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**Economic and Cultural Residential Sorting
of Auckland's Population 1991-2013:
An Entropy Approach**

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Abstract

Auckland, the largest city of New Zealand, is one of the most diverse cities in the world, with more than 40 percent of its population born abroad, more than 200 ethnicities represented and 160 languages spoken. In this paper, we measure residential sorting of individuals in Auckland by their cultural (ethnicity) and economic (age, income, education, occupation) characteristics for the years 1991-2013. We use entropy-based measures of residential sorting as our preferred measure, and find that individuals exhibit the greatest residential sorting by ethnicity, compared with sorting by economic characteristics. We also observe that ethnic sorting declined between 1991 and 2013, for broad ethnic groups, but that sorting within the broad ethnic groups has increased. At the broad occupational groups level, sorting has also declined between 1991 and 2013, but the contribution to sorting of within-broad-group occupations has increased. We also observe that the semi-rural fringes of the city are less diverse than the central urban area.

Keywords

residential sorting
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JEL Codes

Z13, J15, R21, R23

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Disclaimer

The results in this paper are not official statistics. They have been created for research purposes from Census unit record data in the Statistics New Zealand Datalab. The opinions, findings, recommendations, and conclusions expressed in this paper are those of the authors, not Statistics New Zealand. Access to the anonymised data used in this study was provided by Statistics New Zealand under the security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organisation and the results in this paper have been confidentialised to protect these groups from identification and to keep their data safe. Careful consideration has been given to the privacy, security and confidentiality issues associated with using unit record census data.

1. Introduction

A growing concern in many countries is whether residential segregation has important repercussions for individual well-being (Bennett 2011). Residential segregation, also referred to more broadly as spatial sorting is defined as the degree to which groups live away from each other (Denton and Massey 1988, Johnston *et al.* 2007). Throughout this paper, we use the term ‘residential sorting’ to encompass a range of spatial population distribution phenomena that include segregation, isolation, and concentration. Our preferred term is not only broader than the conventional term of spatial segregation, but also carries none of the negative connotations associated with the latter.

Residential sorting can occur in terms of age, income, language, religion, ethnicity, or many other factors like industry of work, or occupation. Schelling (1971) stated that all the factors resulting in residential segregation are interrelated. People locate according to their preferences and constraints, and individuals like to stay in close contact with people with whom they share similar characteristics. Networks are often driven by common ethnicity or language use, as such networks facilitate communication and trust. This leads people of the same ethnicity to cluster together. Moreover, house prices and rents are spatially highly correlated, leading to clearly defined low cost and high cost housing areas. Consequently, people may be found to live near people with a similar income, as their capacity to afford housing is similar. Moreover, industry and occupation are, besides age and education, also important predictors of income. People with similar jobs tend to have similar incomes, generating another source of similarity of residential preferences and choices (Schelling 1971). Although residential sorting is to be expected, it is important to know and understand its extent and pattern, especially because neighbourhood composition influences social and economic outcomes (Maré *et al.* 2012).

Differences in residential location patterns between population groups can lead to sorting-driven inequalities between residential areas. In the United States, the emphasis in the extant literature has been on racial residential segregation, which brings with it all of the disadvantages and advantages associated with race (Bennett 2011). If races are concentrated in particular neighbourhoods, this may exacerbate existing inequality in terms of earnings, wealth and poverty (Grodsky and Pager 2001, Margo 1997). Racially concentrated poor neighbourhoods may be more susceptible to social problems like lower quality social institutions, low property values, lower education, and less employment opportunities (Halpern-Felsher *et al.* 1997, Massey and Denton 1993).

In New Zealand, inequality exists in all five spheres of government policy concerned with welfare and wellbeing, being income, employment, housing, health and education. Spatial segregation or sorting can create a vicious cycle of disadvantages – a lack of secure and well-paid employment leads to low income, which in turn leads to low quality housing. Low quality housing makes it hard to maintain good health. Low income can create barriers to access to good education, which leads to low future employment opportunities for children, which

reinforces income inequality across generations (Dalziel 2013). In New Zealand, inequality manifests itself particularly in the housing market, with bad quality housing impacting on wealth accumulation opportunities and health outcomes (Howden-Chapman *et al.* 1996). In New Zealand, Māori and Pacific peoples live disproportionately in low-income households due to a complex set of circumstances, economic transformations and a succession of past policies, since colonial times for the former, and since the 1970s for the latter. Inequality in housing aggravates already existing serious inequalities in terms of income, wealth, health and quality of living (Rashbrooke 2013). For policy purposes, studies are needed that provide insight into how to bridge the gap between the ‘haves’ and have-nots’ in New Zealand (Rashbrooke 2013).

Ethnicity is an integral element of an individual’s culture (Betancourt and López 1993). In the New Zealand Census, the ethnicity of an individual is defined as any ethnic group the individual identifies with (Statistics New Zealand, 2013). New Zealand residents can affiliate themselves with multiple ethnicities in the Census and some other collections of official data (Kukutai 2008). The extent to which individuals have been identifying with multiple ethnic groups has been increasing. Moreover, resulting from large increases in migration flows since the 1990s and the abolition of a governmental preference for traditional source countries (the United Kingdom and some other European countries) there has been a rise in the number of ethnic identities in New Zealand. The population of New Zealand has also a high rate of residential mobility, as well as increasing inter-ethnic marriage and cohabitation (Statistics New Zealand, 2007). As a consequence of migration and growing ethnic diversity, the ethnic composition of the New Zealand population is changing, which has economic and societal costs and benefits. To maximise the benefits and adapt to changes associated with such an increasingly diverse population, more research is needed to better understand growing ethnic diversity and its impacts (SpoonleY 2014, CaDDANZ 2016).

Our paper explores and adds to the knowledge of residential sorting in Auckland (New Zealand’s most populous region) in a number of ways. First, the ethnic groups we use are much more disaggregated than those used in previous research in New Zealand (and comparable work elsewhere). This is important because of the diversity of ethnicities that make up the Asian and Pacific ‘broad’ ethnic groups in particular. The Asian and Pacific broad ethnic groups are rather heterogeneous and to assume that these broad groups have homogeneous preferences and characteristics distorts the interpretation of residential sorting.

Secondly, unlike much of the previous literature we also consider economic sorting simultaneously with cultural (ethnic) sorting, and include age, income, occupation and qualification as economic variables. Essentially, our paper asks whether cultural sorting is stronger than economic sorting and, additionally, which economic variable exhibits the strongest sorting. We also investigate how the residential sorting patterns in Auckland have changed since the 1991 Census.

Thirdly, while we calculate a range of conventional measures of residential sorting, we also introduce and apply entropy measures of residential sorting. The use of entropy measures has been rather rare in previous studies. There has been no work previously on residential sorting in New Zealand using entropy measures. However, one of the main advantages of entropy measures is their property that an aggregate index can be decomposed into the weighted sum of within-group and between-group measures (Theil 1972).

Fourthly, following Florida and Mellander (2018), we also create a new variable that combines age, income, occupation and qualification to act as an overall indicator variable for economic sorting. No previous studies on residential sorting in New Zealand includes such an economic variable. Finally, we also examine the relationship between cultural and economic residential sorting in Auckland.

The remainder of the paper proceeds as follows. In Section 2, we discuss relevant studies on residential sorting, with a particular focus on New Zealand research. Section 3 describes the data and Section 4 details the methods. Section 5 presents and discusses the results, and Section 6 concludes.

2. Background

Our analysis focuses on the Auckland region of New Zealand. Auckland is the most ethnically diverse region in New Zealand. The major ethnic groups are those of European (59.3 percent), Asian (23.1 percent), Pacific Islander (14.6 percent) and Māori (10.7 percent) ethnicity (Statistics New Zealand, 2013).¹ Auckland is also the most populated of the 16 regions of New Zealand, accounting for one third of the New Zealand population.

Of all countries in which there has been research on residential sorting by ethnicity, education, income and/or occupation, the largest number of studies have been conducted for the U.S. Duncan and Duncan (1955) found that the most segregated occupational groups were the ones with the highest and the lowest rankings in terms of socioeconomic status. Farley (1977) measured the degree of socioeconomic and residential segregation in central cities and densely populated suburban areas and found that minority individuals in the U.S. tend to cluster with other minority group members. Massey (1979) used 1970 Census data and found that segregation of Spanish-Americans and Whites declined with increases in socio-economic status. Simkus (1978) found that gross occupational residential segregation in urbanized areas increased slightly during the 1950s. Taking race into consideration, levels of racial residential segregation between whites and non-whites in the lowest occupation groups in 1960 were low. Denton and Massey (1988) used data from the 1980 U.S. Census to look into patterns of residential segregation by socioeconomic status. They showed that Blacks were strongly

¹ The most recent population census was held on March 6, 2018. The results of that census are not yet available, and are expected to be released from mid-2019. Percentages do not sum to 100 percent, as people can report more than one ethnicity

segregated from ‘Anglos’ irrespective of their occupation, educational qualification, or income. Differences in socioeconomic status resulted in a high degree of residential segregation in the U.S., but with increases in income, education, and occupational status, segregation levels tended to decline (Massey 1979).

Overall, studies in the U.S. (Domina 2006, Duncan and Duncan 1955, Farley 1977, Fischer 2003) show that there is substantial residential segregation based on socioeconomic status. These studies have taken ethnicity, education, income and occupation as indicators of socio-economic status, and have investigated ethnic residential segregation combined with residential segregation by each of the economic variables separately. In contrast, Florida and Mellander (2018) considered occupational, income and educational segregation as well as a combined measure of overall economic segregation.²

For New Zealand, most studies have focused on ethnic residential sorting by means of data from the five-yearly census. In contrast with our paper, which covers the 1991-2013 period, there have been few previous studies concerned with the long-term trends in residential sorting. Moreover, previous studies of residential segregation in New Zealand have mainly looked at a limited number of ethnic groups, or groups by country of origin (Kerr *et al.* 2001, Maré and Timmins 2003). Johnston *et al.* (2002) showed the presence of prominent residential concentration patterns among Polynesians (that is, Pacific Islanders plus Māori). Johnston *et al.* (2005) analysed variations in the degree of residential segregation of the Māori population across the urban areas of New Zealand from 1991 to 2001. Johnston *et al.* (2008) showed that in 2006, the Pacific Islander group was the most residentially segregated in Auckland. Johnston *et al.* (2011) used New Zealand Census data from 1991 to 2006 and found that Pacific Islanders were, in comparison to Māori, more likely to cluster in areas where their co-ethnics dominated.

Few studies in New Zealand have looked at residential sorting by characteristics other than ethnicity. Like Johnston *et al.* (2008), Maré *et al.* (2011) found that the greatest residential sorting in Auckland is by Pacific Islanders, but also by people with university degrees. In another paper, Maré and Coleman (2011) found that ‘own-group’ attraction was a much stronger determinant of residential sorting than urban amenities. Maré *et al.* (2012) found that the Pacific Islanders, people with higher university degrees and with higher levels of education more generally, higher income, and the elderly, exhibited the greatest levels of residential sorting. Finally, Maré *et al.* (2016) studied the residential assimilation of immigrants after their arrival in Auckland, using census data from 1996-2006. The groups included in the study were immigrants from the United Kingdom, China, India, South Africa, and the Republic of Korea. They found distinct patterns of residential assimilation for most of the immigrant groups, and that the longer that immigrants from each group had spent in the host country, the more their residential concentration declined.

² An earlier study, Sharkey (2013), had already compared economic and racial segregation by taking income as the economic variable.

3. Data

We obtained population data from the 1991, 1996, 2001, 2006, and 2013 New Zealand Census of Population and Dwellings for the Auckland region of New Zealand. The New Zealand Census of Population and Dwellings is usually conducted every five years and collects a range of socio-demographic information on each member of the New Zealand population present and normally resident in New Zealand on census night. The census data on each individual include characteristics such as location of usual residence, age, sex, ethnicity, income level, occupation, education, and marital status. These microdata can be aggregated to population statistics at various spatial levels, such as meshblocks and area units. For the purpose of the present paper, each measure of residential sorting (described below) was calculated based on data aggregated to the area unit level.³ The Auckland region is made up of 413 land-based area units, of which 409 had a non-zero usually resident population throughout the period from 1991-2013. Area units with no usually resident population in any of the censuses were dropped from the analysis. In accordance with the strict confidentiality rules laid down by Statistics New Zealand, the summary statistics, counts and calculations are based on data that have been suppressed for raw counts less than six and otherwise randomly rounded to base three.

An ethnic group consists of people who generally have any of the following: common proper name of the group, common elements of culture, similar interests, feelings and actions, or share a common ancestral as well as geographic origin (Statistics New Zealand, 2013). A person's ethnicity is the ethnic group or groups that person identifies with or has a sense of belonging to. It is a measure of cultural affiliation (in contrast to race, ancestry, nationality, or citizenship). Ethnicity is self-perceived, and a person can belong to more than one ethnic group. New Zealand residents can change their ethnic affiliation for statistical purposes at any time. According to the New Zealand Standard Classification of Ethnicity, ethnicity is classified in a hierarchy of four levels.

An individual reporting more than one ethnicity is included in each ethnic group that they report (this is referred to as 'total count' ethnicity) (Statistics New Zealand, 2015). The main (Level 1) ethnic groups defined in the 2006 and 2013 Census by Statistics New Zealand were New Zealand European, Pacific peoples, Māori, Asian, and others. Previous research on ethnic residential sorting in New Zealand, such as Maré *et al.* (2012), has mainly used Level 1 ethnic groups (broad ethnic groups). As it is possible that there is heterogeneity in the characteristics and choices within each of these broad ethnic groups, we use data on Level 2 ethnic groups. The Level 1 and Level 2 classification of ethnicities in New Zealand is shown in Table 1. In our analysis, we proportionally distributed the population counts of the 'not further defined' category for each Level 2 ethnic group into the rest of the Level 2 groups within the same Level 1 ethnic group.

³ Area units are non-administrative areas that are aggregations of meshblocks. In urban areas, an area unit is similar in size to a suburb (Statistics New Zealand, 2013). In this paper, we use 2013 area unit boundaries.

Table 1: Ethnic Group Classification in New Zealand

Ethnic Group Code (Level 1)	Ethnic Group Code Description (Level 1)	Ethnic Group Code (Level 2)	Ethnic Group Code Description (Level 2)		
01	European	10	European not further defined		
		11	NZ European		
		12	Other European		
02	Māori	21	NZ Māori		
03	Pacific Peoples	30	Pacific Island not further defined		
		31	Samoan		
		32	Cook Island Māori		
		33	Tongan		
		34	Niuean		
		35	Tokelauan		
		36	Fijian		
		37	Other Pacific Island		
		04	Asian	40	Asian not further defined
				41	Southeast Asian
42	Chinese				
43	Indian				
44	Other Asian				
05	MELAA	51	Middle eastern		
		52	Latin American/Hispanic		
		53	African		
06	Other	61	Other ethnicity		

Source: Statistics New Zealand (2013).

Two issues affect the comparability of ethnicity data in New Zealand over time. First, the format and wording of the Census ethnicity question changed twice between 1991 and 2001. In 1991 and 2001, the question was almost the same, but both differed substantively from the question in 1996.⁴ Thus, comparability across Censuses is likely to be affected. Some significant changes have been identified, including increased multiple responses in 1996 and a consequent reduction in single responses, and a tendency for respondents to answer the 1996 question on the basis of ancestry (or descent) rather than ethnicity (or cultural affiliation). These inconsistencies apply particularly to the ‘European’ ethnic groups (including ‘New Zealand European’) and the ‘Māori’ ethnic group. In the 1996 data, the count for ‘Other Europeans’ was much higher than in the 1991 or 2001 data. The count for the ‘New Zealand European’

⁴ Specifically, the ethnicity question in the 1996 Census had a different format from that used in 1991 and 2001. In 1996, there was an answer box for ‘Other European’ with additional drop-down answer boxes for ‘English’, ‘Dutch’, ‘Australian’, ‘Scottish’, ‘Irish’, and ‘other’. These were not used in 1991 or 2001. Furthermore, the first two answer boxes for the question were in a different order in 1996 from 1991 and 2001. ‘NZ Māori’ was listed first and ‘NZ European or Pākehā’ was listed second in 1996. The 1991 and 2001 questions also only used the words ‘New Zealand European’ rather than ‘NZ European or Pākehā’ (Pākehā is the Māori word referring to a person of European descent). Also, the 2001 question used the word ‘Māori’ rather than ‘NZ Māori’ (Statistics New Zealand, 2017).

category decreased in 1996, which can be attributed to the fact that in 1996, people saw the additional ‘other European’ category as being more suitable to describe their ethnicity than the ‘New Zealand European’ category (Statistics New Zealand, 2017). For example, van der Pas and Poot (2011) noticed that in the 1996 Census, almost 48,000 identified themselves with the Dutch ethnicity, compared with just 27,866 in 2001 and 29,000 in 2006.

Secondly, the treatment of responses of ‘New Zealander’ to the Census ethnicity question has changed over time. In 2001, ‘New Zealander’ was counted in the New Zealand European category, whereas in 2006, New Zealander was instead included as a new category. The increase in counts for the New Zealand European category from 2006 to 2013 is partly attributable to fewer people identifying themselves as ‘New Zealander’ in 2013.

We use four different variables in our analysis of economic residential sorting (educational attainment, occupation, age, and income). For educational attainment, we use the variable ‘Highest Qualification’⁵ for all years from 1996 onwards. The classifications under this category for 1996 and 2001 are different from that of 2006 and 2013⁶. Due to unavailability of data on the same variable for 1991, we used ‘Highest Secondary School Qualification’⁷ for 1991. These issues affect our results over time somewhat, but is not expected to have impacted on our conclusions.

In the Census, ‘occupation’ is defined as a set of jobs that require an individual aged 15 years and over (including the self-employed) to perform identical sets of tasks (Statistics New Zealand, 2013). We use the New Zealand Standard Classification of Occupations (NZSCO99),⁸ which is a five-level hierarchical classification with nine broad major groups (Statistics New Zealand, 2015). We use Level 2 occupation levels. From 1991 to 2013, reporting and classification of occupations in the New Zealand Census of Population and Dwellings has changed (Hancock, 2015). Since 1996, the group ‘Armed forces’ was included under ‘Personal and Protective Service Workers’. Therefore, we combined these groups for the calculations in 1991 as well.

⁵ Highest qualification is derived for people aged 15 years and over, and combines highest secondary school qualification and post-school qualification to obtain a single highest qualification by category of attainment (Statistics New Zealand, 2015).

⁶ For highest qualification, 2013 and 2006 Census data has limited comparability with 2001 Census data due to the progressive introduction of the National Certificate of Educational Achievement (NCEA) from 2002. NCEA is now the main qualification for secondary school students (Statistics New Zealand, 2013).

⁷ This is the highest secondary school qualification gained by category of attainment, and is collected for people aged 15 years and over (Statistics New Zealand, 2015).

⁸ The Australian and New Zealand Standard Classification of Occupations (ANZSCO) was only introduced in 2006.

Finally, for the remaining economic variables we used five-year age groups, as well as data on total personal income.⁹ The number of income intervals and the bounds have changed over the years due to inflation and real income growth. For simplicity we have not adjusted the data to a common set of intervals. This might affect the year-wise comparability of the sorting values. It is, however, unlikely to impact the conclusions drawn from the analysis.

Table 2 shows the number of groups, according to the selected variables, used in our analysis. We aimed to keep the number of groups similar for all variables, for better comparability in sorting, as residential sorting measures are sensitive to the number of groups (Mondal *et al.* 2019 forthcoming).

Table 2: Number of Groups
By Variable

Variable	1991	1996	2001	2006	2013
Ethnicity	18	18	18	18	18
Occupation	23	23	23	23	23
Qualification	7	11	12	12	12
Age	18	18	18	18	18
Income	13	13	13	14	16

4. Methodology

There are many different measures that can be used as indicators of residential sorting (see e.g. Nijkamp and Poot 2015). Table 3 displays our selected summary measures of residential sorting. Following Johnston *et al.* (2011), our first measure is the *Index of Segregation*, S_g , defined for any population group g , which measures the proportion of people in group g that would have to relocate in order to make their distribution identical to that of all other groups combined. The *Index of Segregation* ranges in value from zero to one, where a value of zero means that the group is distributed proportionately to the total population, and a value of one indicates that all of the group members live separately from other residents (Maré *et al.* 2016, 2012).

Following Cutler *et al.* (1999) and Maré *et al.* (2012), we also calculate the *Index of Isolation*, $I_{sol,g}$, for any group g , which measures the degree to which individuals of group g co-locate with other members of their own group. The *Index of Isolation* takes values between zero and one. Higher values of the index indicate greater isolation of group g from the rest of the population (Maré *et al.* 2016).

⁹ In the Census, total personal income is collected for people aged 15 years and over, who usually live in New Zealand and are present on census night (including those who state not receiving any income). Total personal income is the before-tax income for the respondent, and is collected as an income range rather than an actual dollar income (Statistics New Zealand, 2015).

Thirdly, following Maré *et al.* (2012) we calculate the *Ellison and Glaeser* concentration index, EG_g , a measure of the extent to which group g is concentrated in particular areas. The values of the measure can be positive or negative. A value close to zero indicates that there is a lack of residential sorting. A more positive value for a group means that the group is more than proportionally located in a few areas (Maré *et al.* 2012). The scale of this index is affected by the number of area units used in the calculation, so we multiply the value by 1000 for reporting.

Table 3: Summary Measures of Residential Sorting

Index of Segregation	$S_g = \frac{1}{2} \sum_{a=1}^A \left \frac{P_{ga}}{P_g} - \frac{(P_a - P_{ga})}{(P_{..} - P_g)} \right $
Index of Isolation	$Hsol_g = \frac{\left(\left[\sum_{a=1}^A \pi_{ga} \frac{P_{ga}}{P_a} \right] - \frac{P_g}{P_{..}} \right)}{\left(1 - \frac{P_g}{P_{..}} \right)}$
Ellison and Glaeser Index of Concentration	$EG_g = \frac{\frac{\left\{ \sum_{a=1}^A \left(\pi_{ga} - \frac{P_a}{P_{..}} \right)^2 \right\}}{\left(1 - \sum_{a=1}^A \left(\frac{P_a}{P_{..}} \right)^2 \right)} - \frac{1}{P_g}}{\left(1 - \frac{1}{P_g} \right)}$
Entropy Index of Segregation	$EIS_g = \sum_{a=1}^A \frac{P_a}{P_{..}} \left(1 - \frac{E_a}{\bar{E}} \right),$
where	
	$E_a = -\frac{P_{ga}}{P_a} \ln \left(\frac{P_{ga}}{P_a} \right) - \left(1 - \frac{P_{ga}}{P_a} \right) \ln \left(1 - \frac{P_{ga}}{P_a} \right)$
	$\bar{E} = -\frac{P_g}{P_{..}} \ln \left(\frac{P_g}{P_{..}} \right) - \left(1 - \frac{P_g}{P_{..}} \right) \ln \left(1 - \frac{P_g}{P_{..}} \right)$
Theil's Multi-Group Index of Segregation ¹⁰	$H = 1 - \frac{-\sum_{a=1}^A \sum_{g=1}^G \frac{P_a}{P_{..}} \left(\frac{P_{ga}}{P_a} \ln \left(\frac{P_{ga}}{P_a} \right) \right)}{\sum_{g=1}^G \frac{P_g}{P_{..}} \ln \left(\frac{P_g}{P_{..}} \right)}$

Notes:

P_{ga} refer to the population of group g ($=1, 2, \dots, G$) in area a ($=1, 2, \dots, A$). A subscript dot refers to the sum over that specific subscript, $\pi_{ga} = \frac{P_{ga}}{P_g}$, $\sum_{a=1}^A \pi_{ga} = 1$ for all g . The calculation of E , H and H^* in the case in which there are areas in which group g is not represented requires that we define $0 \cdot \ln(1/0) = \lim_{q \rightarrow 0} [q \ln(1/q)] = 0$.

¹⁰ H measures the extent to which the weighted average of group diversity (in entropy terms) of areas (weighted by area populations) differs from the group diversity of the city. An alternative calculation of an overall city index of residential sorting is to take the group-weighted average of EIS_g . In our paper, we calculate $H^* = \sum_{g=1}^G \frac{P_g}{P_{..}} EIS_g$. This calculation gives approximately the same value as H .

We also calculate the *Entropy Index of Segregation* (EIS_g) for each group g , which was originally proposed by Theil (1972). The entropy of an outcome with probability p is equal to $p \ln(p)$. Hence, in this case entropy measures the extent to which the share of group g in an area differs from the share of group g in the entire population. EIS_g then weights these relative differences by area populations. This index varies between zero (when the group is distributed proportionally to the total population in all area units) to one (when each area contains only one group) (Reardon and Firebaugh 2002).

When the composition of a city's population in terms of groups according to a classification (ethnicity, occupation, etc.) changes, it is useful to have an overall measure of residential sorting for the city that accounts for whether segregated groups are becoming more or less important. This overall measure is *Theil's Multi-group Segregation Index H* (see also White, 1986). Effectively, this index measures the extent to which the weighted average of group diversity (in entropy terms) of areas (weighted by area populations) differs from the group diversity of the city. An alternative way of calculating an overall city index of residential sorting is to take the group-weighted average of EIS_g . This calculation gives approximately the same value as H .

We also calculate Diversity indexes (D)¹¹ for each classification in each census year, both at the Auckland-wide level and for individual Area Units. The diversity index D_a in area a is given by:

$$D_a = - \sum_{g=1}^G \frac{P_{ga}}{P \cdot a} \ln\left(\frac{P_{ga}}{P \cdot a}\right)$$

The maximum and minimum value of D are $\ln(G)$ and zero respectively, where G is the number of groups under consideration. The minimum of zero corresponds to the case of there being only one group represented in the area. The maximum is reached when all groups are represented and of equal size. For example, in our work, we have 18 ethnic groups in Auckland. Thus the maximum value of this diversity index for ethnicity will be $\ln(18) = 2.89$. We divide these indices D_a by $\ln(G)$ to create an evenness index (see Nijkamp and Poot 2015). We then create a Super-diversity index for Auckland by taking the simple average of the five evenness indexes for each year. We also calculate the entropy diversity measure of each area unit in Auckland for each of the five classifications and use choropleth maps to show the spatial distribution of this diversity measure across Auckland. Following Florida and Mellander (2018), we also averaged (with equal weights) the four economic (age, income, qualification and occupation) evenness measures across area units in each census to create an overall economic diversity measure, which can be compared with the cultural diversity measure based on ethnicity.

¹¹ To allow calculation of D even in the case of there being groups who have zero members at some point in time, we define $0 \cdot \ln(1/0) = \lim_{q \rightarrow 0} [q \ln(1/q)] = 0$.

Finally, following Reardon *et al.* (2000), we consider the impact of multi-level classification on *Theil's Multi-group Segregation Index H*. As noted above, this index measures the relative extent to which the diversity of city as a whole differs from the population-weighted average of the area units' diversity. H varies between zero and one. The index is zero when all areas have the same population composition. The index is one if there is no area in which more than one group is represented. Considering different levels of aggregation, we decompose the index values into between-group and within-group components and show how sensitive the sorting index is to the level of aggregation in the classifications. In our case of Auckland, we consider a classification with two levels (coarse – single digit – and more refined – double digit) for both ethnicity and occupation, as only these two measures have multiple levels of classification that allow for this decomposition.

Specifically, consider that $g = 1, 2, \dots, G$ indexes the most detailed classification and that $n = 1, 2, \dots, N$ is an aggregation of these groups into a smaller number of broader groups (i.e. $N \ll G$). Theil's Multi-group Sorting Index values can be decomposed into between-group and within-group components for ethnicity and occupation using the following formula:

$$H = \frac{E_N}{E} H_N + \sum_{n=1}^N \frac{P_n E_n}{PE} H_n$$

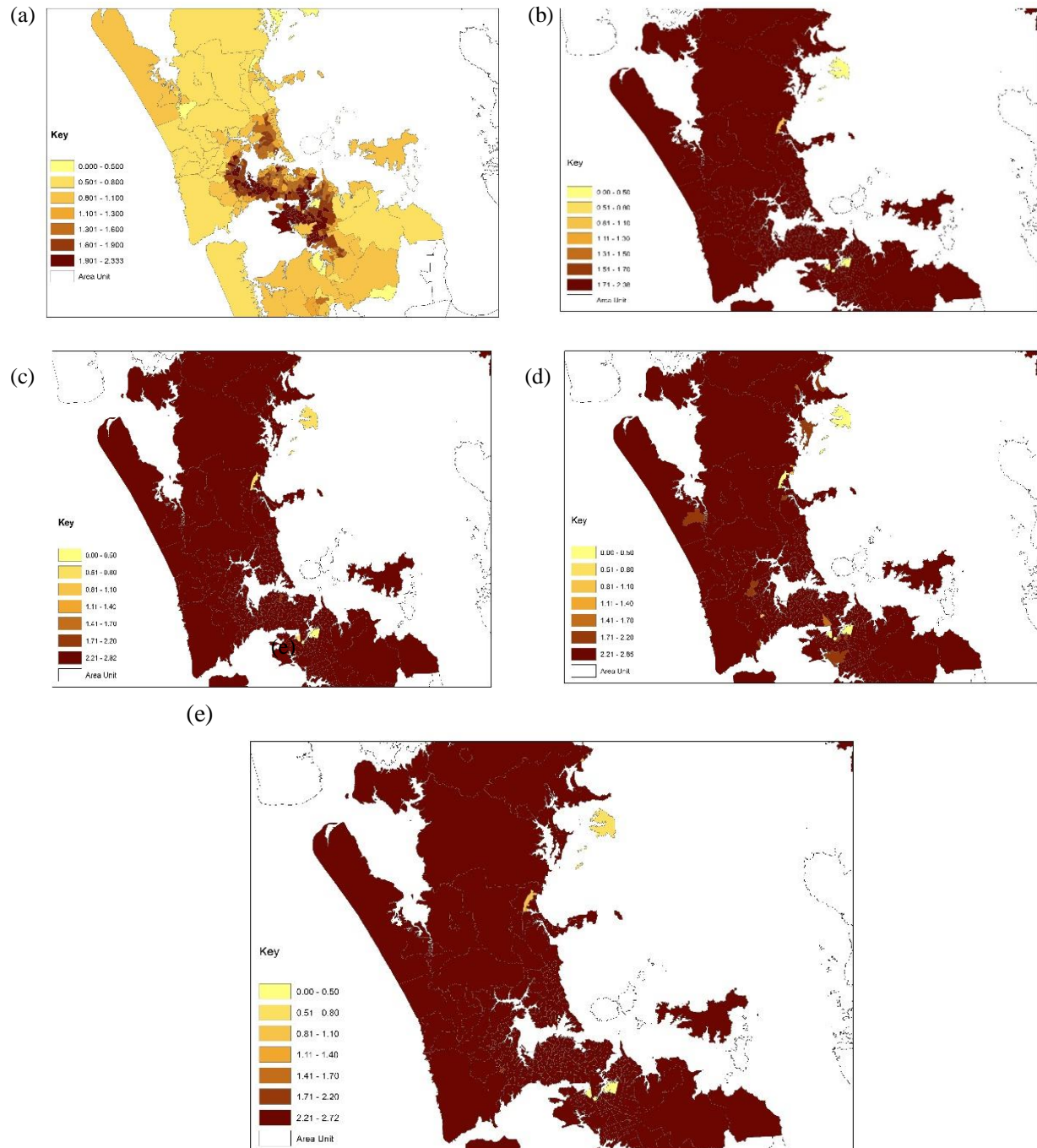
(see Reardon *et al.* 2000). Here, H is the Theil index calculated over all groups in the city (Level 2), H_N is the Theil index calculated among the Level 1 groups, and H_n is the Theil index calculated *within* each of the Level 1 groups. E_N is entropy among the supergroups (Level 1), E_n is the entropy *within* Level 1 group n , and E is the entropy of the population as a whole (that is, level 2). P and P_n are respectively the size of population as a whole and the population size of Level 1 group n .

5. Results

Auckland has become more economically and culturally diverse over the period 1991 to 2013. We show this by calculating the entropy diversity index D_a for each area unit in Auckland for all variables for all of the available census years. Figure 1 shows a choropleth map of the Entropy scores of area units in Auckland for each of the variables in 2013. Lower values represent lower levels of diversity and are signalled by lighter colours on the map. A very prominent pattern of spatial variation in diversity is observed in the figure for ethnicity, wherein the central urban area exhibits much greater diversity than the rural fringes. This makes sense, as central Auckland is highly ethnically diverse. Central Auckland has two large tertiary institutions along with many language schools and other training institutions, which attract students from overseas. Moreover, the two largest contributors to the Skilled Migrant visa category are India and China (Ministry of Business, Innovation and Employment, 2016). Thus, education and employment opportunities result in high ethnic diversity in central Auckland.

The choropleth maps¹² for all the other variables do not show any prominent pattern of spatial differences in diversity.

Figure 1: Diversity in Auckland by Cultural and Economic Variables, 2013



Note:

(a) Diversity by Ethnicity; (b) Diversity by Qualification; (c) Diversity by Age; (d) Diversity by Occupation; (e) Diversity by Income.

¹² For comparison of area unit diversity according to variables, we have kept the categorisation for all the five variables the same (number of groups for each variable), as our intention is to show which variable exhibits the greatest diversity spatially.

Figure 2 shows the relationship between 1991 and 2013 values of the evenness measure of diversity¹³ in each area unit of Auckland for all the variables, where each dot represents one area unit. In the figures, almost all observations for all the variables, except for occupation, lie above the 45-degree line. This means that for most area units in Auckland, diversity has increased between 1991 and 2013, apart for occupation. For occupation, area units appear roughly equally split between those that had increasing diversity and those that had decreasing diversity.

From the results of calculating the super-diversity index (Table 4), we find that super-diversity in Auckland has trended upward between 1991 and 2013. However, in the most recent inter-Censal period (2006-2013) there was a slight decline in super-diversity. This decline is attributable to declines in diversity in occupation (0.892 to 0.871) and ethnicity (from 0.647 to 0.584). In case of occupation, this decline can be attributed to the growing dominance of services and related occupations in New Zealand (Statistics New Zealand,2017.). In case of ethnicity, the same might be due to the huge decline in the ‘other’ ethnic group (06 (level 1), 61(level 2)) from 2006 to 2013¹⁴.

Table 4: Super-Diversity in Auckland 1991-2013

Year	Ethnicity	Income	Age	Occupation	Qualification	Super-diversity
1991	0.402	0.949	0.948	0.896	0.878	0.815
1996	0.465	0.922	0.951	0.893	0.848	0.816
2001	0.505	0.949	0.949	0.900	0.884	0.838
2006	0.647	0.969	0.952	0.892	0.894	0.871
2013	0.584	0.970	0.956	0.871	0.922	0.861

Notes

We calculate Auckland-wide diversity indexes (D) for each classification in each census years where $D = -\sum_{g=1}^G \frac{P_g}{P} \ln\left(\frac{P_g}{P}\right)$. We divide these values by $\ln(G)$, where G is the number of groups, to create an Evenness Index (see Nijkamp and Poot 2015). We take the simple average of the five Evenness Indexes for each year to create our super-diversity index.

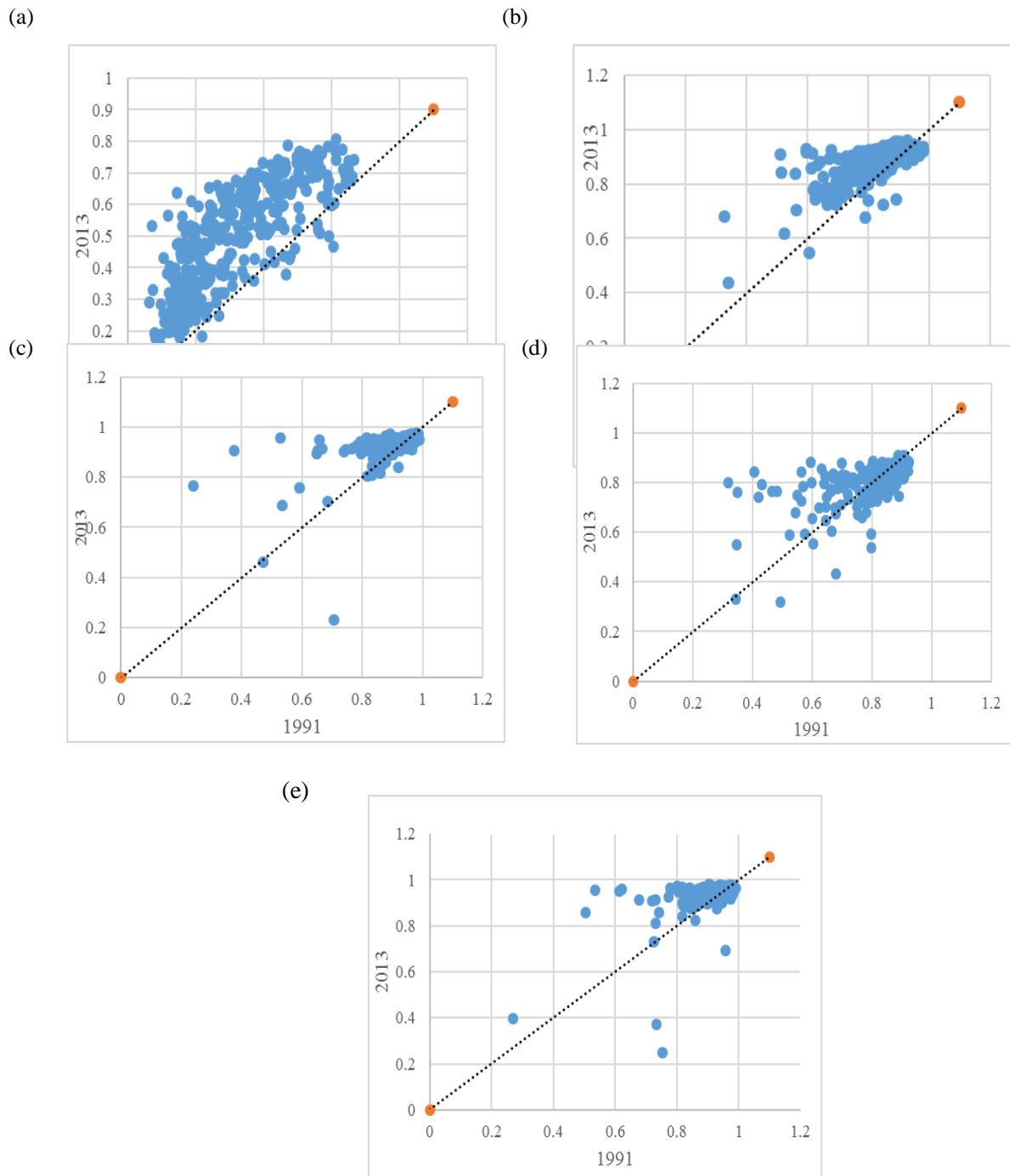
¹³ The evenness measure of diversity is the entropy diversity measure:

$$D_a = -\sum_{g=1}^G \frac{P_{ga}}{P \cdot a} \ln\left(\frac{P_{ga}}{P \cdot a}\right)$$

divided by $\ln(G)$, where G is the number of groups in the classification.

¹⁴ This number has declined because the number of people calling themselves New Zealander declined from 430,000 in 2006 to just under 66,000 in 2013 (Statistics New Zealand, 2013).

Figure 2: Cultural and Economic Diversity of Auckland Area Units
 A Comparison between 1991 and 2013



Notes

- (a) Ethnicity
- (b) Qualification
- (c) Age
- (d) Occupation
- (e) Income

Diversity is measured by means of the Evenness Index.

Sorting by Ethnicity

Table 5 shows the values of measures of residential sorting by ethnic group in Auckland in 2013. The corresponding values for the years 1991, 1996, 2001 and 2006 are shown in the Appendix.

Table 5: Measures of Residential Sorting of Ethnic Groups in Auckland, 2013

Ethnicity	Share of Total Responses (%)	ISeg	IIsol	EG	EIS
New Zealand European	56.8	0.337	0.145	0.365	0.128
Other European	5.78	0.15	0.007	0.369	0.026
New Zealand Maori	8.43	0.273	0.039	1.26	0.061
Samoan	5.39	0.517	0.109	5.11	0.199
Cook Island Maori	2.16	0.533	0.059	6.64	0.189
Tongan	2.35	0.548	0.065	7.17	0.202
Niuean	1.08	0.534	0.022	5.24	0.159
Tokelauan	0.065	0.868	0.006	22.6	0.261
Fijian	0.349	0.488	0.005	3.63	0.115
Other Pacific Island	0.193	0.704	0.008	10.7	0.197
Southeast Asian	1.73	0.346	0.015	2.45	0.081
Chinese	6.27	0.399	0.065	2.90	0.124
Indian	5.41	0.415	0.067	3.95	0.136
Other Asian	1.96	0.379	0.02	2.97	0.096
Middle Eastern	0.597	0.471	0.013	6.60	0.131
Latin American/Hispanic	0.091	0.774	0.004	13.4	0.198
African	0.147	0.722	0.008	12.9	0.203
Others (including 'New Zealander')	1.2	0.2	0.003	0.527	0.031

Note: ISeg -Index of Segregation, IIsol-Index of Isolation, EG-Ellison-Glaeser concentration index, E- Entropy Index of Segregation.

The Index of Segregation shows that the African, Latin American/Hispanic, Tokelauan and 'Other Pacific Island' ethnic groups are consistently the most residentially sorted ethnic groups. The least residentially sorted ethnic groups are consistently New Zealand European, Other European, and New Zealand Māori. This implies that the shares of these three groups in area unit populations (strictly speaking total responses regarding ethnicity) do not vary much across area units. The Chinese ethnic group became more segregated from 1991 to 2006 (with little change since then), while the Indian ethnic group has become more segregated throughout the period since 1991.

The Index of Isolation measures the extent to which people disproportionately live in areas where they make up a large share of the population. The Index of Isolation is consistently highest for the New Zealand European ethnic group followed by Samoan. Hence Europeans and Samoans are attracted to Area Units where they are a relatively large share of the population. The Index of Isolation decreased for the New Zealand European group from 2001

to 2006 then increased in 2013,¹⁵ which might be due to the change in group share (which decreased from 2001 to 2006, then increased in 2013). The Ellison-Glaeser concentration index shows that New Zealand European is the ethnic group with the least residential sorting, while the African, Hispanic and Tokelauan groups exhibit the greatest residential sorting

According to the Entropy Index of Segregation, we find in Table 5 that the Other European, New Zealand Māori, Other Asian and Others ethnic groups are consistently the least residentially sorted. For them, the spatial variation in their share of population (responses) is relatively small. The African, Hispanic, Samoan, Tongan and Tokelauan ethnic groups are the most residentially sorted in 2013.

Overall, the measures provide similar evidence for the relative ranking of the groups in terms of residential sorting. The Index of Segregation, Ellison-Glaeser concentration index and the Entropy Index provide similar evidence but the Index of Isolation gives instead different rankings. The conflicting evidence from the Index of Isolation is due to the fact that it measures a different aspect of population distribution to the other measures. The Index of Isolation for any group g measures the degree to which individuals of group g co-locate with other members of their own group whereas the other indexes measure the extent to which group g is concentrated in particular areas. The Index of Isolation is not significantly correlated with any of the other measures.¹⁶

Table 6 shows the Entropy Index of Segregation for ethnicity. We observe that for all Level 2 ethnic groups within the Pacific broad ethnic group, along with the Chinese and Indian ethnic groups, there has been an increase in spatial sorting. These groups appear to show Schelling-type behaviour in that these migrant groups increasingly seek to live with their co-ethnics (Schelling 1971). In Auckland, groups of Chinese are clustered in the wealthier suburbs of Remuera and Epsom, but most are concentrated in middle-priced suburbs (e.g. Mount Roskill and Mount Albert). The Indian population is also observed to have major concentrations in these areas.

A large number of Asian students are concentrated in central Auckland, which is near the largest tertiary institutions (Ho 2015). Friesen (2008) also found a significant level of clustering for the Asian population in Auckland. According to Friesen and Ho, this pattern is observed due to the fact that these ethnic groups look for advantages to co-locate with their own-group members. A ‘zone of familiarity’, including provision of ethnic goods and services and employment in ethnic businesses run by co-ethnics is what triggers this Schelling-type behaviour for Asians (especially Indian and Chinese). Poulsen *et al.* (2004) state that despite policies promoting multiculturalism in New Zealand, Asian ethnic groups choose to maximise their economic success. Many are involved in small businesses serving their own community

¹⁵ Details can be found in the Appendix.

¹⁶ Details can be found in Appendix

and thus reside in neighbourhoods with a larger proportion of those of Chinese or Indian ethnicity. In contrast to the Chinese, Indian and Pacific groups, Table 6 shows that for the New Zealand European, South-East Asian, and all of the Level 2 ethnic groups within the MELAA¹⁷ broad ethnic group, residential sorting has declined over time.¹⁸

Table 6: Entropy Index of Segregation by Ethnicity
Auckland, 1991-2013

Ethnicity	1991	1996	2001	2006	2013
New Zealand European	0.145	0.020	0.131	0.095	0.128
Other European	0.018	0.023	0.020	0.024	0.026
New Zealand Maori	0.097	0.078	0.075	0.071	0.061
Samoan	0.196	0.196	0.188	0.189	0.199
Cook Island Maori	0.175	0.170	0.156	0.155	0.189
Tongan	0.165	0.179	0.178	0.184	0.202
Niuean	0.152	0.152	0.139	0.134	0.159
Tokelauan	0.239	0.225	0.198	0.176	0.261
Fijian	0.114	0.075	0.102	0.078	0.115
Other Pacific Island	0.247	0.161	0.159	0.157	0.001
Southeast Asian	0.174	0.091	0.081	0.073	0.081
Chinese	0.060	0.063	0.110	0.120	0.124
Indian	0.087	0.085	0.096	0.109	0.136
Other Asian	0.266	0.110	0.109	0.101	0.096
Middle Eastern	0.231	0.113	0.094	0.099	0.131
Latin American/Hispanic	0.368	0.233	0.216	0.166	0.198
African	0.346	0.250	0.211	0.181	0.203
Others	0.405	0.305	0.399	0.033	0.031

In terms of overall ethnic residential sorting, Theil's Multi-group Segregation Index (H) (see Table 7) shows a decline in ethnic residential sorting between 1991 and 2001 (the extremely low value in 1996 is due to the drastic change in ethnic classification in that year through the introduction of the New Zealander category). The decline in sorting is concentrated in the period to 2006.

Table 7: Theil's Multi-Group Index of Residential Sorting
by Ethnicity and Socioeconomic Variables, Auckland, 1991-2013

Year	Ethnicity	Qualification	Occupation	Income	Age	Economic
1991	0.135	0.028	0.035	0.015	0.015	0.023
1996	0.039	0.036	0.031	0.015	0.014	0.024
2001	0.122	0.029	0.027	0.015	0.013	0.021
2006	0.096	0.028	0.024	0.015	0.013	0.020
2013	0.122	0.025	0.025	0.015	0.014	0.020

Note: The Economic Index of residential sorting is the simple average of the Theil multi-group index for qualification, occupation, income and age.

¹⁷ Middle Eastern, Latin American/Hispanic and African.

¹⁸ Details can be found in the Appendix for the other spatial sorting measures.

Sorting by Other Variables

In line with the results reported in Figure 1, residential sorting by education, occupation, income, and age is much less apparent than for ethnicity.¹⁹ We find that the greatest residential sorting is exhibited by people with high income, high education and the elderly. These results are consistent with previous research (Maré *et al.* 2012).

Looking at residential sorting by occupation, we observe that the groups with the highest levels of residential sorting (the ‘Legislators and Administrators’, ‘Building and Related Workers’ and ‘Market Orientated Agricultural and Fishery Workers’) according to the Index of Segregation and Entropy Index of Segregation values, showed declines in residential sorting from 1991 to 2006. There has been an increase in residential sorting for the same groups from 2006 to 2013 according to the latter index.

From Table 7, we find that the average sorting by income and age has remained fairly constant over time. Residential sorting by occupation shows a downward trend from 1991 to 2006. This might be due to a number of factors. The female labour force participation rate has increased in New Zealand (from 54.3 percent in 1991 to 64.5 percent in 2006) (Statistics New Zealand, 2017). There is gender segregation in employment by occupation. At the same time occupational segregation has declined and there has been a structural transformation in employment towards employment in services. Consequently, whereas there were historically ‘blue collar’ (male employment dominated) and ‘white collar’ area unit, that distinction has become less over time – leading to lower spatial sorting by occupation.

To identify which among the five chosen characteristics - ethnicity, age, income, education or occupation - exhibits the greatest degree of residential sorting in Auckland, we compare the Theil Index values in Table 7. It is clear that the greatest degree of residential sorting occurs by ethnicity. Among the economic variables, residential sorting is greatest by occupation.

The final column of Table 7 reports the value based on the index for all economic variables. The Economic Index of residential sorting is the simple average of the Theil multi-group index for qualification, occupation, income and age. Comparing these values with the first column, we see that cultural sorting (that is, ethnic sorting) in Auckland is much greater than economic sorting.

Table 8 reports the correlation between our cultural and economic diversity measures across the area units. We find that economic and cultural diversity are significantly and positively correlated. This may arise because ethnicity often remains a good predictor of income and employment (Sampson 2012, Sharkey 2013). Consequently, Area Units that exhibit great ethnic diversity are also diverse economically. Florida and Mellander (2018) find similarly a positive correlation between racial and economic segregation.

¹⁹ Details can be found in the Appendix.

Table 8: Correlation between Cultural and Economic Diversity of Area Units

Auckland, 1991-2013

Year	Correlation
2013	0.395*** (0.00)
2006	0.495*** (0.00)
2001	0.327*** (0.00)
1996	0.337*** (0.00)
1991	0.403*** (0.00)

Notes $N = 409$. p -values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The Economic diversity index of an area is calculated as the simple average of the Evenness Index (Entropy score/ $\ln(G)$, where G is the number of groups) across the four economic variables. Cultural diversity is measured by the evenness index for ethnicity.

It is useful to consider the extent to which the different measures of sorting yield similar rankings for groups. To investigate this, we now look at the group correlations between the different measures of residential sorting for the year 2013.²⁰ We find that the Entropy Index of ethnic sorting has a positive and significant correlation with the Index of Segregation and the Ellison-Glaeser concentration index for ethnicity. The relation is positive but not statistically significant in case of the Index of Isolation.

In the case of sorting by occupation, income and age, we find that the Entropy Index has positive and statistically significant correlations with all the other measures. Finally, for education, there is a positive and significant correlation between Entropy Index and the Index of Sorting and the Ellison-Glaeser concentration index.

Finally, we show how sensitive the Theil's Multigroup measure of sorting is to the level of aggregation, by decomposing the H values into between-group and within-group components.²¹ We do this for our cultural variable (ethnicity) and one economic variable (occupation). The results for ethnicity are reported in Table 9. The Theil at level 2 column repeats the index values already reported in Table 7. The between-groups sorting and within groups sorting fluctuate considerably over time. This is not surprising given that there have been notable changes in the ethnic classification and the responses by census respondents in successive censuses. These changes were already discussed earlier in the paper. In terms of shares, The results imply that there is less co-location of Level 1 ethnic groups (for example,

²⁰ Details can be found in the Appendix.

²¹ The data used for the Level 1 calculation has been constructed from the Level 2 data sheets (using bottom-up approach), so that the total population count at both levels are the same.

Pacific Islanders) than before, but that they are more segregated *between* Level 2 ethnic sub-groups within their Level 1 groups (for example, Samoan, Cook Island Māori, Tongan, etc.). In other words, Level 2 ethnic groups are increasingly sorting away from other Level 2 groups within the same Level 1 broad ethnic group. For instance, there are fewer suburbs that are generic Pacific Island communities, with Samoan, Tongan and other Pacific groups increasingly located separately from each other.

Table 9: Decomposition of Theil’s Multi-Group Index of Residential Sorting
by Ethnicity, Auckland 1991-2013

	Theil at Level 2	Between Level 1 Groups	Within Level 1 Groups	Between Group Proportion (%)	Within Group Proportion (%)
1991	0.135	0.054	0.080	40.3	59.7
1996	0.039	0.031	0.008	78.9	21.1
2001	0.122	0.066	0.056	53.8	46.2
2006	0.096	0.038	0.057	40.1	59.9
2013	0.122	0.044	0.078	36.0	64.0

Measured by H , sorting by occupation in 2013 is similarly less than it was in 1991 (Table 10). However, the between major occupational group proportion increased between 1991 and 2006, before declining. Overall, people are less residentially sorted according to their Level 2 occupational groups (for example, Legislators and Administrators, Corporate Managers) than before, and also less sorted *between* their Level 1 groups (for example, Legislators, Administrators and Managers). The 2006-2013 increase in the ‘within groups’ contribution to residential sorting appears to be against the longer-term trend.

Table 10: Decomposition of Theil’s Multi-Group Index of Residential Sorting
by Occupation, Auckland 1991-2013

	Theil at Level 2	Between Level 1 Groups	Within Level 1 Groups	Between Group Proportion (%)	Within Group Proportion (%)
1991	0.0345	0.0115	0.0231	33.2	66.8
1996	0.0309	0.0111	0.0199	35.8	64.2
2001	0.0269	0.0109	0.0159	40.7	59.3
2006	0.0244	0.0099	0.0145	40.6	59.4
2013	0.0245	0.0071	0.0174	29.0	71.0

Section 6. Conclusions

The main objective of this paper was to identify whether individuals exhibit the greatest level of residential sorting by their cultural or economic characteristics in Auckland. We used a range of different measures of residential sorting, with our preferred measures being entropy based, given that these measures have the most desirable properties (Massey and Denton 1988), including the property of interpreting an aggregate measure as a weighted sum of between-group residential sorting and within-group residential sorting. We find that residential sorting is greater by cultural than by economic variables. At the area unit level, there is considerable spatial difference in ethnic diversity, but not so much in terms of economic characteristics. We also find that the elderly, more educated, high income people, and people in some specific jobs exhibit notable levels of residential sorting in Auckland.

This result might seem surprising, given that we can imagine enclaves of privilege or relative deprivation. Why then, do the data not support this? Part of the reason is likely to be our chosen level of geographical aggregation. In urban areas, an area unit is approximately the size of a suburb, with an average population of about 1500. If we were to complete our analysis at a lower level of geographical aggregation (for example, mesh blocks, which are roughly neighbourhoods or city blocks), we might observe more residential sorting by these other characteristics. However, small cell sizes would become problematic when conducting this analysis across many groups and many small geographical areas, leading to a greater degree of necessary suppression of data counts (Statistics New Zealand requires this due to concerns about confidentiality of data). This explains why previous analyses that have used meshblock-level data (for example, Maré *et al.* 2011), have used more aggregated ethnic or other groups. Our analyses should be seen as complementary to that earlier work.

According to the Entropy Index values, the New Zealand European and the New Zealand Māori ethnic groups are consistently the least residentially sorted. At the other extreme, the African, Hispanic and Tokelauan ethnic groups are the most residentially sorted. We also observe growing residential sorting of the populations of Chinese and Indian ethnicity. This may represent an extension of previous ethnic enclaves (Maré *et al.* 2011) at the neighbourhood level to collections of contiguous neighbourhoods or suburbs as the population of those ethnicities grow over time. While the central city is extraordinarily diverse in terms of its usually resident population, outlying suburbs and especially peri-urban areas exhibit much lower levels of diversity. These observations add to our understanding of the current and changing nature of ethnic diversity in Auckland.

Our findings contribute to the extant literature on residential sorting in a number of ways. First, though we estimate the traditional indexes of residential sorting, our interpretation is mainly based on the results from the less-commonly-used and rather underappreciated entropy-based measures. We strongly recommend the use of entropy-based measures in future research, as along with many desirable properties, they are least sensitive to group-size (Mondal *et al.* 2019 forthcoming).

Secondly, this is among the first studies to consider residential sorting within and between broad ethnic groups. This is important because the broad (Level 1) ethnic groups are very heterogeneous and may not represent the characteristics and choices of their component (Level 2) groups. For instance, the ‘Asian’ broad ethnic group includes diverse Level 2 groups such as Southeast Asian, Chinese and Indian. An argument could be made that even the Level 2 groups are too heterogeneous (for example, Southeast Asian), and that Level 3 groups (Thai, Vietnamese, etc.) would be an improvement. We leave that as an exercise for future research.

Our results show that residential sorting *between* the (Level 1) groups in 2013 is contributing much less to overall residential sorting than before. Thus, it is becoming increasingly more important to look at residential sorting at a much finer scale. Previous studies in New Zealand have found that the Pacific group tend to co-locate with their own group members the most (Johnston *et al.* 2011, Maré *et al.* 2012). However, using finer-grained (Level 2) ethnic groups we observe that although the Level 2 ethnic groups under the broad Pacific group are also highly residentially segregated, the most residentially segregated groups are those under the MELAA group. That the conclusions change depending on the level of analysis demonstrates the importance of considering the appropriate level of ethnic aggregation.

This study could be extended in a number of ways. In addition to using even more finer-grained ethnic groups, more complex patterns and trends in residential sorting could be identified by combining cultural and socio-economic variables through cross-tabulated groups (for example, ethnicity-income and ethnicity-qualification). We note that one of the limitations of this work is that there have been changes in Census questions, categories, and definitions. However, except where noted in the text we expect that those changes have had effects that are no more than minor. Also, when looking at residential sorting by occupation, we only looked at individuals who are employed, and not at the unemployed (who, by definition, have no occupation). Future analyses could attempt to address this, perhaps by including unemployed as an additional category. Finally, this paper is one of the few that include occupation and age in studying residential sorting in New Zealand. Though we find a less pronounced pattern of residential sorting by these variables (except for increased residential sorting of the very old), the further investigation of these and other socio-economic variables, as well as of other cultural variables like language and religion, offers future research prospects.

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Appendix

Table A1: Correlations between Sorting Measures for Ethnicity, 2013

	Population (%)	ISeg	IIsol	EG	E
Population (%)	1				
ISeg	-0.297 (0.167)	1			
IIsol	0.740*** (0.0004)	-0.195 (0.48)	1		
EG	-0.349 (0.156)	0.929*** (0.000)	-0.332 (0.178)	1	
E	-0.1330 (0.599)	0.930*** (0.008)	0.128 (0.613)	0.831*** (0.000)	1

Notes

$N=18$

p -values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

ISeg-Index of Segregation.

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index, E- Entropy Index.

Table A2: Correlations between Sorting Measures for Occupation, 2013

	Population (%)	ISeg	IIsol	EG	E
Population (%)	1				
ISeg	-0.594*** (0.0028)	1			
IIsol	-0.033 (0.88)	0.318 (0.139)	1		
EG	-0.445** (0.0335)	0.906*** (0.000)	0.556*** (0.0059)	1	
E	-0.550*** (0.0065)	0.978*** (0.000)	0.473** (0.023)	0.967*** (0.000)	1

Notes: N=23

p -values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

ISeg-Index of Segregation.

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index.

E- Entropy Index of Segregation.

Table A3: Correlations between Sorting Measures for Age, 2013

	Population (%)	ISeg	IIsol	EG	E
Population (%)	1				
ISeg	-0.825*** (0.000)	1			
IIsol	-0.717*** (0.001)	0.890*** (0.000)	1		
EG	-0.718*** (0.001)	0.961*** (0.000)	0.868*** (0.000)	1	
E	-0.757*** (0.000)	0.980*** (0.000)	0.909*** (0.000)	0.992*** (0.000)	1

Notes

N=18

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A4: Correlations, Sorting Measures for Income, 2013

	Population (%)	ISeg	IIsol	EG	E
Population (%)	1				
ISeg	-0.646*** (0.007)	1			
IIsol	-0.281 (0.293)	0.845*** (0.000)	1		
EG	-0.509** (0.044)	0.928*** (0.000)	0.950*** (0.000)	1	
E	-0.582** (0.018)	0.979*** (0.000)	0.916*** (0.000)	0.983*** (0.000)	1

Notes

N=16

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A5: Correlations between Sorting Measures for Qualification, 2013

	Population (%)	ISeg	IIsol	EG	E
Population (%)	1				
ISeg	-0.312 (0.324)	1			
IIsol	0.719*** (0.008)	0.317 (0.316)	1		
EG	-0.469 (0.124)	0.932* (0.000)	0.0451 (0.889)	1	
E	-0.236 (0.461)	0.986*** (0.000)	0.364 (0.245)	0.942*** (0.000)	1

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A6: Measures of Residential Sorting of Ethnic Groups in Auckland, 2006

Ethnicity	Share of Total Responses (%)	ISeg	IIsol	EG	E
New Zealand	49.2	0.281	0.105	0.384	0.095
European					
Other European	5.42	0.139	0.006	0.347	0.024
NZ Maori	10.7	0.292	0.053	1.456	0.071
Samoan	6.3	0.497	0.108	5.006	0.189
Cook Island Maori	2.56	0.484	0.051	5.944	0.155
Tongan	2.77	0.52	0.065	7.004	0.184
Niuean	1.31	0.486	0.021	4.785	0.134
Tokelauan	0.107	0.702	0.004	10.645	0.176
Fijian	0.352	0.386	0.003	2.477	0.078
Other Pacific Island	0.259	0.549	0.01	10.166	0.157
Southeast Asian	1.44	0.337	0.011	2.402	0.073
Chinese	5.44	0.401	0.057	2.926	0.120
Indian	3.55	0.384	0.04	3.666	0.109
Other Asian	1.73	0.399	0.02	3.213	0.101
Middle Eastern	0.623	0.405	0.01	5.039	0.099
Latin	0.066	0.726	0.002	8.73	0.166
American/Hispanic					
African	0.175	0.62	0.009	13.599	0.181
Others	8.08	0.187	0.016	0.524	0.033

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A7: Measures of Residential Sorting of Ethnic Groups in Auckland 2001

Ethnicity	Share of Total Responses (%)	ISeg	IIsol	EG	E
New Zealand European	62.6	0.339	0.142	0.321	0.131
Other European	5.14	0.121	0.004	0.255	0.020
NZ Maori	11.0	0.299	0.056	1.464	0.075
Samoan	5.96	0.497	0.105	5.246	0.188
Cook Island Maori	2.45	0.481	0.049	6.252	0.156
Tongan	2.36	0.521	0.055	7.051	0.178
Niuean	1.30	0.489	0.022	5.312	0.139
Tokelauan	0.085	0.766	0.004	12.851	0.198
Fijian	0.259	0.456	0.004	3.69	0.102
Other Pacific Island	0.178	0.606	0.006	8.821	0.159
Southeast Asian	0.95	0.344	0.009	2.707	0.081
Chinese	3.86	0.37	0.042	3.178	0.110
Indian	2.38	0.362	0.024	3.279	0.096
Other Asian	1.02	0.409	0.013	3.714	0.109
Middle Eastern	0.368	0.424	0.005	3.69	0.094
Latin American/Hispanic	0.039	0.836	0.003	16.623	0.216
African	0.069	0.794	0.004	16.603	0.211
Others	<0.001	0.993	0.001	992	0.399

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A8: Measures of Residential Sorting of Ethnic Groups in Auckland 1996

Ethnicity	Share of Total Responses (%)	ISeg	IIsol	EG	E
New Zealand European	35.8	0.113	0.022	0.112	0.020
Other European	47.6	0.125	0.03	0.092	0.023
NZ Maori	6.90	0.319	0.045	1.799	0.078
Samoan	3.39	0.521	0.087	6.559	0.196
Cook Island Maori	1.39	0.512	0.042	7.544	0.170
Tongan	1.18	0.557	0.035	7.703	0.179
Niuean	0.75	0.53	0.018	6.419	0.152
Tokelauan	0.041	0.835	0.003	16.93	0.225
Fijian	0.208	0.391	0.002	2.485	0.075
Other Pacific Island	0.076	0.678	0.003	8.263	0.161
Southeast Asian	0.43	0.393	0.006	3.586	0.091
Chinese	1.54	0.308	0.01	1.945	0.063
Indian	1.11	0.364	0.012	3.341	0.085
Other Asian	0.147	0.483	0.003	4.942	0.110
Middle Eastern	0.078	0.566	0.001	4.739	0.113
Latin American/Hispanic	0.013	0.898	0.001	28.19	0.233
African	0.012	0.913	0.001	35.441	0.250
Others	0.003	0.967	0.001	105.542	0.305

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A9: Measures of Residential Sorting of Ethnic Groups in Auckland 1991

Ethnicity	Share of Total Responses (%)	ISeg	IIsol	EG	E
New Zealand European	70.6	0.361	0.1783	0.251	0.145
Other European	6.2	0.139	0.0077	0.348	0.018
NZ Maori	10.5	0.347	0.0709	2.03	0.097
Samoan	5.13	0.508	0.0986	6.37	0.196
Cook Island Maori	2.15	0.510	0.0513	7.98	0.175
Tongan	1.53	0.537	0.0314	6.54	0.165
Niuean	1.15	0.514	0.0229	6.44	0.152
Tokelauan	0.062	0.843	0.0051	20.2	0.239
Fijian	0.185	0.512	0.0030	4.44	0.114
Other Pacific Island	0.037	0.877	0.0033	26.17	0.247
Southeast Asian	0.222	0.633	0.0075	11.7	0.174
Chinese	1.2	0.303	0.0079	1.97	0.060
Indian	0.886	0.373	0.0109	3.26	0.087
Other Asian	0.028	0.908	0.0031	34.93	0.266
Middle Eastern	0.035	0.865	0.0026	22.6	0.231
Latin American/Hispanic	0.004	0.983	0.0024	227	0.368
African	0.006	0.975	0.0024	150	0.346
Other	<0.001	0.994	0.0014	990	0.405

Notes:

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A10: Measures of Residential Sorting by Occupation in Auckland, 1991

Occupation	Percentage of Population	ISeg	IIsol	EG	E
Legislators & Administrators	0.013	0.972	0.005	126	0.361
Corporate Managers	14.8	0.173	0.024	0.428	0.033
Physical, Mathematical & Engineering Science Professionals	1.83	0.201	0.005	0.5	0.036
Life Science & Health Professionals	2.82	0.209	0.01	0.887	0.021
Teaching Professionals	3.90	0.162	0.006	0.392	0.048
Other Professionals	3.54	0.251	0.015	1.29	0.013
Physical Science & Engineering Associate Professionals	3.66	0.116	0.004	0.157	0.044
Life Science & Health Associate Professionals	0.93	0.226	0.004	0.636	0.022
Other Associate Professionals	7.86	0.162	0.012	0.377	0.006
Office Clerks	12.70	0.079	0.005	0.065	0.013
Customer Service Clerks	4.63	0.12	0.004	0.189	0.028
Personal & Protective Services Workers	7.10	0.137	0.021	0.734	0.008
Salespersons, Demonstrators & Models	5.65	0.092	0.003	0.091	0.246
Market Orientated Agricultural & Fishery Workers	3.00	0.54	0.161	10.8	0.016
Building Trade Workers	5.36	0.126	0.006	0.237	0.030
Metal & Machinery Trades Workers	3.88	0.202	0.009	0.647	0.039
Precision Trade Workers	1.11	0.222	0.004	0.617	0.033
Other Craft & Related Trades Workers	1.62	0.212	0.004	0.591	0.120
Industrial Plant Operators	0.75	0.431	0.014	4.30	0.069
Stationary Machine Operators & Assemblers	4.55	0.295	0.03	1.59	0.044
Drivers and Mobile Machinery Operators	2.90	0.253	0.011	0.974	0.142
Building & Related Workers	0.26	0.599	0.005	4.92	0.120
Labourers & Related Elementary Service Workers	7.20	0.235	0.029	0.94	0.048

Notes:

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A11: Measures of Residential Sorting by Occupation in Auckland, 1996

Occupation	Percentage of Population	ISeg	IIsol	EG	E
Legislators & Administrators	0.064	0.86	0.005	23.7	0.242
Corporate Managers	14.7	0.179	0.026	0.428	0.032
Physical, Mathematical & Engineering Science Professionals	2.26	0.168	0.004	0.364	0.025
Life Science & Health Professionals	2.57	0.209	0.009	0.821	0.034
Teaching Professionals	3.93	0.149	0.005	0.327	0.017
Other Professionals	3.76	0.258	0.016	1.27	0.049
Physical Science & Engineering Associate Professionals	3.13	0.121	0.004	0.186	0.014
Life Science & Health Associate Professionals	0.84	0.219	0.003	0.509	0.038
Other Associate Professionals	9.28	0.138	0.01	0.261	0.016
Office Clerks	12.3	0.077	0.004	0.064	0.006
Customer Service Clerks	4.73	0.101	0.003	0.126	0.010
Personal & Protective Services Workers	7.91	0.112	0.011	0.305	0.016
Salespersons, Demonstrators & Models	6.21	0.091	0.003	0.089	0.007
Market Orientated Agricultural & Fishery Workers	3.10	0.499	0.12	8.50	0.201
Building Trade Workers	4.82	0.132	0.006	0.264	0.016
Metal & Machinery Trades Workers	3.07	0.195	0.007	0.594	0.029
Precision Trade Workers	1.04	0.231	0.004	0.698	0.040
Other Craft & Related Trades Workers	1.50	0.209	0.004	0.562	0.031
Industrial Plant Operators	0.747	0.409	0.01	2.97	0.105
Stationary Machine Operators & Assemblers	3.96	0.299	0.025	1.52	0.065
Drivers and Mobile Machinery Operators	2.66	0.258	0.011	0.992	0.043
Building & Related Workers	0.316	0.533	0.005	3.84	0.125
Labourers & Related Elementary Service Workers	7.10	0.231	0.028	0.908	0.047

Notes:

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A12: Measures of Residential Sorting by Occupation in Auckland, 2001

Occupation	Percentage of Population	ISeg	IIsol	EG	E
Legislators & Administrators	0.959	0.354	0.008	2.36	0.0817
Corporate Managers	15.1	0.16	0.02	0.311	0.0249
Physical, Mathematical & Engineering Science Professionals	3.20	0.164	0.006	0.390	0.0231
Life Science & Health Professionals	2.71	0.192	0.008	0.759	0.0289
Teaching Professionals	4.45	0.128	0.005	0.23	0.0129
Other Professionals	5.22	0.231	0.017	0.964	0.0402
Physical Science & Engineering Associate Professionals	2.97	0.12	0.004	0.203	0.0140
Life Science & Health Associate Professionals	0.875	0.208	0.002	0.446	0.0351
Other Associate Professionals	9.72	0.101	0.006	0.138	0.0093
Office Clerks	11.4	0.076	0.004	0.064	0.0053
Customer Service Clerks	4.44	0.109	0.003	0.13	0.0094
Personal & Protective Services Workers	7.81	0.106	0.008	0.19	0.0122
Salespersons, Demonstrators & Models	5.94	0.091	0.003	0.09	0.0069
Market Orientated Agricultural & Fishery Workers	2.64	0.442	0.076	6.35	0.1539
Building Trade Workers	4.69	0.144	0.006	0.318	0.0174
Metal & Machinery Trades Workers	2.67	0.206	0.007	0.646	0.0307
Precision Trade Workers	0.841	0.242	0.003	0.753	0.0418
Other Craft & Related Trades Workers	1.20	0.222	0.004	0.608	0.0339
Industrial Plant Operators	0.604	0.426	0.008	2.83	0.1055
Stationary Machine Operators & Assemblers	3.85	0.31	0.027	1.57	0.0698
Drivers and Mobile Machinery Operators	2.6	0.296	0.013	1.27	0.0554
Building & Related Workers	0.409	0.438	0.005	2.46	0.0997
Labourers & Related Elementary Service Workers	5.67	0.234	0.022	0.875	0.044

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A13: Measures of Residential Sorting by Occupation in Auckland, 2006

Occupation	Percentage of Population	ISeg	IIsol	EG	E
Legislators & Administrators	1.29	0.301	0.008	1.51	0.0597
Corporate Managers	17.0	0.151	0.02	0.258	0.0227
Physical, Mathematical & Engineering Science Professionals	3.69	0.161	0.006	0.359	0.0213
Life Science & Health Professionals	2.90	0.175	0.007	0.574	0.0253
Teaching Professionals	4.74	0.107	0.003	0.145	0.0092
Other Professionals	5.65	0.215	0.016	0.784	0.0355
Physical Science & Engineering Associate Professionals	2.87	0.106	0.003	0.147	0.0105
Life Science & Health Associate Professionals	0.85	0.192	0.002	0.367	0.0311
Other Associate Professionals	11.1	0.071	0.004	0.069	0.0055
Office Clerks	9.51	0.073	0.003	0.063	0.0047
Customer Service Clerks	3.74	0.11	0.003	0.149	0.0093
Personal & Protective Services Workers	7.67	0.104	0.007	0.167	0.0108
Salespersons, Demonstrators & Models	5.39	0.088	0.002	0.081	0.0061
Market Orientated Agricultural & Fishery Workers	2.22	0.421	0.056	6.082	0.136
Building Trade Workers	4.67	0.146	0.006	0.323	0.0178
Metal & Machinery Trades Workers	2.36	0.214	0.006	0.673	0.0322
Precision Trade Workers	0.80	0.226	0.003	0.602	0.0376
Other Craft & Related Trades Workers	0.99	0.217	0.003	0.544	0.0326
Industrial Plant Operators	0.53	0.481	0.008	3.7	0.1233
Stationary Machine Operators & Assemblers	3.14	0.316	0.022	1.63	0.0691
Drivers and Mobile Machinery Operators	2.55	0.296	0.013	1.31	0.0556
Building & Related Workers	0.44	0.407	0.004	2.10	0.0912
Labourers & Related Elementary Service Workers	5.95	0.247	0.025	0.947	0.0482

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A14: Measures of Residential Sorting by Occupation in Auckland, 2013

Occupation	Percentage of Population	ISeg	IIsol	EG	E
Legislators & Administrators	1.21	0.33	0.009	1.75	0.0736
Corporate Managers	18.6	0.132	0.017	0.19	0.0182
Physical, Mathematical & Engineering Science Professionals	4.43	0.15	0.007	0.307	0.0215
Life Science & Health Professionals	3.49	0.172	0.008	0.504	0.0278
Teaching Professionals	5.74	0.095	0.003	0.089	0.0078
Other Professionals	6.83	0.19	0.015	0.582	0.0304
Physical Science & Engineering Associate Professionals	2.88	0.109	0.003	0.086	0.0128
Life Science & Health Associate Professionals	0.92	0.224	0.003	0.472	0.0428
Other Associate Professionals	11.8	0.063	0.003	0.034	0.0044
Office Clerks	9.07	0.082	0.004	0.067	0.0062
Customer Service Clerks	3.51	0.121	0.003	0.168	0.0129
Personal & Protective Services Workers	7.77	0.111	0.006	0.169	0.0110
Salespersons, Demonstrators & Models	5.14	0.1	0.003	0.09	0.0083
Market Orientated Agricultural & Fishery Workers	1.92	0.469	0.064	8.137	0.171
Building Trade Workers	3.70	0.17	0.007	0.395	0.0230
Metal & Machinery Trades Workers	2.01	0.252	0.008	0.866	0.0475
Precision Trade Workers	0.41	0.461	0.005	2.50	0.105
Other Craft & Related Trades Workers	0.67	0.354	0.005	1.44	0.0769
Industrial Plant Operators	0.32	0.676	0.011	7.55	0.193
Stationary Machine Operators & Assemblers	2.23	0.325	0.017	1.55	0.0738
Drivers and Mobile Machinery Operators	1.97	0.304	0.012	1.31	0.0621
Building & Related Workers	0.20	0.722	0.007	7.80	0.189
Labourers & Related Elementary Service Workers	5.20	0.236	0.021	0.821	0.0452

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A15: Measures of Residential Sorting According to Age in Auckland, 1991

Age	Percentage of Population	ISeg	IIsol	EG	E
0-4	8.20	0.13	0.009	0.317	0.015
5-9	7.67	0.112	0.006	0.216	0.011
10-15	7.92	0.109	0.006	0.2	0.010
15-19	7.36	0.105	0.005	0.186	0.010
20-24	6.23	0.12	0.006	0.227	0.013
25-29	7.67	0.138	0.009	0.337	0.016
30-34	8.48	0.105	0.006	0.189	0.010
35-39	8.27	0.081	0.003	0.095	0.006
40-44	8.39	0.103	0.005	0.157	0.009
45-49	6.68	0.112	0.005	0.206	0.010
50-54	5.46	0.116	0.005	0.222	0.011
55-59	4.37	0.128	0.004	0.288	0.013
60-64	4.21	0.163	0.007	0.509	0.022
65-69	3.64	0.198	0.009	0.825	0.031
70-74	2.64	0.251	0.01	1.255	0.043
75-79	1.74	0.29	0.01	1.825	0.058
80-84	0.788	0.364	0.007	2.81	0.080
85+	0.287	0.544	0.007	6.951	0.138

Notes: ISeg-Index of Segregation, IIsol-Index of Isolation, EG-Ellison-Glaesar concentration index, E- Entropy Index of Segregation

Table A16: Measures of Residential Sorting According to Age in Auckland, 1996

Age	Percentage of Population	ISeg	IIsol	EG	E
0-4	7.84	0.119	0.007	0.226	0.013
5-9	8.34	0.106	0.006	0.169	0.010
10-14	7.46	0.095	0.004	0.133	0.009
15-19	6.38	0.108	0.007	0.195	0.012
20-24	5.36	0.121	0.006	0.22	0.014
25-29	6.79	0.146	0.009	0.343	0.018
30-34	8.49	0.116	0.007	0.223	0.013
35-39	8.64	0.08	0.003	0.081	0.006
40-44	8.13	0.08	0.003	0.083	0.006
45-49	7.92	0.106	0.005	0.158	0.009
50-54	6.16	0.113	0.005	0.187	0.011
55-59	4.96	0.12	0.005	0.195	0.012
60-64	3.87	0.141	0.005	0.335	0.017
65-69	3.59	0.179	0.008	0.638	0.028
70-74	2.92	0.213	0.010	0.94	0.036
75-79	1.85	0.27	0.009	1.49	0.053
80-84	0.949	0.327	0.007	2.23	0.072
85+	0.34	0.505	0.006	5.02	0.122

Notes: ISeg-Index of Segregation, IIsol-Index of Isolation, EG-Ellison-Glaesar concentration index, E- Entropy Index of Segregation

Table A17: Measures of Residential Sorting According to Age in Auckland, 2001

Age	Percentage of Population	ISeg	IIsol	EG	E
0-4	7.54	0.121	0.007	0.213	0.013
5-9	8.28	0.098	0.005	0.140	0.010
10-14	8.25	0.098	0.005	0.127	0.009
15-19	6.45	0.100	0.004	0.152	0.009
20-24	4.90	0.135	0.008	0.290	0.018
25-29	5.94	0.152	0.009	0.357	0.020
30-34	7.95	0.122	0.007	0.220	0.013
35-39	9	0.077	0.003	0.081	0.005
40-44	8.56	0.071	0.003	0.061	0.005
45-49	7.58	0.089	0.003	0.099	0.006
50-54	7.06	0.108	0.005	0.158	0.009
55-59	5.33	0.113	0.004	0.178	0.010
60-64	4.19	0.127	0.004	0.232	0.012
65-69	3.10	0.161	0.006	0.509	0.019
70-74	2.67	0.205	0.008	0.931	0.032
75-79	1.88	0.248	0.009	1.32	0.045
80-84	0.939	0.328	0.008	2.30	0.068
85+	0.389	0.462	0.006	3.95	0.111

Notes: ISeg-Index of Segregation, IIsol-Index of Isolation, EG-Ellison-Glaesar concentration index, E- Entropy Index of Segregation.

Table A18: Measures of Residential Sorting According to Age in Auckland, 2006

Age	Percentage of Population	ISeg	IIsol	EG	E
0-4	6.69	0.115	0.006	0.207	0.012
5-9	7.66	0.104	0.006	0.163	0.011
10-14	7.81	0.096	0.005	0.132	0.009
15-19	6.33	0.106	0.005	0.177	0.010
20-24	4.62	0.175	0.018	1.1	0.033
25-29	5.03	0.187	0.012	0.631	0.029
30-34	6.95	0.126	0.007	0.246	0.014
35-39	8.52	0.076	0.003	0.07	0.005
40-44	9.29	0.07	0.003	0.062	0.004
45-49	8.50	0.079	0.003	0.076	0.005
50-54	7.28	0.09	0.004	0.102	0.007
55-59	6.65	0.113	0.005	0.182	0.010
60-64	4.96	0.125	0.005	0.221	0.012
65-69	3.82	0.139	0.005	0.37	0.016
70-74	2.64	0.184	0.007	0.787	0.026
75-79	1.90	0.238	0.009	1.39	0.041
80-84	0.989	0.304	0.008	2.14	0.064
85+	0.387	0.477	0.007	4.89	0.120

Notes: ISeg-Index of Segregation, IIsol-Index of Isolation, EG-Ellison-Glaesar concentration index, E- Entropy Index of Segregation

Table A19: Measures of Residential Sorting According to Age in Auckland, 2013

Age	Percentage of Population	ISeg	IIsol	EG	E
0-4	4.24	0.101	0.008	0.201	0.012
5-9	5.88	0.111	0.003	0.188	0.011
10-14	7.34	0.111	0.006	0.19	0.012
15-19	7.01	0.094	0.007	0.158	0.010
20-24	5.69	0.112	0.008	0.251	0.014
25-29	5.12	0.17	0.012	0.719	0.026
30-34	4.73	0.183	0.01	0.578	0.025
35-39	5.94	0.112	0.004	0.184	0.010
40-44	8.15	0.076	0.003	0.082	0.005
45-49	8.94	0.073	0.003	0.071	0.005
50-54	8.97	0.075	0.003	0.067	0.005
55-59	6.59	0.085	0.003	0.091	0.006
60-64	6.67	0.106	0.004	0.155	0.009
65-69	4.49	0.126	0.006	0.261	0.013
70-74	3.18	0.145	0.006	0.445	0.018
75-79	2.93	0.185	0.007	0.805	0.026
80-84	2.17	0.244	0.011	1.70	0.044
85+	1.95	0.326	0.018	3.00	0.077

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A20: Measures of Residential Sorting according to Total Personal Income in Auckland, 1991

Income	Percentage of Population	ISeg	IIsol	EG	E
Nil income /Loss	4.99	0.125	0.006	0.273	0.014
\$1-\$2500	5.17	0.113	0.006	0.203	0.012
\$2501 - \$5,000	3.31	0.087	0.002	0.088	0.007
\$5,001 - \$7,500	6.63	0.155	0.012	0.443	0.021
\$7501 - \$10,000	13.5	0.14	0.015	0.289	0.018
\$10,001 - \$15,000	14.6	0.097	0.007	0.127	0.009
\$15,001 - \$20,000	11.1	0.072	0.003	0.061	0.005
\$20,001 - \$25,000	9.87	0.064	0.002	0.046	0.004
\$25,001 - \$30,000	9.33	0.076	0.004	0.081	0.006
\$30,001 - \$40,000	10.6	0.11	0.008	0.194	0.014
\$40,001 - \$50,000	5.14	0.172	0.008	0.428	0.023
\$50,001 - \$700,00	3.41	0.264	0.013	1.142	0.048
\$70,001 or More	2.36	0.428	0.032	4.485	0.119

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A21: Measures of Residential Sorting According to Total Personal Income in Auckland, 1996

Income	Percentage of Population	ISeg	IIsol	EG	E
Loss	0.185	0.576	0.005	6.21	0.014
Zero Income	4.96	0.137	0.007	0.32	0.012
\$1 - \$5,000	9.61	0.075	0.004	0.079	0.007
\$5,001 - \$10,000	14.1	0.127	0.013	0.224	0.021
\$10,001 - \$15,000	14.6	0.11	0.01	0.183	0.018
\$15,001 - \$20,000	9.24	0.073	0.003	0.063	0.009
\$20,001 - \$25,000	8.83	0.079	0.003	0.078	0.005
\$25,001 - \$30,000	9.66	0.072	0.003	0.066	0.004
\$30,001 - \$40,000	12.6	0.087	0.006	0.114	0.006
\$40,001 - \$50,000	6.74	0.141	0.008	0.304	0.014
\$50,001 - \$70,000	5.10	0.216	0.012	0.684	0.023
\$70,001 - \$100,00	2.27	0.337	0.014	1.9	0.048
\$100,001 or More	2.06	0.466	0.034	5.167	0.119

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A22: Measures of Residential Sorting according to Total Personal Income in Auckland, 2001

Income	Percentage of Population	ISeg	IIsol	EG	E
Loss	0.738	0.228	0.003	0.739	0.036
Zero Income	4.85	0.121	0.005	0.231	0.012
\$1 - \$5,000	8.67	0.085	0.004	0.107	0.007
\$5,001 - \$10,000	11.0	0.115	0.008	0.183	0.011
\$10,001 - \$15,000	13.0	0.116	0.01	0.207	0.013
\$15,001 - \$20,000	8.46	0.081	0.003	0.082	0.006
\$20,001 - \$25,000	7.69	0.088	0.003	0.09	0.006
\$25,001 - \$30,000	8.53	0.084	0.003	0.085	0.005
\$30,001 - \$40,000	13.7	0.070	0.004	0.06	0.005
\$40,001 - \$50,000	8.60	0.100	0.005	0.142	0.010
\$50,001 - \$70,000	8.00	0.170	0.012	0.392	0.025
\$70,001 - \$100,000	3.52	0.277	0.014	1.17	0.052
\$100,001 or More	3.24	0.419	0.04	3.80	0.119

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A23: Measures of Residential Sorting According to Total Personal Income in Auckland, 2006

Income	Percentage of Population	ISeg	IIsol	EG	E
Loss	0.628	0.22	0.002	0.647	0.033
Zero Income	5.60	0.118	0.005	0.203	0.011
\$1 - \$5,000	7.51	0.087	0.004	0.12	0.007
\$5,001 - \$10,000	7.50	0.106	0.005	0.153	0.009
\$10,001 - \$15,000	10.5	0.116	0.008	0.201	0.011
\$15,001 - \$20,000	7.85	0.098	0.005	0.155	0.008
\$20,001 - \$25,000	6.77	0.086	0.003	0.09	0.006
\$25,001 - \$30,000	6.95	0.098	0.004	0.125	0.008
\$30,001 - \$35,000	6.84	0.085	0.003	0.089	0.006
\$35,001 - \$40,000	7.44	0.071	0.002	0.059	0.004
\$40,001 - \$50,000	10.2	0.074	0.003	0.07	0.005
\$50,001 - \$70,000	11.5	0.12	0.01	0.187	0.015
\$70,001 - \$100,000	5.59	0.21	0.013	0.614	0.034
\$100,001 or More	5.05	0.388	0.048	2.74	0.110

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A24: Measures of Residential Sorting According to Total Personal Income in Auckland, 2013

Income	Percentage of Population	ISeg	IIsol	EG	E
Loss	0.457	0.305	0.003	1.02	0.058
Zero income	8.59	0.123	0.008	0.218	0.014
\$1-\$5,000	6.34	0.092	0.004	0.14	0.008
\$5,001-\$10,000	5.25	0.104	0.004	0.164	0.009
\$10,001-\$15,000	7.99	0.105	0.005	0.141	0.009
\$15,001-\$20,000	8.46	0.112	0.007	0.233	0.011
\$20,001-\$25,000	6.55	0.1	0.004	0.174	0.008
\$25,001-\$30,000	5.56	0.078	0.002	0.076	0.005
\$30,001-\$35,000	5.15	0.08	0.002	0.061	0.005
\$35,001-\$40,000	5.7	0.083	0.002	0.077	0.006
\$40,001-\$50,000	9.27	0.065	0.002	0.043	0.004
\$50,001-\$60,000	7.73	0.07	0.002	0.057	0.005
\$60,001-\$70,000	5.99	0.083	0.003	0.084	0.007
\$70,001-\$100,000	8.97	0.143	0.01	0.27	0.020
\$100,001-\$150,000	4.73	0.254	0.016	0.94	0.049
\$150,001 or More	3.27	0.445	0.044	3.97	0.135

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaeser concentration index

E- Entropy Index of Segregation.

Table A25: Measures of Residential Sorting by Qualification in Auckland, 1991

Qualification	Percentage of Population	ISeg	IIsol	EG	E
No School Qualification	38.4	0.193	0.052	0.272	0.040
School Certificate	21.8	0.075	0.006	0.056	0.006
Sixth Form Certificate, University Entrance	17.6	0.141	0.017	0.253	0.019
Higher School Certificate, Higher Leaving Certificate	6.61	0.168	0.01	0.483	0.021
University Bursary, Scholarship	6.56	0.283	0.035	1.56	0.065
Overseas Qualification	4.34	0.283	0.035	1.56	0.025
Other School Qualification	4.67	0.172	0.008	0.54	0.023

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A26: Measures of Residential Sorting by Qualification in Auckland, 1996

Qualification	Percentage of Population	ISeg	IIsol	EG	E
School Certificate Qualification	13.2	0.084	0.005	0.08	0.0065
Sixth Form Qualification	10.7	0.072	0.004	0.066	0.0054
Higher School Qualification	6.08	0.16	0.014	0.44	0.0244
Basic Vocational Qualification	3.81	0.081	0.002	0.069	0.0054
Skilled Vocational Qualification	6.82	0.132	0.007	0.248	0.0154
Intermediate Vocational Qualification	1.63	0.162	0.003	0.345	0.0204
Advanced Vocational Qualification	9.05	0.165	0.013	0.392	0.0230
Bachelor Degree	7.15	0.31	0.041	1.693	0.0748
Higher Degree	2.99	0.341	0.023	2.332	0.0781
Overseas School Qualification	2.89	0.118	0.003	0.204	0.0115
No Qualification	35.6	0.239	0.078	0.426	0.0609

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A27: Measures of Residential Sorting by Qualification in Auckland, 2001

Qualification	Percentage of Population	ISeg	IIsol	EG	E
No Qualification	24.4	0.238	0.06	0.547	0.055
Fifth Form Qualification	15.4	0.091	0.007	0.098	0.008
Sixth Form Qualification	12.1	0.058	0.003	0.034	0.003
Higher School Qualification	7.20	0.14	0.011	0.35	0.019
Other NZ Secondary School Qualification	0.02	0.924	0.003	36.657	0.283
Overseas Secondary School Qualification	7.89	0.139	0.009	0.276	0.016
Basic Vocational Qualification	4.18	0.062	0.001	0.028	0.003
Skilled Vocational Qualification	4.93	0.136	0.005	0.249	0.014
Intermediate Vocational Qualification	2.07	0.104	0.001	0.116	0.008
Advanced Vocational Qualification	8.65	0.143	0.009	0.28	0.017
Bachelor Degree	9.40	0.277	0.04	1.198	0.063
Higher Degree	3.73	0.312	0.022	1.806	0.067

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A28: Measures of Residential Sorting by Qualification in Auckland, 2006

Qualification	Percentage of Population	ISeg	IIsol	EG	E
No Qualification	22.5	0.247	0.061	0.606	0.057
Level 1 Certificate	13.2	0.099	0.007	0.119	0.009
Level 2 Certificate	11.1	0.053	0.002	0.027	0.003
Level 3 Certificate	9.67	0.086	0.007	0.184	0.010
Level 4 Certificate	9.10	0.12	0.007	0.179	0.012
Level 5 Diploma	4.05	0.096	0.002	0.116	0.007
Level 6 Diploma	5.38	0.14	0.006	0.278	0.015
Bachelor Degree and Level	13.0	0.245	0.04	0.789	0.053
Post-graduate and Honours	1.79	0.278	0.009	1.32	0.050
Masters Degree	2.37	0.282	0.011	1.35	0.054
Doctorate Degree	0.497	0.436	0.006	3.58	0.101
Overseas Secondary School	7.33	0.149	0.009	0.316	0.017

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.

Table A29: Measures of Residential Sorting by Qualification in Auckland, 2013

Qualification	Percentage of Population	ISeg	IIsol	EG	E
No Qualification	17.01	0.237	0.048	0.628	0.0516
Level 1 Certificate	11.49	0.12	0.009	0.184	0.0132
Level 2 Certificate	10.46	0.072	0.003	0.064	0.0050
Level 3 Certificate	10.61	0.082	0.009	0.178	0.0102
Level 4 Certificate	8.419	0.129	0.008	0.22	0.0138
Level 5 Diploma	4.423	0.08	0.002	0.056	0.0050
Level 6 Diploma	4.984	0.127	0.005	0.212	0.0123
Bachelor Degree and Level 7 Qualification	16.4	0.201	0.033	0.472	0.0379
Post-graduate and Honours Degrees	2.93	0.224	0.009	0.77	0.0361
Masters Degrees	3.56	0.247	0.012	0.939	0.0441
Doctorate Degree	0.747	0.409	0.008	2.99	0.0971
Overseas Secondary School Qualification	8.92	0.158	0.012	0.358	0.0198

Notes

ISeg-Index of Segregation

IIsol-Index of Isolation

EG-Ellison-Glaesar concentration index

E- Entropy Index of Segregation.