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Housing and transport expenditure: Socio-spatial indicators of affordability in Auckland

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ABSTRACT

Traditional measures of housing affordability are expressed solely as a function of housing cost and income. This one-dimensional view of affordability ignores transportation costs, which represent a sizable proportion of household expenditure. Conventional measures are problematic due to the extent to which housing location influences transportation costs. Consequently, narrowly construed definitions of housing affordability are misleading indicators of housing stress. This study quantitatively examines intra-metropolitan combined housing and transport affordability in Auckland, New Zealand. The research utilises disaggregate zonal data to develop comprehensive indicators of commuting costs. These indicators are applied to give an integrated affordability index for each statistical area unit within Auckland City. The results suggest that once commuting costs are incorporated into measures, a very different pattern of affordability emerges.

Introduction

Urban sprawl, the low density expansion of the urban fringe, has typified the contemporary development of many cities in Australasia, North America and the British Isles. Yet the normative issue of whether this trend should persist is strongly contested. Not surprisingly, certain aspects of the debate have become relatively entrenched. The diffuse nature of lower density urban forms, *ceteris paribus*, tend to result in decreased accessibility, longer average transport distances, and greater private vehicle use (Anderson, Kanaroglou, & Miller, 1996; Horner, 2002; Low, Gleeson, Green, & Radović, 2005; Newman & Kenworthy, 1989).[1] Higher vehicle use has a number of repercussions from an environmental perspective including the emission of greenhouses gases and pollutants injurious to human health. Low density development, *ipso facto*, demands more land for housing and infrastructure per capita, resulting in more green space, habitats of ecological importance, and productive agricultural land being consumed on the urban periphery. Proponents of low density urban fringe development, however, assert that urban sprawl is merely consumer preference writ large and a means of urban development which is conducive to housing affordability. The economic logic of the latter relies on the premise that a greater supply of available land via urban expansion will lower property prices. This is supported by a number of widely cited affordability studies which have contended that housing prices could be lowered by planning authorities taking a more permissive approach towards urban fringe development (for instance Demographia International (2011), Glaeser and Gyourko (2003) and Quigley and Raphael (2005)).

Spatial planners and other decision makers are therefore ostensibly confronted with a tension between affordability objectives and environmental considerations. However, if housing affordability arguments are to be used to justify urban sprawl, then the definition and methodologies of housing affordability need to be re-examined to ensure that economic benefits of housing location are not inaccurately over-stated. Central to the argument forwarded by this paper is the assertion that conventional measures of housing affordability are not only inadequate, but are to a large extent meretricious. The current housing affordability paradigm ignores other significant costs, namely those of transportation, which represent a sizable proportion of household expenditure. This is a substantial shortcoming given the degree to which housing location influences on-going transportation costs. Lower housing prices in outlying urban areas are often offset by high automobile dependency, long commuting distances, and the associated costs of petrol and vehicle maintenance. The omission of

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[1] This is made more complex by the increasing polycentricity of cities which can allow for workers to live closer to their workplace and therefore undertake shorter commuting trips (Anas, Arnott, & Small, 1998; Gordon, Richardson, & Jun, 1991).

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transportation costs from affordability measures therefore leads to the perception that outlying development and low density cities are affordable. Not only do narrow measures of affordability misrepresent the degree and location of housing affordability stress, but the results of such studies may also be used to advocate for changes to the land use rules which shape urban development patterns, and lead to forms of development which are less affordable in the long term.

This paper focuses on the direct financial costs of owning or renting a house and commuting to work, hereafter referred to as *Combined Housing and Transport* (CHT) for Auckland City.

Three research questions are posed: (1) How does household housing and commuting expenditure vary spatially within Auckland? (2) How does measured affordability differ when commuting expenditure is included in developed affordability indicators? (3) What policy implications do these findings have for urban planning in Auckland and other metropolitan centres? By mapping intra-metropolitan CHT affordability in Auckland, the research shows how combined housing and transport affordability varies spatially within the city, and how this differs from conventional measures which do not consider transport costs. The paper critically examines the current perception of housing affordability in outlying areas through the development of a set of empirical indicators and in doing so, queries a narrative which has favoured greenfield development and sprawl, while opposing planning restrictions on development.

Housing costs and metrics of housing affordability

Traditional housing affordability measures

The basic commonality underlying housing affordability indicators is that they attempt to measure the financial burden of housing, typically across some area of geographic space. The concept of 'housing affordability' is itself highly polysemous, having a number of definitions and methodological approaches used in its measurement. These include house price to income ratio (Suhaida et al., 2011), residual income after housing costs (Stone, 2006), and purchase and repayment affordability (Gan & Hill, 2009). While there is no single agreed measure, the most frequently employed is that of housing expenditure-to-income ratio (Hulchanski, 1995; Jewkes, Delgadillo, & Lucy, 2010; Stone, 2006). The dichotomy between what is affordable and unaffordable is typically delineated by a 30%-of-income threshold, with housing costs greater than this deemed unaffordable (Hulchanski, 1995; Nepal, Tanton, & Harding, 2010). While the qualifier 'arbitrary' or 'subjective' often prefixes discussion of such affordability thresholds, their ubiquity suggests some level of value. However, caution must be given to reducing housing down to affordable unaffordable dichotomies for a concept which has properties more consistent with a continuum (Robinson, Scobie, & Hallinan, 2006).

Housing affordability indicators, namely the housing expenditure-to-income ratio, have a number of limitations. Affordability measures tend to have a narrow scope, satisfied with viewing affordability for median income households of a given area (Gan & Hill, 2009). The most commonly cited criticism of conventional housing affordability indicators is their inability to differentiate between the quality of housing (for instance see Bogdon and Can (1997) and Stone (2006)). A neighbourhood exhibiting high housing prices may simply be suggestive of more positive attributes relative to other areas. Alternatively, Stone (2006) notes that a household could spend less than 30% of their income on housing which is structurally unsafe, inadequate for the needs of its inhabitants, or poorly located with respect to work. Higher housing expenditure in proportion to income should not therefore be unquestionably equated with being inimical to household interests. That being said, housing affordability indicators can provide a meaningful measure of the financial burden of housing facing middle and lower income families.

While the aforementioned issues have occupied affordability research, there has been a distinct neglect of other costs associated with housing choice. Most prominently, housing affordability studies generally neglect the spatial dimensions of transport cost despite the strong influence of housing location on household transport expenditure. A central tenant underlying many urban economic models, most notably the monocentric city (or spatial equilibrium) model, is that there is a perfect trade-off between transport and housing expenditure; in equilibrium a competitive market ensures CHT costs are constant throughout the city regardless of location (Glaeser, 2008).[2] While many such simplifying assumptions utilised in mainstream economics imperfectly represent individuals and urban systems, there is some worth in the idea that transportation costs increase with distance from employment clusters, and that therefore there should be some effect on housing prices to account for this. The theory is reinforced by other urban economics research (for instance Bajic (1983), Gibbons and Machin (2005) and So, Tse, and Ganesan (1997)) which presents strong evidence of transportation savings derived from accessibility to employment centres being at least partially capitalised into residential housing value. From this perspective, higher house prices, *ceteris paribus*, should be found in more accessible neighbourhoods.

Combined housing and transport affordability

Recent studies have begun to address the transport-related flaws in housing affordability measures, particularly in terms of the geography of housing and transport. Research undertaken by Currie and Senbergs (2007) found that households living in peripheral neighbourhoods tend to own more vehicles than their inner city counterparts. The lack of easily accessible public transport in these outlying areas necessitates ownership of a car to access jobs and services, which can represent a large and on-going financial burden for low income families (Currie & Senbergs, 2007). Viggers and Howden-Chapman (2011) suggest that residing in inaccessible locations can harm the financial sustainability of home-ownership. Their study of Auckland found higher rates of mortgagee sales in areas where households exhibited long commuting distances and lacked viable public transport (Viggers & Howden-Chapman, 2011). Research in Australia suggests that rising oil prices pose the greatest financial risk to those living in peripheral suburbs where higher levels of vehicle use and lower incomes are found (Dodson & Sipe, 2008). Dodson and Sipe (2008) go onto express the need for further research which specifically examines the geography of CHT expenditure.

A nascent strand of research has developed the means of explicitly pricing inter and intra-metropolitan CHT affordability in North American and Australian cities. One of the first such studies, conducted by Lipman (2006), investigated inter-urban and intra-urban variation in CHT expenditure as a percentage of income. The Center for Transit-Oriented Development (2006) and Center for Transit-Oriented Development (2011) developed an index which mapped CHT affordability at a finer geographic scale. Kellett Morrissey, and Karuppannan's (2012) study of Adelaide showed that the inclusion of transport costs changes the location of those areas deemed unaffordable, with peripheral neighbourhoods being particularly prominent in terms of their new found unaffordability. Kellett et al. (2012) also explored variation in transportation expenditure under a num-

[2] The mathematical workings are comprehensively explained in Anas et al. (1998).

ber of conditions related to vehicle size and number of vehicles owned, finding that the fixed cost of car ownership takes up a sizable portion of total transportation expenditure.

These studies suggest, at least in the Australian and United States contexts, that housing in outlying areas is in actuality not as affordable as commonly perceived. In this regard, narrowly construed indicators limit understanding of the measured phenomena and beget inadequate solutions to problems of affordability. Accordingly, there is a strong need to broaden housing affordability measures so as to encompass the significant costs associated with housing location. Notwithstanding the noteworthy examples mentioned, there is a dearth of research which has directly measured intra-metropolitan CHT affordability. Further insight is needed into the impact of transportation expenditure on measured affordability. A better understanding of CHT affordability could contribute to central and local government policy and spatial planning, as well as to wider community debates on the issue. This is particularly true of Auckland City, where approximately one third of all New Zealanders reside and where urban growth strategies remain strongly contested.

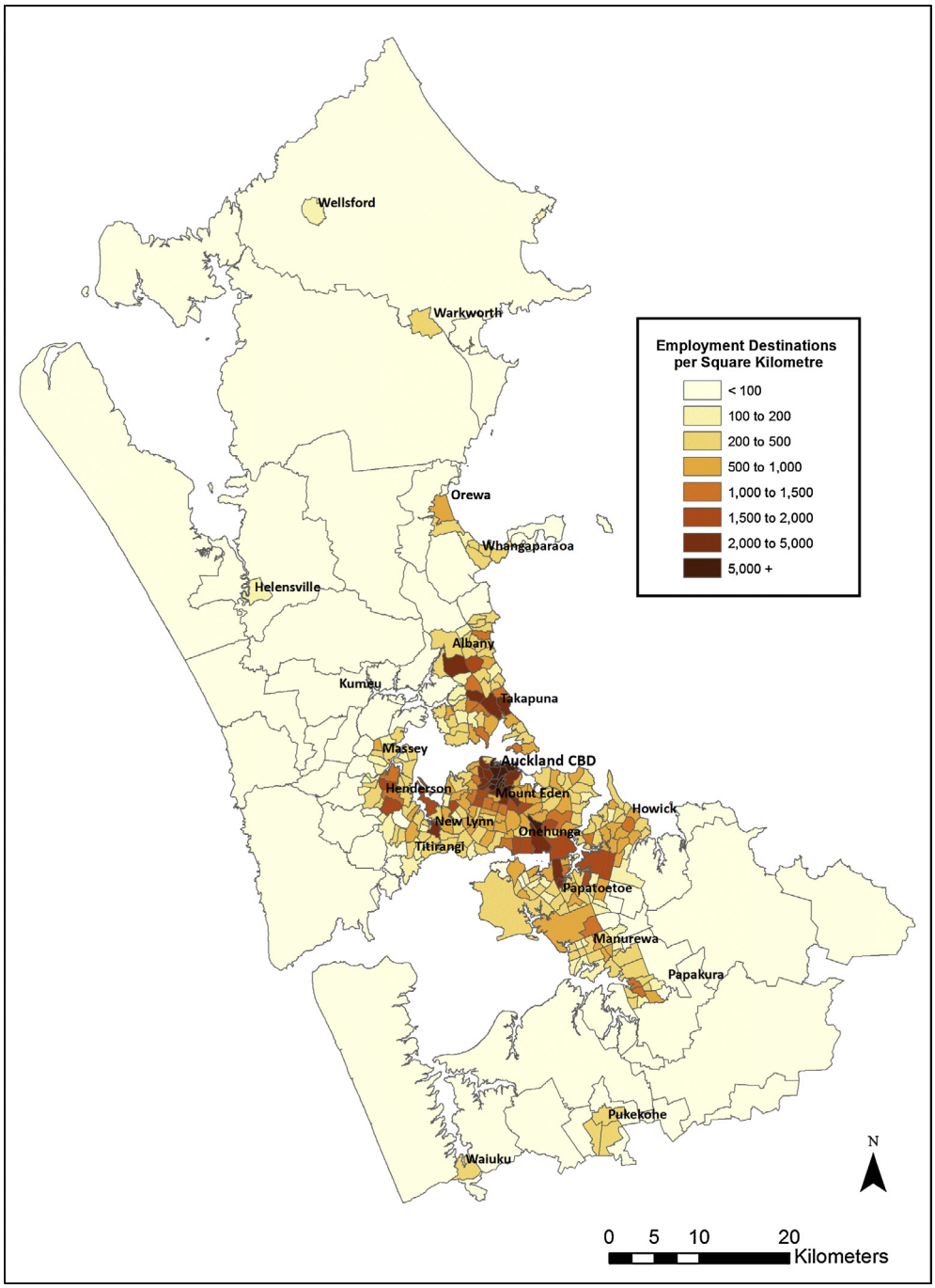


Fig. 1. Employment densities within Auckland. (The figure is generated with GIS software using data from the 2006 census of individuals' usual employment destinations.)

Methodology

Study area

Auckland continues to grow at a rapid pace. In recent years the population has increased by 1.6% per annum, a rate of growth which shows no sign of abating (Statistics New Zealand, 2011). Combined with a relatively strong economic outlook, this growth has intensified demand for housing within the city. Between 2002 and 2007, the nominal median house price within the former Auckland region more than tripled (from $139,000 to $443,000), significantly outpacing proportional income gains over the same period (The Commerce Committee, 2008). In terms of urban geography, the city's form is polycentric in nature with a number of employment centres throughout the city. Fig. 1 shows employment densities by statistical area unit in Auckland, using work location data from the 2006 census. The figure illustrates the dominance of the Auckland CBD and Central Auckland generally, with significant employment sub centres located in South Auckland around Onehunga, and on the North Shore around Takapuna and Albany. Population densities in Auckland show similar patterns to that seen in Fig. 1. There is a general trend of increasing density as one moves into the core of Auckland, although there exist a number of outlying settlements on the urban periphery with densities comparable to parts of central Auckland.

Auckland planning controls have been criticised by a variety of commentators within the New Zealand media and government. A recent report by The New Zealand Productivity Commission (2012) concludes that 'smart growth' strategies increase housing prices and result in declining housing affordability. The report consequently calls on the Council to open "...significant tracts of greenfield and brownfield land to the market in Auckland" (The New Zealand Productivity Commission, 2012:10). The city's growth boundary has been a particularly contentious policy. The Commerce Committee (2008) criticised the city's growth boundaries for causing price distortions due to the limited availability (and therefore high price) of land. Such debate has put intense pressure on the council to relax planning restrictions on greenfield development towards the urban periphery. However, the Auckland Spatial Plan is strongly underpinned by compact city ideals and directs the majority of intensification to take place in the core of Auckland as well as around existing centres in more peripheral areas. The Plan also subscribes to other ideals which are frequently advocated in the planning literature which would help to lower transportation costs, including encouraging mixed-use development, improving and extending public transport, and creating more walkable neighbourhoods.

Housing and income data

In this paper, household-level housing and commuting expenditure are aggregated and expressed as a proportion of income at the area unit level. Zonal data are sourced on the housing expenditure and income of households within the administrative boundary of the newly formed Auckland City Council. Median rather than mean values are generally calculated for each attribute to avoid the skewing of data by outliers.[3] Data on the median total before-tax household income are obtained from the most recent available New Zealand census (2006). Housing expenditure data are also sourced from the 2006 census, using median household rent as a proxy for housing expenditure (see Table 1).

Table 1
Elements of the housing affordability measure and their proxy variables.

Measure	Proxy variable
Median housing expenditure	Household rent
Median income	Total (gross) household income
Mean commuting expenditure	Cost of vehicle ownership + commuting distance × typical costs per unit of distance

The use of rental payments (rather than mortgage payments) as a proxy for housing expenditure has a number of advantages. Research shows that long-term house prices and rents are closely related (Gallin, 2008; Meese & Wallace, 1994). For rental properties, the cost of maintenance and payments to local authorities (e.g. rates) are capitalised into the rental price of the home. Furthermore, rental averages arguably give a better indication as to the true cost of owner-occupied housing, reflecting the market price of housing in a given neighbourhood and therefore the opportunity cost of home ownership.

Commuting distance and travel expenditure variables

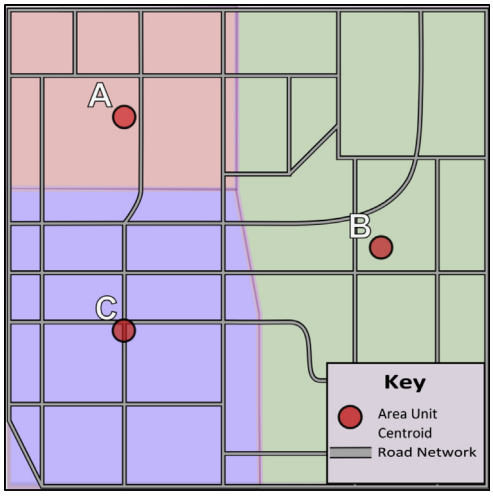
A procedure estimating commuting expenditure from census data on commuting origins, destinations and modes of transport is developed based on the approach reported by Kellett et al. (2012). A dataset, purposively customised by Statistics New Zealand, details the number of individuals commuting between each area unit and their mode of transport within the 'Super City'.[4] Road network distances between the geographic centroid of each possible area unit pair are then calculated by using ArcGIS 10. This involves determining the centroid of each of the 365[5] mainland statistical area units within the Auckland City boundary. A road centre line shape file from Land Information New Zealand (LINZ) is then acquired and built into a network dataset from which analyses could be conducted. The shortest route through the road network is calculated, giving a complete matrix of distances between each area unit origin and every potential area unit destination within the Super City. Calculated distance data are then cross-referenced with the dataset provided by Statistics New Zealand. A simplified example of this is shown in Fig. 2 to illustrate the resulting output.

Once commuting distance is known, it is possible to price commuting expenditure according to the mode of transport used. Average per kilometre user costs for rail and bus travel in Auckland are provided from a study by Ian Wallis Associates (2011). These figures are adjusted to take into account price increases over the period between the census and the study. For private vehicle travel, running costs are calculated on a per kilometre basis. In order to do this, the study utilised data from the New Zealand Automobile Association (AA) on the average total running costs of owning a petrol vehicle. These are calculated and categorised by the AA according to four basic engine size splits. As engine size data are not available at the area unit level, vehicle engine size is set at the Auckland regional average for a light passenger vehicle in 2006 (2175 cc) (Ministry of Transport, 2012b). It has also been assumed that vehicles run on petrol due to the low prevalence of diesel operated vehicles in New Zealand (in 2010, diesel vehicles

[3] The one exception is calculated commuting expenditure where mean values are used so as to account for different modes of transport.

[4] Categories detailed are as follows: worked from home; did not go to work today; private car, truck or van; company car, truck, or van; passenger in a car, truck, van, or company bus; public bus; train; motor cycle or power cycle; bicycle, walked or jogged; other; not elsewhere included.

[5] A number of area units had to be excluded due to insufficient data.



Residence Area Unit	Work Place Area Unit	Private Car, Truck or Van Count	Public Bus Count	[Other means]	Network Distance (km)
A	A	28	4	[…]	3.5
A	B	29	10	[…]	10
A	C	40	15	[…]	7
B	A	25	8	[…]	10
B	B	19	3	[…]	5
B	C	45	12	[…]	11
C	A	3	1	[…]	7
C	B	1	1	[…]	11
C	C	9	8	[…]	3.5

Fig. 2. Schematic showing a hypothetical three area unit region and the resulting output. Network distance is determined by GIS calculation of the shortest road distance between two given centroids. Once found, the network distances are combined with the census dataset giving the number of trips between each area unit and the mode of transport used.

comprised just 8.6% of the light passenger fleet (Ministry of Transport, 2011)).

The fixed costs of vehicle ownership are also sourced from the AA. However, these are only provided for new vehicles, consequently figures are adjusted to more accurately reflect average vehicle characteristics (a mean vehicle car age of 12.1 years is recorded for 2006 (Land Transport New Zealand (2007)). Fixed costs include the vehicle value, warrant of fitness, registration, and cost of insurance.[6] In order to calculate the cost of comprehensive insurance, a quote is obtained from a leading insurance provider, and then adjusted to take into account nominal price rises since 2006.[7] Certain indirect commuting costs were not incorporated into the initial stage of indicator development, such as parking expenditure and the temporal component of travel.

The total distances travelled by each mode of transport are summed according to their respective area unit of origin (place of usual residence). The mode distances are then multiplied by their per kilometre (variable) costs as presented in Table 2. The fixed cost of vehicle ownership (shown in Table 3) is also multiplied by the number of vehicles to which households have access. Mean travel expenditure for commuters in each area unit is calculated and integrated with median housing and income data to developed indices of Combined Housing and Transport (CHT) affordability.

Table 2
Variable costs of commuting utilised by the research.

Mode of transport	Cost ($NZD) per km
Passenger vehicle	27.4c
Bus	21.8c
Rail	9.8c
Active (on foot or bicycle)	0c

Table 3
Annual fixed costs of vehicle ownership (assuming 12 year old, 2200 cc petrol car).

Component	Cost ($NZD)
Vehicle value	$7500
Comprehensive insurance	$645
Registration	$200
Warrant of fitness (twice annually)	$90
Total outlay	$8435
Interest on outlay (at 9.4%)	$793
Depreciation	$500
Total fixed costs	$2228

CHT indicator development and data analysis

Studies looking at affordability typically employ metropolitan-wide income figures. This research deviates from previous approaches by presenting two overall measures of affordability. Housing expenditure, income, and commuting expenditure are combined to develop two primary indices of CHT affordability. The first (CHT Index 1) presents affordability as combined housing and commuting expenditure as a proportion of a given area unit's

[6] A 2009 Ministry of Transport study revealed that 79% of vehicle owners had comprehensive insurance for their vehicle while 6.7% have no form of coverage (Ministry of Transport, 2009).

[7] Statistics New Zealand provide data on changes to insurance premiums between 2006 and 2012. The insurance coverage is selected for a 12 year old 2.2 l sedan, insured for $7500.

Box 1 CHT Affordability Index 1 and 2 equations.

CHT Affordability Index 1: CHT affordability for commuters, using area unit income

$$\text{CHT Affordability} = \frac{R_A + H_{AVC}(P_f \times V_M)}{I_{AU}}$$

where R_A = median annual household rent, H_{AVC} = mean household annual commuting variable cost (see equation below), V_M = mean number of vehicles to which households have access, P_f = fixed cost of vehicle ownership, I_{AU} = area unit median annual household income.

$$\text{Mean Household Annual Commuting Variable Cost } (H_{aVC}) = \left(\frac{(P_V \times D_V)+(P_{TR} \times D_{TR})+(P_{BU} \times D_{BU})}{N_t}\right) \times W_H$$

where P_V = per kilometre vehicle cost, P_{TR} = per kilometre train passenger cost, P_{BU} = per kilometre bus passenger cost, D_V = aggregate annual vehicle distance (in km) travelled by those who drove a private or company vehicle, D_{TR} = aggregate annual distance (in km) travelled by train commuters, D_{BU} = aggregate annual distance (in km) travelled by bus commuters, N_t = total number of Commuters. This includes those who drove a private vehicle (car, truck or van); drove a company vehicle (car, truck or van); are a passenger in a vehicle (car, truck, van, or company bus); public bus; train; bicycle; walked or jogged. Motorcyclist and 'other' travel categories excluded, W_H = Auckland region mean number of workers per household.

Note: It is assumed that per kilometre cost for cyclists, walkers, joggers, and passengers in a vehicle are zero.

CHT Affordability Index 2 uses the same method as that shown above, but with income (I_{AU}) given as the median Auckland region annual household income (I_R).

median household income. Information garnered from the Index may be used by public sector organisations to locate areas requiring greater housing assistance and improved public transportation links. The second (CHT Index 2) develops an indicator of CHT expenditure as a proportion of the Auckland-wide median income. Utilising the area unit's median income provides a more robust indication of the financial burden of housing and transport *currently experienced* by the median Auckland household in each area. While arguably more abstract, using the Auckland-wide median income presents a more accurate and valid picture of how affordable an area *would be* for a typical family to reside in. Moreover, as income is held constant across the city with this measure, the variation of absolute transport and housing costs by location is shown. CHT Index 2 could be useful for decision making regarding where urban development should be promoted or avoided. The equations used to develop these indices of CHT affordability are shown in Box 1. The final affordability rating for each mainland area unit falling within the Auckland boundary[8] is then mapped using ArcGIS. Elements of the final CHT indices are also mapped to emphasise trends and the impact of different factors on an area's CHT affordability.[9]

Results

Housing expenditure

A mapped presentation of housing expenditure data as a percentage of the median Auckland household income is shown in Fig. 3. The results reveal that the cost of housing tends to decline with distance from the nucleus of Auckland city. This trend is particularly apparent at the northern and southern extent of the city boundaries, with greater variation in housing expenditure found in area units closer to central Auckland.

Transportation modes, distance and expenditure

A series of transportation indicators are developed to explain factors underlying the spatial variation in transportation expenditure. Census data demonstrate that residents in area units proximate to large employment centres tend to have fewer vehicles, shorter journey to work trip lengths, and a higher proportion of commuters cycling, walking, or using public transport to travel to work. The transportation trends are typified by the results displayed in Fig. 4, which examines the mean commuter variable cost across each area unit. Fig. 4 and its underlying analysis take into consideration only the marginal cost of travel (while ignoring fixed costs of vehicle ownership) for those who commute by vehicle, train, bus, bicycle, or on foot. In so doing, it presents the savings derived from low-cost forms of transport and shorter commuting distances – latent benefits which are ignored using conventional housing affordability measures. Fig. 4 explicitly demonstrates the high cost of commuting associated with outlying housing locations, where there tends to be lower uptake of public and active transport combined with long average work journeys. The most spatially inaccessible area units exhibit mean annual commuter variable costs at an order of magnitude larger than the most accessible inner city neighbourhoods. Results show that average journey to work trip lengths by vehicle generally increase with distance from large employment centres, particularly the Auckland CBD. Fig. 4 can be compared with Fig. 1 which shows employment densities throughout Auckland and therefore approximates the location of employment centres. While transportation costs are more difficult to observe and evaluate compared to housing costs, once modelled, they expose a strong contrasting trend to the aforementioned measures of household rent as a percentage of income.

Combined housing and transport affordability

Results obtained from analysis of CHT affordability indices are presented in Figs. 5 and 6. CHT Index 1 suggests that the current financial burden of housing and transport is generally highest for commuters residing directly within employment centres, and area units on the northern perimeter of Auckland. The city-wide income measure, CHT Index 2, shows that the most affordable areas for households seeking a home are located in the lower central, inner-west, and inner-south of Auckland. Inner-west Auckland and settlements on the city's northern extent such as in Wellsford, Warkworth, Orewa, and Helensville appear more affordable using

[8] The 2006 area units do not conform exactly to the southern boundary of the new unitary authority. Area units which overlap are included, however, the commuting data use a 'best-fit' methodology whereby the meshblocks which most closely conformed with the boundary are included. The final output is also redrawn using this best-fit approach. However, housing expenditure and income data are based on the full area unit data.

[9] To avoid occurrence of the ecological fallacy, it is necessary for statistics to only be interpreted at the area unit level. Households residing within a given zone should not be assumed to be facing CHT affordability burdens identical to their area unit's overall rating. The maps and aggregate data sets can conceal large variation within area units, including low income households bearing heavy CHT burdens.

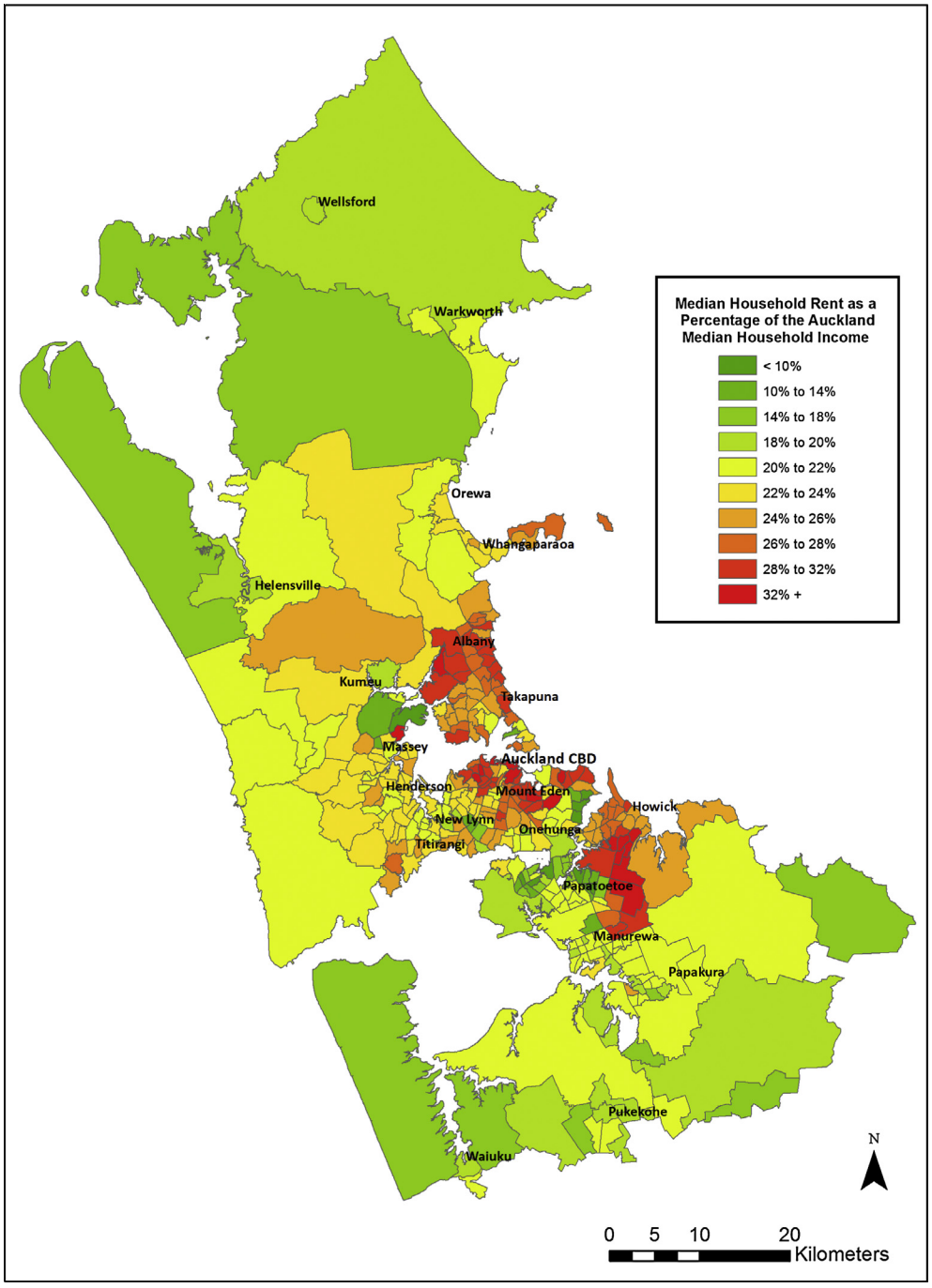


Fig. 3. Median household rent as a percentage of the Auckland median household income.

this measure due to their low median household income and modest overall expenditure on housing and commuting. The least affordable locations are the Auckland CBD, surrounding Botany Downs and Albany, and area units far removed from employment centres such as on the south-eastern perimeter and in north-west Auckland.

Importantly, the results suggest that once commuting costs are incorporated into indicators, a very different pattern of affordability emerges. Inner city areas are associated with low commuting costs and outlying areas with high commuting costs. These costs are not insignificant. The mean annual variable cost for some peripheral areas is greater than five times the amount borne by many central Auckland neighbourhoods. While many accessible neighbourhoods command a high housing price, low concomitant commuting expenditure can often compensate for this expense. Low transportation costs evident in neighbourhoods proximate to significant employment clusters ameliorate their measured, and therefore perceived, 'unaffordability'. Equally, there is decreased affordability on the urban fringe compared to measures which exclude transport costs. This is evident in Fig. 7, which shows the percentage increase in the proportion of income spent when commuting costs are included in the indicator (i.e. when CHT affordability indicators are compared to narrower housing affordability measures). When transport costs are included, the proportion of income spent in many areas of central Auckland increases by less than 30% while the increase in some peripheral areas is over 70%. These trends are further demonstrated by Figs. 8 and 9. Area units with longer average work journeys are associated with lower

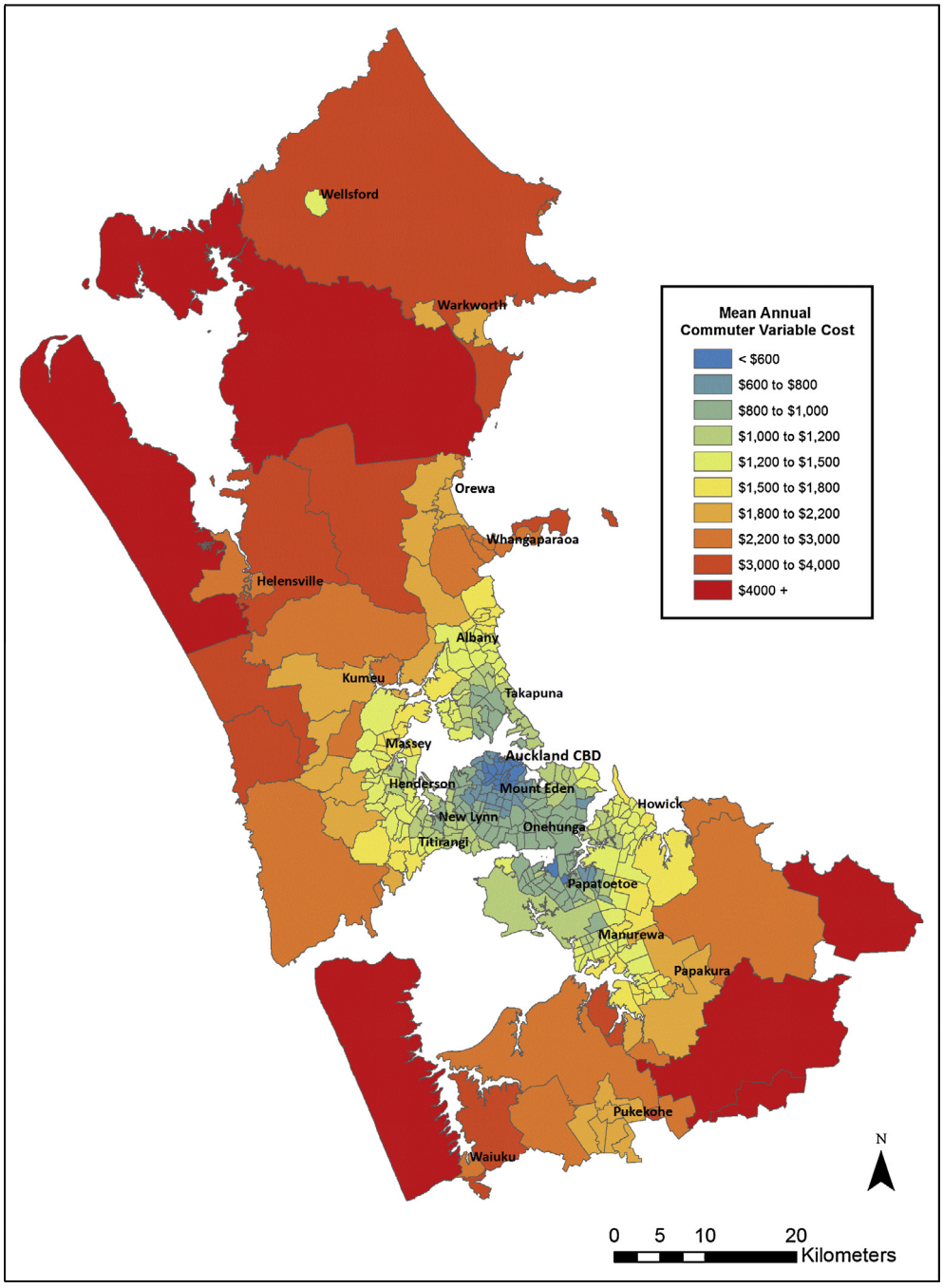


Fig. 4. Mean annual commuter variable cost.

(i.e. improved) housing affordability and higher CHT affordability levels. Paired indices thus exhibit increasingly greater divergence as area unit commuting distance increases.

Sensitivity analysis using parking rates

Sufficiently detailed data were not available to incorporate parking costs into the developed CHT indices. Such an analysis would have necessitated a survey of parking habits at the area unit level, a task beyond the scope of this study. However, a sensitivity analysis of developed indicator CHT 1 was conducted, to demonstrate the magnitude of impact which might be expected from the inclusion of parking rates. Table 4 shows parking rates for Auckland Transport operated car parks. From these data, a high, medium and low parking rate of $17, $8 and $4 respectively were applied as indicative daily parking rates for the Auckland region. Fig. 10 presents the outputs from this analysis, showing the considerable impact which a high parking rate in particular has on the developed CHT index. The impact on those travelling greater than 15,000 km per annum is especially pronounced, although the magnitude of the index increases are similar across the other commuting distance splits (see Table 5).

Discussion

Empirically derived indicators and spatial mapping of housing and commuting expenditure facilitate an abstraction of their dif-

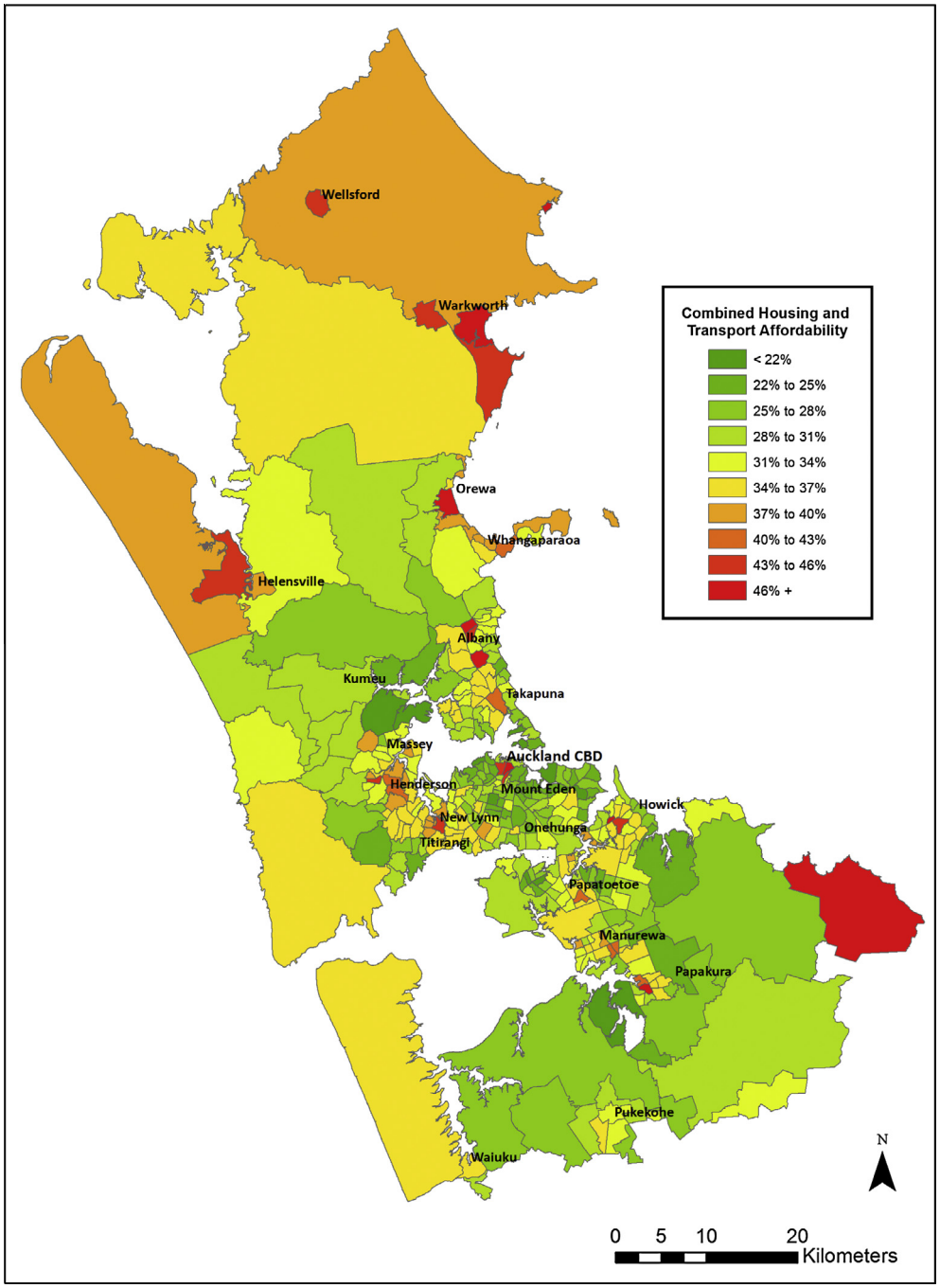


Fig. 5. CHT affordability for commuters, using area unit median income (CHT Index 1).

fering impact across Auckland. While one of the underlying ideas of the monocentric city model is that CHT costs are held constant across the city, the reality of Auckland is more dynamic. Auckland's unusual topography and polycentric form add considerable complexity, and many of the findings are difficult to articulate without arbitrarily dividing the city into segments. Nevertheless, it is possible to establish patterns of social and spatial differentiation related to CHT affordability from the developed indicators.

Housing expenditure broadly declines as distance from employment centres increases; the most significant employment areas being the Auckland CBD and second tier centres such as Albany and Takapuna. A number of factors are likely to contribute to higher prices in centrally located neighbourhoods, including lifestyle choices related to inner city amenities and services. However, proximity to jobs and the attendant reduction in commuting costs appear to play a large role. There are some exceptions to this overarching trend. For example, a number of low cost areas relatively close to central Auckland or other employment hubs in South Auckland are evident. Many of these areas are associated with high rates of state and council-owned housing where residents pay below market rents. The use of median rental values to develop CHT indicators should negate some of the direct influence of this except in area units where public housing makes up a substantial proportion of all properties. However, there may also be indirect impacts which stem from state or council-owned dwellings. Clusters of such properties may devalue surrounding areas due to negative

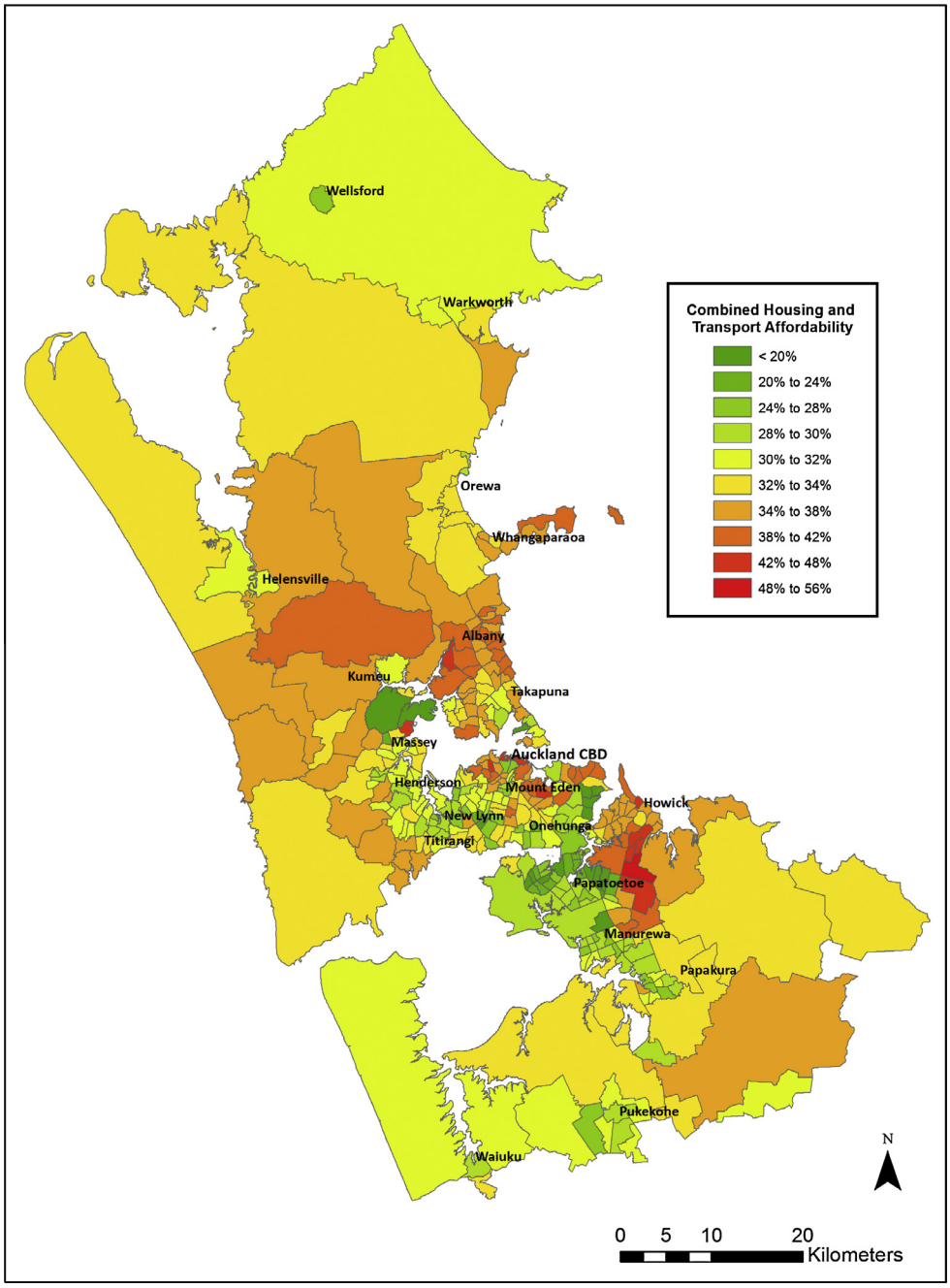


Fig. 6. CHT affordability for commuters, using the Auckland median income (CHT Index 2).

associations, poorer amenities, and perceptions of higher crime and social delinquency.

Equally, enclaves of high housing expenditure are evident in areas which are not particularly accessible to large employment centres. These areas are likely to have features which attract more affluent residents willing to pay for up-market housing in a desirable neighbourhood. The general quality of housing (such as size, age, and condition) and surrounding amenities (such as green space, harbour views, the quality of local schools) is not held constant across area units. For instance, inner city Auckland has a higher proportion of apartments and attached dwellings compared to the outlying suburbs. An urban fringe area may have a high proportion of recently developed housing compared to more established suburbs in central Auckland.

Commuting expenditure show an antithetical trend to that of housing outlays. Neighbourhood location strongly influences household commuting costs, with travel expenditure tending to increase with distance from employment centres. Households residing in area units far removed from large employment centres (particularly the Auckland CBD) face longer average journeys to work. Transportation costs are not only lowered in accessible neighbourhoods as a result of shorter commutes, but also because residents tend to own fewer vehicles, use public transport more frequently, and are more likely to walk or cycle to work. The cost of public transport per unit of distance travelled is far less than that of a private vehicle. For instance, the data utilised in the study's methodology gives the marginal cost of private vehicle usage at almost three times that of rail in Auckland. For walking and cycling,

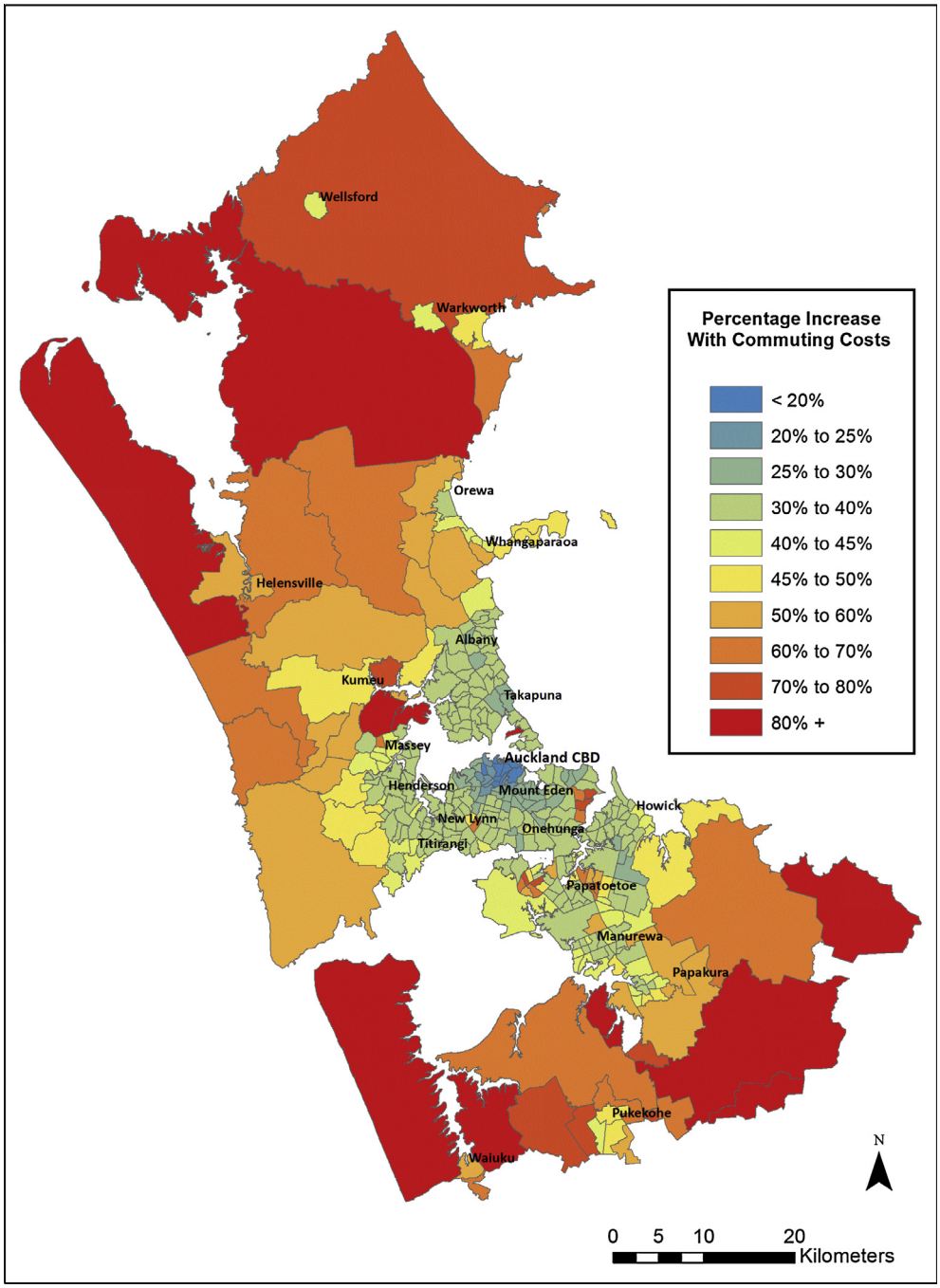


Fig. 7. Percentage increase in the proportion of income spent when commuting costs are included in the housing affordability indictor.

the marginal cost is effectively zero given that the opportunity cost of time is not included. Walking, cycling, or using public transport can therefore produce substantial savings for households. Additionally, the mean number of private vehicles that a household has access to is higher in Auckland's outlying area units. Remote neighbourhoods often exhibit heavy car dependence as result of fewer employment opportunities and services being within walking distance or easily accessed via public transport. The resulting necessity for owning multiple vehicles can occupy considerable household resources. As noted by Kellett et al. (2012), a high proportion of overall transportation costs are fixed and borne by vehicle owners regardless of distance travelled. These fixed costs include the initial outlay in purchasing the vehicle, warrant of fitness and registration costs, and depreciation in value. Income factors may contribute to the vehicle ownership trend; for instance, Currie and Senbergs (2007) found a positive relationship between income and the number of vehicles owned in Melbourne. While the effect of income requires further investigation, it is difficult to dispute the influence of spatial accessibility on transportation outlays.

While observed affordability can vary with the form of measure employed, each CHT index presents a separate, yet valid, conception of affordability. CHT Index 1 is particularly useful for identifying specific metropolitan areas facing severe CHT unaffordability. CHT Index 2 can be applied to demonstrate spatial pressures more effectively as income is held constant across area units. Conse-

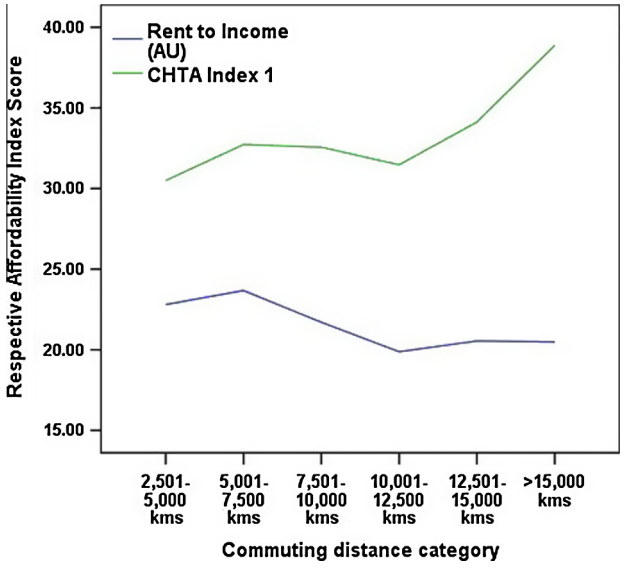


Fig. 8. Area unit income measures comparison.

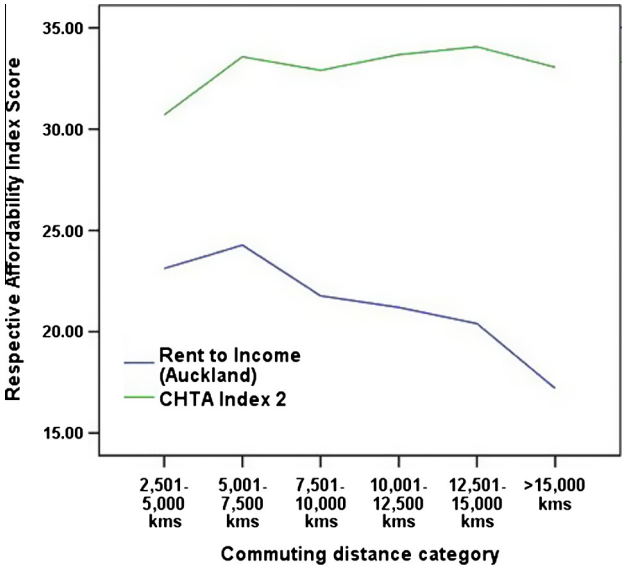


Fig. 9. Auckland-wide income measures comparison.

Table 4
Parking rates for Auckland transport operated car parks in the Auckland region (Auckland Transport, 2013).

Auckland Parking area	Daily rate	Annual cost (based on 229 day work year)
CBD	$17.00[a]	$3893
Takapuna	$8.00	$1832
Manukau	$5.00	$1145
New Lynn	$4.00	$916
Henderson	$4.00	$916

[a] $13 early bird rate.

quently, greater attention has been given to CHT Index 2 as the general findings for Auckland may be characteristic of comparable low density cities. There is a prevailing trend of higher CHT values as average commuting distances increase. CHT Index 2 shows outlying districts tend to be less affordable, and of these areas, those within or adjacent to local employment hubs generally have the

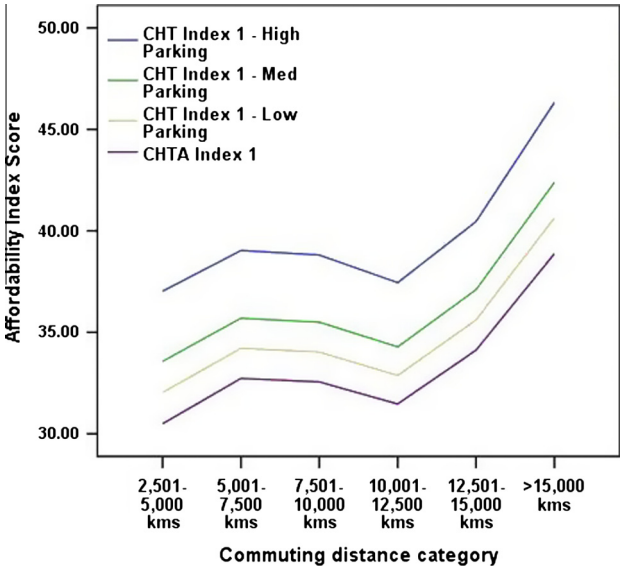


Fig. 10. Sensitivity analysis of CHT Index 1 – using high, medium and low parking rates.

lowest expenditure on housing and commuting. The Index therefore strongly suggests that accessibility to employment centres plays a large role in CHT affordability. However, some of the areas suffering the highest CHT burden are still found in the Auckland CBD, around Albany and south of Howick (Botany Downs). As previously noted, these tend to be highly desirable and affluent neighbourhoods where housing is strongly sought after. Furthermore, areas within the CBD are not exclusively residential, but loci of strong competition between different land uses. The demand for such locations is reflected in residents' high median housing expenditure. However, these CHT levels do not hold for inner Auckland generally, with contiguous area units being significantly more affordable. When comparing the CHT indices to their traditional affordability counterparts, area units on the metropolitan periphery of Auckland become comparatively less affordable when commuting expenditure is incorporated into the measures. Area units within and adjacent to employment centres become relatively more affordable, attributable to the accrual of transportation savings to those living in highly accessible locations.

The aforementioned trends may be even more pronounced with the inclusion of all transportation expenditure. The rationale for focusing on commuting costs is largely one of pragmatism given that commuting distances are fairly constant and predictable over monthly intervals of time compared to trips for other purposes. Census data also often include information on their population's home and work locations, allowing for commuting distances to be relatively easily calculated at the neighbourhood or city scale without needing to survey or sample. Furthermore, Redmond and Mokhtarian (2001) note that a commuting focus is justified in other studies due to many non-work trips based around journey to work trips (and therefore commuting distance is a strong indicator of a household's overall transport costs). A recent New Zealand household survey found that "work-related travel (travel to main job or other jobs and travel on employers business) accounts for nearly one third of all household driving time and distance" (Ministry of Transport, 2012a:6). Nevertheless, the measure will underestimate total transportation outlays; a fact which needs to be acknowledged. How the non-work component of travel varies spatially within Auckland is unclear. There is limited research into non-work related transport, particularly spatial analyses similar to this study and the relationship between commuting and non-work travel (Wang, Grengs, & Kostyniuk, 2013).

Table 5
Descriptive statistics of CHT 1 sensitivity analysis – using high, medium and low parking rates.

Index	*N*	Minimum	Maximum	Mean	Std. deviation
CHTA Index 1	365	15.72	61.17	31.69	6.27
CHT Index 1 – High Parking Scenario	365	20.75	72.20	38.12	7.52
CHT Index 1 – Med Parking Scenario	365	18.09	66.36	34.71	6.83
CHT Index 1 – Low Parking Scenario	365	16.91	63.77	33.20	6.55

Broad results from both developed CHT affordability measures are consistent with the findings of comparable North American and Australian studies. The Center for Neighborhood Technology (2011:22) compares their CHT index with a conventional housing measure, suggesting that "the outlying counties that present some of the lowest housing costs in the region look much different when considered through the lens of combined [housing and transportation] costs". Kellett et al. (2012) note that 'drive 'til you qualify' behaviour may be imprudent from a wider affordability perspective. However, comprehensive affordability measures, are required to reveal such vulnerabilities. It is essential that researchers continually probe and reflect on the fundamental elements, methods, and indicators used to evaluate the phenomena.

The use of conventional housing affordability measures can serve to bolster arguments against planning regulations which serve to reduce urban sprawl. Downs (2005) suggests that the tendency to restrict development on low priced land found on the urban periphery gives an impression of anti-sprawl measures harming housing affordability. Yet residents of these fringe neighbourhoods are likely to face some of the highest levels of on-going CHT unaffordability. The influential *Annual Demographia International Housing Affordability Survey* investigates the affordability of globally relevant urban areas across the Anglosphere. Using the median multiple measure,[10] the report finds the sprawling cities of the United States to be the most affordable. This includes those cities notorious for interminable commutes, heavy private vehicle dependency, and insatiable sprawl such as Atlanta, Houston, Detroit, and Phoenix. The report surmises that *laissez faire* land use planning is indubitably the cause of these cities' 'affordability' (Demographia International, 2011). However, the developed indicators of affordability reported in Demographia are narrowly construed, highlighting that conclusions on the influence of different forms of development on affordability cannot be credibly viewed without due consideration of transportation costs. Housing expenditure therefore should not be considered in isolation. Narrowly defined indicators lead to a systematic underestimation of the affordability of low density urban fringe development. This finding also extends to affordability at larger scales. When aggregated at the metropolitan-level, measures disregarding transport costs will overestimate the affordability of low-density sprawling cities. Equally, high density, transit-oriented cities will be shown as excessively unaffordable. The savings due to accessibility and the costs of distance are ignored. Socio-spatial indicators such as the developed CHT indices represent important planning tools in this regard.

While developed CHT metrics focus on the private economic costs of location, the inclusion of transportation costs somewhat reconciles the polarity between housing affordability and environmental and social considerations. The findings are suggestive of long-term environmental consequences of low density fringe development. Peripheral neighbourhoods are associated with lower uptake of non-motorised and public transport for commuting, high levels of vehicle ownership and use, and long commuting distances. Consequently, these areas would be shown to be considerably less affordable if the wider societal costs associated with housing and vehicle travel were fully borne by consumers. Driving imposes external costs on society that are not incurred by the motorist, something which is encompassed under the economic concept of externalities. Negative externalities include nuisance by way of increased congestion, noise, and pollutants, and risk of accidents (Horner, 2004; Jakob, Craig, & Fisher, 2006).[11]

Failure to account for negative transport externalities has contributed to the overuse of private vehicles from a societal perspective, effectively subsidising outlying development, and encouraging a diffuse and overextended urban form (Anas et al., 1998). Moreover, there are other negative externalities associated with urban fringe development beyond those related to transport, including greater per capita cost of infrastructure and other public service provision, as well as the loss of rural amenity values (Brueckner, 2000; Carruthers & Ulfarsson, 2003). Implementing specially targeted Pigovian taxes and fees would give greater incentive for people to reside in closer proximity to places of employment and encourage the use of public and active transport. While this would lead to greater efficiency, the desirability of implementing such policies can be debated. There are clear equity concerns if harsh economic mechanisms are put in place without adequate redistribution of income. While market outcomes can often maximise the *overall* social benefit, poorer segments of society do not necessarily profit from their implementation. Low income households in relatively inaccessible neighbourhoods may be disproportionately affected, especially in areas where public transport cannot be easily substituted for car use (Nechyba & Walsh, 2004; Perreau, 2007).

Policy implications

The findings and recommendations of this study accord with the Auckland Spatial Plan's principles and goals. Many of the areas nominated for development are those found to have greater employment densities and lower commuting costs, such as the areas surrounding the core of Auckland and outlying employment centres. However, while the research results broadly lend empirical support to Auckland's nascent development strategy, specificities can still be debated. Under the current Plan, the majority of new housing capacity is to be accommodated within existing centres within the city's growth boundary, the Rural–Urban-Boundary (RUB), while greenfield development is to be limited outside its confines (Auckland Council, 2012). The RUB is a matter of some contention. The Auckland Council essentially determines the quantity and location of land made available for residential construction, whereas appropriate fees and taxes would leave this to be largely determined by the market.[12]

Although the results of this study suggest that urban compaction and densification should be favoured regardless of which approach is used, authors, such as Clark (2013), note that facile

[10] The median house price to median annual income ratio of a given area.

[11] These external costs are not insignificant. Jakob et al. (2006) estimate that if Auckland "motor vehicle users were to pay the full amount of the costs they impose on the society and the environment, the 2001 petrol and diesel prices would both need to be increased by $0.68 per l" (Jakob et al., 2006:63).

[12] In the New Zealand case, many of these fees and taxes would require government intervention.

stipulations can overlook the disparate trade-offs of such policy. There are valid reasons for allowing the suburban preference averred by many people (Viguié & Hallegatte, 2012). Many people take pleasure in the privileges of cultivating their own garden and having a home which affords a high degree of privacy. It also removes one from the high density living of inner city areas where noise, congestion, and pollution can be intensified. While acknowledging that an urban compaction strategy would reduce the number of households able to attain the 'quarter acre dream', sprawl should nevertheless be limited when considered from CHT affordability, energy, and environmental perspectives.

The general research approach and findings of this study are transferable to similar contexts beyond Auckland, and accordingly have implications for planning more broadly. The linkages between transport costs and overall housing affordability need to be considered by the planning community so that these can be taken into account while formulating spatial plans and land use policy. Transport and accessibility are central to affordability. The results of this study suggest that development should be focused on accessible neighbourhoods in order to fully exploit their transportation advantages. Such land-use strategy needs to be supplemented with investment in public transport and cycle ways to allow residents to readily substitute private vehicles for other means of travel. Short-sighted development decisions which ignore this may have severe and irreversible economic consequences. Current development patterns contribute to an energy intensive urban form which will struggle to adapt to future price shocks, either caused by supply restrictions, conflicts, or carbon pricing (Næss, 2006:242). It is therefore imperative that policy makers come up with more creative and sustainable solutions to housing problems than simply releasing swathes of land on the urban fringe. Increasing the supply of housing, *ceteris paribus*, will lower the price of housing. This is a fundamental tenet of economics and is difficult to disagree with. However, the manner in which the housing supply is improved is important. In particular, the location and density of residential development will have strong implications for associated transportation costs, CHT affordability, and long term ecological sustainability.

Conclusions

This paper argues that current conceptions and measures of housing affordability are flawed in their omission of transportation expenditure. Comparison of the developed CHT affordability indices shows that when commuting expenditure is appropriately considered, outlying areas become relatively less affordable, while those areas close to employment centres become relatively more affordable. The systematic exclusion of transport costs from housing affordability studies therefore profoundly influences representations of affordability and thus conclusions on outlying development and urban sprawl. This research empirically demonstrates that when CHT indicators are used at the neighbourhood scale, they more accurately convey the locational value of centrally located housing, and thus if used at the metropolitan scale, they better show the affordability of compact cities. Accordingly, this paper fundamentally asserts that there needs to be a shift from narrowly construed definitions of affordability to more comprehensive indicators and indices incorporating transportation costs. Taken together, the findings suggest that housing affordability is inextricably linked to location and accessibility. Improving housing affordability in Auckland and other major cities requires more cross-sectoral and multi-dimensional solutions than permitting unbridled urban expansion. Policy-makers need to take into account the relationship between housing and transport costs, and strike a balance between an adequate supply of land for development and densification (to minimise distances to employment hubs and transport nodes). Greater densities in neighbourhoods proximate to employment centres and transport nodes would help spur further improvements in public transport, while an increased housing supply in centrally located areas would help to lower house prices in these neighbourhoods.

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References

Anas, A., Arnott, R., & Small, K. A. (1998). Urban spatial structure. *Journal of Economic Literature, 36*, 1426–1464.
Anderson, W. P., Kanaroglou, P. S., & Miller, E. J. (1996). Urban form, energy and the environment: A review of issues, evidence and policy. *Urban Studies, 33*, 7–35.
Auckland Council (2012). *The Auckland plan*. Auckland: Auckland Council.
Auckland Transport (2013). *Parking in Auckland*. <http://www.aucklandtransport.govt.nz> Accessed 22.10.13.
Bajic, V. (1983). The effect of a new subway line on housing prices in metropolitan Toronto. *Urban Studies, 20*, 147–158.
Bogdon, A. S., & Can, A. (1997). Indicators of local housing affordability: Comparative and spatial approaches. *Real Estate Economics, 25*, 43–80.
Brueckner, J. K. (2000). Urban sprawl: Diagnosis and remedies. *International Regional Science Review, 23*, 160–171.
Carruthers, J. I., & Ulfarsson, G. F. (2003). Urban sprawl and the cost of public services. *Environment and Planning B: Planning and Design, 30*, 503–522.
Center for Neighborhood Technology (2011). *Housing + transportation affordability in Washington, DC*. Chicago: Center for Neighborhood Technology.
Center for Transit-Oriented Development, & Center for Neighborhood Technology (2006). *The affordability index: A new tool for measuring the true affordability of a housing choice*. Washington, DC.
Clark, T. A. (2013). Metropolitan density, energy efficiency and carbon emissions: Multi-attribute tradeoffs and their policy implications. *Energy Policy, 53*, 413–428.
Currie, G., & Senbergs, Z. (2007). *Exploring forced car ownership in metropolitan Melbourne*. Australasian Transport Research Forum 2007.
Demographia International (2011). *7th Annual demographia international housing affordability survey*.
Dodson, J., & Sipe, N. (2008). Shocking the suburbs: Urban location, homeownership and oil vulnerability in the Australian city. *Housing Studies, 23*, 377–401.
Downs, A. (2005). Smart growth: Why we discuss it more than we do it. *Journal of the American Planning Association, 71*, 367–378.
Gallin, J. (2008). The long-run relationship between house prices and rents. *Real Estate Economics, 36*, 635–658.
Gan, Q., & Hill, R. J. (2009). Measuring housing affordability: Looking beyond the median. *Journal of Housing Economics, 18*, 115–125.
Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics, 57*, 148–169.
Glaeser, E. (2008). *Cities, agglomeration, and spatial equilibrium*. Oxford: Oxford University Press.
Glaeser, E., & Gyourko, J. (2003). The impact of building restrictions on housing affordability. *Economic Policy Review, 9*, 21–39.
Gordon, P., Richardson, H. W., & Jun, M. J. (1991). The commuting paradox evidence from the top twenty. *Journal of the American Planning Association, 57*, 416–420.
Horner, M. W. (2002). Extensions to the concept of excess commuting. *Environment and Planning A, 34*, 543–566.
Horner, M. W. (2004). Spatial dimensions of urban commuting: A review of major issues and their implications for future geographic research. *The Professional Geographer, 56*, 160–173.
Hulchanski, J. D. (1995). The concept of housing affordability: Six contemporary uses of the housing expenditure-to-income ratio. *Housing Studies, 10*, 471–491.
Ian Wallis Associates (2011). *Auckland passenger transport performance study*. Auckland: Auckland Regional Council.
Jakob, A., Craig, J. L., & Fisher, G. (2006). Transport cost analysis: A case study of the total costs of private and public transport in Auckland. *Environmental Science and Policy, 9*, 55–66.
Jewkes, M., Delgadillo, L. M., & Lucy, M. (2010). Weaknesses of housing affordability indices used by practitioners. *Journal of Financial Counseling and Planning, 21*, 43–52.

Kellett, J., Morrissey, J., & Karuppannan, S. (2012). The impact of location on housing affordability. In *6th Australasian housing researchers' conference*. Adelaide: The University of Adelaide.

Land Transport New Zealand (2007). *New Zealand motor vehicle registration statistics 2006*. Palmerston North: Land Transport New Zealand.

Lipman, B. (2006). *A heavy load: The combined housing and transportation burdens of working families*. Washington, DC: Center for Housing Policy.

Low, N., Gleeson, B., Green, R., & Radović, D. (2005). *The green city: Sustainable homes, sustainable suburbs*. Sydney: University of New South Wales.

Meese, R., & Wallace, N. (1994). Testing the present value relation for housing prices: Should I leave my house in San Francisco? *Journal of Urban Economics, 35*, 245–266.

Ministry of Transport (2009). In Ministry of Transport (Ed.), *Vehicle insurance in New Zealand*. Wellington.

Ministry of Transport (2011). *The New Zealand vehicle fleet: Annual fleet statistics 2010*. Wellington, New Zealand.

Ministry of Transport (2012a). In M. O. Transport (Ed.), *New Zealand household travel survey 2008–2011: Driver travel*.

Ministry of Transport (2012b). *Transport volume: Fleet information*.

Næss, P. (2006). *Urban structure matters: Residential location, car dependence and travel behaviour*. New York: Routledge.

Nechyba, T. J., & Walsh, R. P. (2004). Urban sprawl. *Journal of Economic Perspectives, 18*, 177–200.

Nepal, B., Tanton, R., & Harding, A. (2010). Measuring housing stress: How much do definitions matter? *Urban Policy and Research, 28*, 211–224.

Newman, P. W. G., & Kenworthy, J. R. (1989). Gasoline consumption and cities. *Journal of the American Planning Association, 55*, 24–37.

Perreau, K. (2007). Wanting to get up and go: Challenges and opportunities for transport energy policy in New Zealand. In *International association for energy economics conference*. Wellington, New Zealand.

Quigley, J. M., & Raphael, S. (2005). Regulation and the high cost of housing in California. *The American Economic Review, 95*, 323–328.

Redmond, L., & Mokhtarian, P. (2001). The positive utility of the commute: Modeling ideal commute time and relative desired commute amount. *Transportation, 28*, 179–205.

Robinson, M., Scobie, G. M., & Hallinan, B. (2006). In N. Z. Treasury (Ed.), *Affordability of housing: Concepts, measurement and evidence*. Wellington: New Zealand Treasury.

So, H. M., Tse, R. Y. C., & Ganesan, S. (1997). Estimating the influence of transport on house prices: Evidence from Hong Kong. *Journal of Property Valuation and Investment, 15*, 40–47.

Statistics New Zealand (2011). *Subnational population estimates: At 30 June 2011*. Wellington: Statistics New Zealand.

Stone, M. E. (2006). What is housing affordability? The case for the residual income approach. *Housing Policy Debate, 17*, 151–184.

Suhaida, M., Tawil, N., Hamzah, N., Che-Ani, A., Basri, H., & Yuzainee, M. (2011). Housing affordability: A conceptual overview for house price index. *Procedia Engineering, 20*, 346–353.

The Commerce Committee (2008). *Inquiry into housing affordability in New Zealand*. Wellington: Report Presented to the House of Representatives.

The New Zealand Productivity Commission (2012). *Housing affordability inquiry*. Wellington: The New Zealand Productivity Commission.

Viggers, H., & Howden-Chapman, P. (2011). Urban form, public transport and mortgagee sales. In K. Witten, W. Abrahamse, & K. Stuart (Eds.), *Growth misconduct? Avoiding sprawl and improving urban intensification in New Zealand* (pp. 159–177). Wellington: Steele Roberts Aotearoa.

Viguié, V., & Hallegatte, S. (2012). Trade-offs and synergies in urban climate policies. *Nature Climate Change, 2*, 334–337.

Wang, X., Grengs, J., & Kostyniuk, L. (2013). Visualizing travel patterns with a GPS dataset: How commuting routes influence non-work travel behavior. *Journal of Urban Technology, 20*, 105–125.