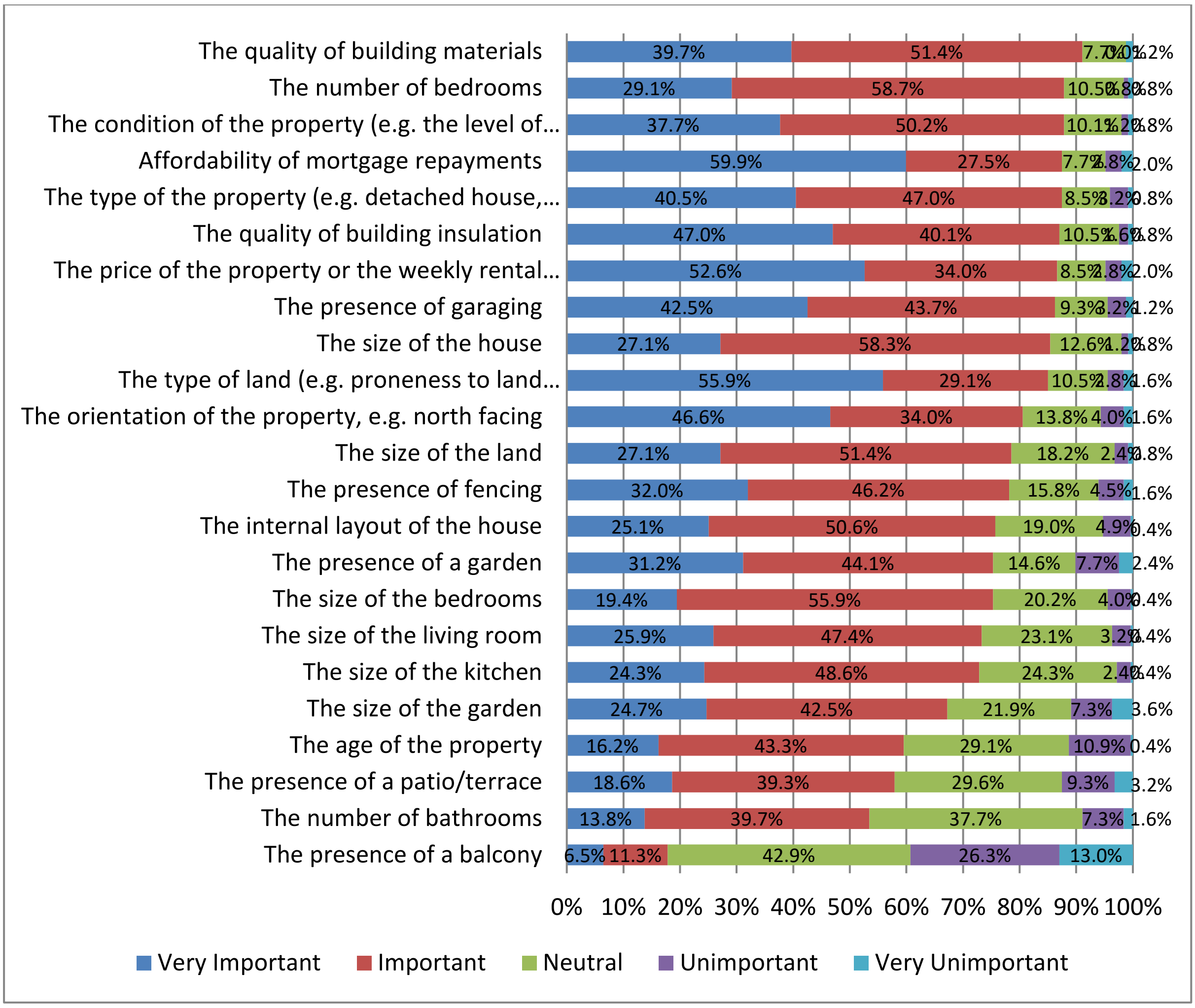


Figure 9.3 Rating of house-related factors (N=247)

Some of the above factors can be grouped together. For instance, quality of building materials (91.1%), quality of building insulation (87.1%) and condition of the property (87.9%) can be grouped into a group of building quality. This factor has been found in the existing literature to be an important factor that influences house purchase decision. For instance, the results of a study done in Sydney (Australia) by Burnley et al. (1997) suggest that one of the reasons people relocate is to obtain a better quality house. Similarly, the results of a study done by Koklic and Vida (2009) in several areas of Slovenia also found that house quality is an important factor considered by people when making decisions regarding whether or not to purchase a prefabricated house.

The type of property (e.g. detached house, apartment and terrace house) was considered very important or important by 87.4% of the respondents. This result is in line with the results of a study done by Haarhoff et al. (2012) in Auckland. They found that Aucklanders' preference for detached houses remains strong. It should be noted that a report published by New Zealand statistics indicated that in 2006, 81% of private houses in the country were defined as detached houses (Goodyear et al., 2012). This highlights New Zealanders' preferences for such a house type. The results of a study in Edmonton (Canada) also suggest that house type is the most important factor that people consider when making house purchase decisions (Hunt, 2010). A study done in Seattle (USA) by Lee and Waddell (2010) investigated households' decisions, whether to relocate or stay at a current house location, using house and location factors. They found that house type is also a factor that appears significant.

The attributes of house size (85.4%), number of bedrooms (87.9%) and presence of garaging (86.2%) can also be grouped together. The results of a study done by Earnhart (2002) on housing choices in Kansas (USA) suggest that house and lot sizes appear to be more important than other house-related factors (e.g. the number of bedrooms and bathrooms, house style and age of the house). Similarly, the results of a study by Molin et al. (1996) on housing preferences of middle class families in Meerhoven (Netherlands) suggest that tenancy type (rent vs. own) is as important as house-related factors (i.e. the number of bedrooms and the size of the living room).

Two factors, i.e. the type of land (e.g. proneness to land subsidence) (85%) and the orientation of the property (e.g. north facing) (80.6%), seem to be found important only in this study. This is expected, as both factors might be relevant only for the residents of Christchurch (i.e. land subsidence) or New Zealand (i.e. property orientation).

10 Conclusions

The project aimed to address research questions in item #3 (p.12) of the Building Research Levy Prospectus: *"What are the opportunities and barriers that exist around growth and expansion of mixed use housing/commercial developments? What is the potential for mixed use development to support increased high quality densification in cities? What lessons can be learnt from good practice from New Zealand and overseas?"*

These questions were addressed in the two stages of this project. In the first stage, the characteristics of mixed-use developments in New Zealand and overseas were identified from the literature review. These characteristics were categorised as follows: (1) density of development, (2) diversity of land use, (3) social (and cultural) diversity, (4) design, (5) distance accessibility, and (6) public transport accessibility. Factors (e.g. location) that might contribute to the success or failure of mixed-use development projects were also identified. Furthermore, the relations between mixed-use and travel behaviour were examined by means of a literature study. The results show that such relations appear to be much more complex than initially anticipated, as results of many existing studies were contradictory and inconclusive. There seems to be an indication that people who are living in a mixed-use urban neighbourhood walk, cycle and use public transport more often than those living in a single-use neighbourhood. This trend can still be observed even after controlling for residential self-selection. This shows the potential of mixed-use development to alter people's travel behaviour. However, those results do not necessarily suggest that every mixed-use development project will have the same desired effect on travel behaviour, as the outcome might be affected by many other factors. For instance, mixed-use development projects (regardless of whether or not it implements sound mixed-use concepts) located in or near the CBD are more likely to alter people's transport behaviour than mixed-use projects in a remote location.

The second stage aimed to identify the weights attached to selected mixed-use factors by means of an empirical study in Christchurch, to assess the opportunities and barriers regarding mixed-use development in Christchurch. The results suggest that there is much to do to make mixed-use development an attractive option for the residents of Christchurch and its surrounding districts. Most residents of Christchurch and the surrounding districts prefer to live in the outer-suburban areas of Christchurch rather than in the inner-suburban areas. Accordingly, they are more sensitive to increases in land price in the inner-suburban areas than in the outer-suburban areas. Land price (and accordingly house affordability) appears to be one of the most important factor that influence people's house purchase decisions. This is also confirmed with the results of the rating tasks with 87.4% and 86.6% of the respondents indicating that the affordability of mortgage repayments and the price of the property, or the weekly rental price, are very important or important factors.

Furthermore, the current trends of increasing the density of development (considered important by 59.1% of the respondents) will further reduce the attractiveness of inner-suburban properties and might deter people from living in a mixed-use neighbourhood. This, however, might be solved with having good neighbourhood and building designs that allow people to maintain their privacy and to feel safe.

An increase in diversity of land use (considered important by 34.8% of the respondents) seems to have an influence on the attractiveness of inner-suburban properties, with some types of activity having more positive effects than others. The results of rating various activities show that people would like to live near a park (89.1%), a playground (64.8%), a supermarket (64.4%), a school (51.8%), and a restaurant (51%). The increase in commuting time has the smallest impact on the probability of choosing an outer-suburban property. However, the results of rating neighbourhood factors show that travel times to various destinations (e.g. workplace, local shops and children's school) seem to be important factors. Thus, further investigation is required to elucidate this issue. Furthermore, studies are also needed to establish the amount of time that people are willing to spend to travel to these destinations by foot, bicycle and public transport.

The results suggest that to make mixed-use development projects attractive, mixed-use neighbourhoods have to be carefully designed to ensure that people's need for quietness/privacy (considered important by 87.9% of the respondents) and safety (87.4%) are met. Proneness to flooding (83.4%), noise (77.7%), the type of road in front of the property (76.9%), the amount of traffic in the neighbourhood (76.9%), and air quality (70.4%) should also be considered when planning and designing mixed-use neighbourhoods. Subsequently, the results of this study suggest that house purchase decision-making is a complex process that involves consideration of not only neighbourhood factors but also house factors, such as quality of building materials (91.1%), number of bedrooms (87.9%), condition of the property (87.9%), type of property (87.4%), quality of building insulation (87.1%), presence of garaging (86.2%), size of the house (85.4%), type of land (85%), and orientation of the property (80.6%).

The results of this study imply that the current attempt to create a more sustainable urban environment through mixed-use development may well not produce the desired outcome, especially when mixed-use projects are not carefully planned and designed. Besides, for mixed-use development projects to be successful, the location of such a project plays a very important role. As long as properties in outer suburbs are available at cheaper prices, mixed-use properties in inner suburbs might be regarded as less desirable options, especially for first-home buyers. Thus, the current expansion of low-density housing development in many New Zealand suburban areas, including Christchurch, results in suburban environments which depend heavily on motorized private vehicles. Efforts to promote and create mixed-use areas are likely to be ineffective, unless the expansion of low-density housing developments in outer-suburban areas is curtailed.

The results of this study shed light on important factors that are needed to consider by the City Council, planners and architects to make mixed-use neighbourhoods an attractive option for the residents of Christchurch and its surrounding districts. However, the preferences of New Zealanders who are living in other cities, such as Wellington and Auckland, might be different to the preferences of residents of Christchurch. For instance, historically, Wellington has a lower figure of car ownership and use than Christchurch and mixed-use development seems to be better integrated there. There is a need to carry out a similar study in Auckland and Wellington, to identify the preferences of New Zealanders there. The knowledge it will help City Councils, planners and architects in New Zealand to better understand whether there is a need to develop city-specific mixed-use guidelines or whether a national mixed-use guideline will suffice. The results show that there appears to be a low level of readiness to accept and live in mixed-use neighbourhoods. However, people's perceptions of mixed-use development might change over time as a result of various factors (e.g. an increase/decrease in fuel and property prices, better quality buildings, etc.). Therefore, it is important to develop a survey to capture changes in people's readiness for mixed-use development in Christchurch. The survey designed for this study could be used as a base for developing such a survey.

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