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Towards Superdiverse Aotearoa: Dimensions of Past and Future Ethnic Diversity in New Zealand and its Regions

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Abstract

We use census data for New Zealand, nationally since 1945 and regionally since 1996, to quantify ethnic diversity trends using summary measures. Additionally, we generate national and subnational ethnic population projections by means of a cohort change method that permits a higher level of disaggregation than Stats NZ's official projections. On average, we find that diversity will be growing faster in less-diverse regions. However, when we divide regions into non-overlapping high-, medium- and low-diversity groups, we find that these groups persist over time, but with notable changes in diversity ranking projected to occur within the medium-diversity group. Future research on growing diversity could usefully focus on those regions.

Keywords: superdiversity; ethnic diversity; population projections

Aotearoa New Zealand is an incredibly diverse country in terms of ethnicity of the population. In the 2013 Census (the latest census for which data were available at the time of writing), Statistics New Zealand recorded over 80 ethnic groups that each had at least 1000 members, in a total population of around 4.2 million (Statistics New Zealand, 2014a).[1] Increasing diversity has a long history. After initial contact with Europeans, Aotearoa New Zealand remained 98% Māori until the Treaty of Waitangi was signed in 1840, after which diversity resulted –

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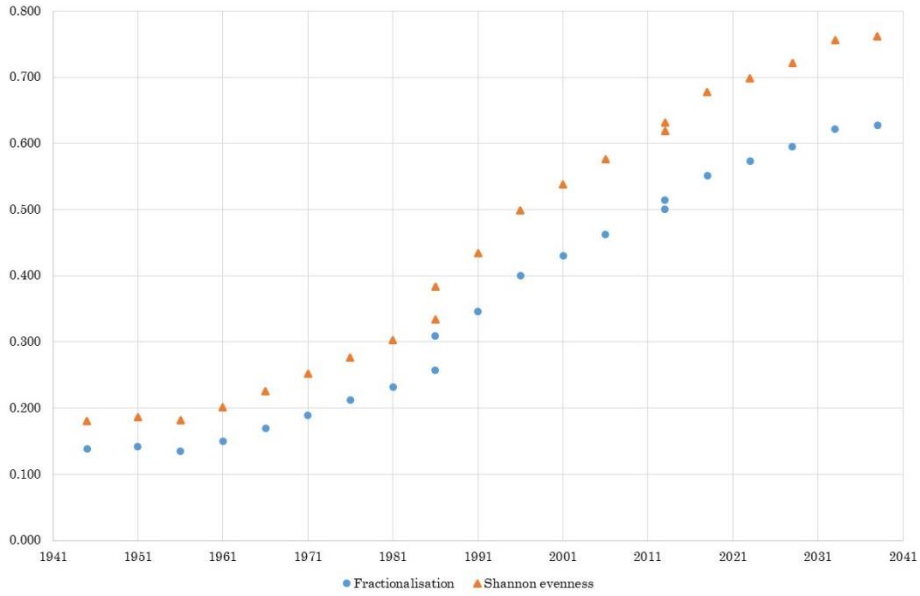
in a mathematical sense – during the remainder of the 19th century. This was a result of Māori population decline due to disease and war, combined with large migratory flows from Britain and high fertility among the settlers (Pool, forthcoming). From the early 20th century, migration from Britain continued and, since the 1950s, has combined with successive waves from mainland Europe, the Pacific, and more recently from Asia. Even though those calling themselves 'New Zealand European' remain more than half of the population, Aotearoa New Zealand can be credibly labelled a 'superdiverse' country, certainly in terms of the metropolitan areas (Spoonley, 2014).

To illustrate the growth in ethnic diversity since the latter half of the 20th century, Figure 1 displays the trends in two summary indices of diversity at the national level since 1945, using census data from 1945 to 2013 and official projections of ethnicity for 2013 to 2038. The first index is the *fractionalisation index*, which measures the chance that two randomly selected individuals do not have the same ethnicity. The second index is the *Shannon evenness index*, which originates from information theory. Further details on both measures will be given later in the paper.[2] Even though the measurement of ethnicity has varied radically over the decades, starting with being race- and ancestry-based, to prioritised assignment of ethnicity, to total responses, these measures at the macro level are quite robust to definitional changes, with one exception – until 1986, each individual in the census was assigned only one ethnic identifier, even if they reported multiple ethnic affiliations. From 1986 onwards, ethnicity has been tabulated on the basis of total responses; i.e. counting those people who reported more than one ethnicity multiple times. To illustrate the difference, Figure 1 displays measures for 1986 based on both definitions. Allowing for multiple responses of course increases the chance that two randomly selected individuals have at least one ethnicity not in common, resulting in a step-change increase in measured diversity in 1986. The recording of multiple responses, therefore, led to an upward shift in the diversity measures.

Figure 1 has been constructed in terms of having five ethnic groups defined: (1) Māori, (2) Pacific, (3) Asian, (4) Middle Eastern, Latin American, or African, and (5) European and ethnicities other than those aforementioned. Figure 1 clearly shows the dramatic increase in ethnic diversity over the seven decades since World War II. The chance of two

randomly selected individuals having different ethnicities was only 15 per cent in the 1950s but increased to more than 50 per cent by 2013. Only once did diversity appear to decline in an inter-censal period: between 1951 and 1956. This is due to a large wave of migration from the Netherlands to New Zealand at that time, encouraged by the governments of both countries (van der Pas & Poot, 2011).

Figure 1: Ethnic diversity of the New Zealand population, 1945–2013 (historical) and 2018–2038 (projected, based on ethnic classification at level 1)



Note: The fractionalization index is defined in Equation (1); the Shannon evenness index is defined in Equation (3). From 1986 onwards, ethnicity is tabulated on the basis of total responses. For 1986, the smaller index values are those calculated by means of tabulation of prioritised ethnicity. For 2013, the figure shows index values based on actual census data and index values based on the base population for the population projections (the latter yield slightly higher diversity).

The Dutch immigrants boosted the numbers of those assigned to the European ethnicity, and thereby reduced the growth in ethnic diversity. Figure 1 also displays future diversity growth derived from 2017 national ethnic population projections with a base year of 2013. Due to using a slightly different resident population base than the census population, diversity in the projections starts off slightly higher than in the census.

Figure 1 shows that diversity is projected to continue to increase in the future, with some levelling off by the 2030s.

A diverse population comes with both opportunities and challenges. The CaDDANZ (Capturing the Diversity Dividend of Aotearoa/New Zealand) research programme has the underlying premise that there is a diversity dividend to be identified and measured (see caddanz.org.nz). However, investigating the existence and extent of any such diversity dividend is beyond the scope of this paper. Instead, we focus on a much simpler question: How has ethnic diversity in Aotearoa New Zealand changed over time, and how is it projected to change in the future? In investigating this question, we seek not only to understand the ethnic diversity for Aotearoa New Zealand in aggregate, but also ethnic diversity in each of its sixteen regions.

Understanding our country's past and projected future experience of diversity at both the national and regional levels is important for a number of reasons. Looking at the past allows us to recognise how rapidly (or otherwise) diversity has increased in Aotearoa New Zealand overall, and in each region. Some regions have clearly experienced a rapid increase in diversity, while others have thus far remained relatively unaffected. Understanding the changing diversity of Aotearoa New Zealand's regions may help to contextualise other socio-economic trends. Moreover, recognising that not all places have seen the same changes in ethnic diversity may also help us to contextualise differences in the responses of different regions to diversity.

Looking to the future is equally, if not more, important. Many public services are targeted at particular ethnic groups (Callister, 2007), so recognising the population trajectory (in terms of size, age distribution and spatial distribution) is important for planning future public services. Investments in health, education and community services infrastructure in part depend on understanding future ethnic diversity. Moreover, the private sector and non-government organisations also need to understand the potential future demand for their services, and this in turn depends in part on future ethnic diversity.

However, measuring past and future diversity comes with a number of challenges and, as we explain below, projecting future ethnic populations requires a number of additional assumptions that render traditional methods of population projection largely infeasible. In this paper, we present

a mostly descriptive analysis of past and future trends in ethnic diversity for Aotearoa New Zealand and its regions. We focus on the inter-regional comparisons and trends over time, as this will be of most use in interpreting past and projected future socio-economic trends. A more thorough explanation of the underlying models will be available in a future paper by the same authors.

Over the last decade, there has also been growing interest internationally in projecting ethnic populations at subnational levels. In the United Kingdom, much of the research has been conducted by a group at Leeds University (see, for example, Rees et al. (2012), or Frey (2015) for the USA). A brief literature review is provided in Lomax, Wohland, Rees, and Norman (2019). In most cases, ethnic projections are based on applying ethnic-group-specific assumptions regarding fertility, mortality, migration and inter-ethnic mobility to a conventional cohort-components projection model. However, this is only feasible at a relatively low level of spatial and ethnic disaggregation.

Our paper makes several contributions to the New Zealand literature. First, we extend the extant literature measuring diversity (and residential sorting) in Aotearoa New Zealand by considering *all* of New Zealand's regions. Previous studies have, for the most part, considered Auckland as a case study. Second, we consider ethnicity at a more disaggregated level than extant studies, which have usually considered only broad ethnic groups (specifically European/Pākehā, Māori, Pacific, Asian). Third, we look at both past *and* future diversity, while most previous studies have exclusively focused on past diversity. Finally, we use a different method for ethnic population projections than is used in Stats NZ's official population projections.

Measurement of diversity in Aotearoa New Zealand

There are many ways to measure the (ethnic) diversity of the population in a geographical setting. These can be broadly grouped into two types (see Nijkamp and Poot, 2015) that measure either: (1) how diverse the population is *in* particular areas (allowing for comparing diversity values across areas), or (2) how the spatial distribution of groups varies *across* areas – also referred to as segregation or sorting. In this paper, we focus on the former approach, but most of the New Zealand literature has been concerned with

the latter. The two approaches are of course not independent: when individuals are strongly sorted across areas in terms of their ethnicity, i.e. when segregation is high, the diversity of any specific area is likely to be relatively low. Consequently, we need to consider how individuals belonging to different ethnic groups are allocated both within and across geographical areas.

In New Zealand, several studies have investigated ethnic diversity using one (or more) measures of residential sorting. These studies are heavily dependent on research from two research teams, centred firstly on the University of Bristol and Macquarie University, and secondly on Motu Economic and Public Policy Research. From the former research team, Johnston, Poulsen, and Forrest (2002) used data from the 1996 Census of Population and Dwellings, and their preferred measure of sorting was the proportion of the population of each ethnic group compared with a variety of threshold values. They found substantial concentration of Pacific Island and Māori populations, with the majority of Pacific Peoples and one third of Māori in Auckland living in a meshblock where the majority of the population were Pacific Peoples. In contrast, Asians were not concentrated, while Europeans were concentrated in areas where they dominated. Johnston et al.'s (2002) analysis considered fairly disaggregated groups (24 ethnic groups), but only considered the Auckland urban area, and at only one point in time.

Johnston, Poulsen, and Forrest (2005) then extended this analysis over time and over different urban areas, using census data from 1991 and 2001, and with a specific focus on Māori. They found that the higher the proportion of Māori in the population, the more segregated those Māori were into separate residential areas. The degree of sorting of Māori was less in Auckland (and Wellington) than in other regions, due to the co-location of Māori with Pacific Peoples. Johnston, Poulsen, and Forrest (2008) instead focused on the Asian and Pacific ethnic groups, again using threshold-based measures of sorting, limited to the Auckland region but including all four censuses from 1991 to 2006. They demonstrated a pattern of 'dispersed concentration', with different Asian and Pacific ethnic subgroups concentrated in different neighbourhoods of Auckland. They also noted that Asian subgroups share geographic areas with Europeans to a much greater extent than do Māori or Pacific Peoples. Johnston, Poulsen, and Forrest (2011) used Moran's I and Getis and Ord's G^* on census data from 1991 to

2006 to investigate the clustering of ethnic groups in the Auckland region. They found that Europeans were most likely to cluster in areas where they were a majority, and in contrast, in areas where Asian groups clustered, Asians were not the dominant ethnic groups. Pacific Peoples and Māori lay between these two extremes.

From the second research team, Maré, Coleman, and Pinkerton (2011) used data for the Auckland region from the 2006 Census and confirmed the existence of substantial clustering of ethnic groups (European/Pākehā, Māori, Pacific, Asian), as well as clustering by country of birth. Maré and Coleman (2011) extended the analysis by investigating data from the 1996, 2001 and 2006 Censuses, and confirmed a similar level of clustering in each census. Maré, Pinkerton, Poot, and Coleman (2012) used data on the 2006 Census, again limited to the Auckland region, and applied a battery of different measures of residential sorting. They found that ethnicity-based sorting is stronger than sorting by other variables (including birth country, income, age and education), and that the Māori and Pacific ethnic groups tend to co-locate while other groups tend to locate in different areas. Maré, Pinkerton, and Poot (2016) followed birth cohorts from different countries across censuses from 1996 to 2006 who resided in Auckland and found that their residential location became less clustered over time. They concluded that "persistent concentration of immigrant groups within Auckland is nevertheless the outcome of a dynamic process of ongoing adjustment" (Maré et al., 2016, p. 392).

More recently, additional research has been conducted at the University of Waikato. Mondal, Cameron, and Poot (2019) used data from the Auckland region from 1991 to 2013, and more disaggregated (n = 18) ethnic groups than much of the earlier research. They confirmed that many of the results from earlier research apply when more disaggregated groups are considered, including the primacy of residential sorting by ethnicity in comparison with other variables (specifically income, age, education and occupation). They also found that smaller ethnic groups, such as the African, Latin American/Hispanic, Tokelauan and 'Other Pacific Island' groups, were consistently the most residentially sorted, while the least residentially sorted ethnic groups were consistently the New Zealand European, Other European, and New Zealand Māori groups. Looking over time, the Chinese ethnic group became more segregated from 1991 to 2006 (with little change since then), while the Indian ethnic group became more segregated

throughout the period since 1991. Overall, they found that evenness of ethnic distribution in Auckland (i.e. how evenly distributed ethnic groups are compared with their overall proportions of the population) has been increasing over time generally. This accords with an anecdotal perception of increasing diversity of the Auckland population, both in total and across different neighbourhoods and suburbs.

To summarise, the research on the diversity of the New Zealand population has focused extensively on the Auckland region. Much less research has been devoted to understanding diversity (or residential sorting) in areas outside Auckland. Moreover, much of the research has been limited by considering highly-aggregated ethnic groups. This potentially hides important heterogeneity in the residential sorting of smaller component subgroups. For instance, understanding the residential sorting of the Pacific ethnic group probably tells us little about the sorting of the Fijian, Samoan or Tokelau ethnic groups. Indeed, Mondal et al. (2019) showed that sorting of subgroups within broad ethnic groups is increasingly becoming the dominant feature of ethnic residential sorting. For example, over time in Auckland, there have been fewer suburbs that are generic Pacific Island communities, with Samoan, Tongan and other Pacific ethnic subgroups increasingly located separately from each other.

Data, methods and population projections model

The measurement of ethnic diversity is not straightforward. There are several issues that must be considered. The first and biggest issue is how to classify and count individuals. This issue arises because ethnicity is not a characteristic that allows people to be easily separated into mutually exclusive categories. Since each person can affiliate with more than one ethnicity (and in the New Zealand Census, up to six ethnicities can be recorded for each person),[3] in order to create mutually exclusive categories for analysis, assumptions about how the categorisation is to be conducted are required.

To illustrate this challenge, consider the New Zealand Standard Classification of Ethnicity, as presented in Table 1. Table 1 shows the classification at two levels. Level 1 categorises ethnic affiliation into six groups: (1) European, (2) Māori, (3) Pacific, (4) Asian, (5) Middle Eastern, Latin American, or African, and (6) Other. Level 3 of the classification

consists of 37 ethnicities, each of which is a subgroup of one of the Level 1 ethnicities (except for Māori, which is a unique category at both Level 1 and Level 3 of the classification).

If each person was affiliated to a single ethnicity, then categorisation would be trivial. However, because a person can affiliate to more than one ethnicity, at Level 1 there are 15 possible single or multiple-ethnicity combinations that involve just one or two ethnicities. This extends to 703 single or multiple-ethnicity combinations involving just one or two ethnicities at Level 3. If you consider the possibility of six ethnicities, then the number of potential single or multiple-ethnicity combinations at Level 3 increases to about 2.8 million. In reality, most combinations will have zero, or very few people, but even then, a means of managing this complexity is required.

One frequently adopted approach is to use prioritised ethnicity, which was the default approach in most research in New Zealand until relatively recently. This approach first assumes that any person who reports Māori as one of their ethnicities is Māori. Then, each person who is not Māori but reports Pacific as one of their ethnicities is allocated to the Pacific ethnic group. Then, each person who is not Māori or Pacific, but reports Asian as one of their ethnicities is allocated to the Asian ethnic group. Then, everyone else is allocated to a merged 'European or Other' category. This approach ensures that every person is allocated to one, and only one, category. An analogous approach can be used to develop prioritised ethnicity at Level 3, but with more steps involved. This appears to have been the approach in all the research cited in the previous section, with the exception of Mondal et al. (2019).

The key limitation with adopting a prioritised ethnicity approach for the purposes of measuring ethnic diversity or residential sorting is that it ignores a lot of diversity that arises from multiple-ethnic affiliation. That is, a person who identifies as both Māori and Fijian is considered only to be Māori, which necessarily underestimates the diversity of the population. The impact at the macro level was demonstrated by the difference in the diversity measures for 1986 in Figure 1, with prioritisation lowering diversity by 15–20%. This presents problems both cross-sectionally, as well as over time, if people change their ethnic affiliations, adopting new ethnicities and dropping previous ethnicities.

Table 1: NZ Standard Classification of Ethnicity, Level 1 and Level 3

Level 1 Classification	Level 3 Classification
1 European	100 European nfd
	111 New Zealand European
	121 British and Irish
	122 Dutch
	123 Greek
	124 Polish
	125 South Slav
	126 Italian
	127 German
	128 Australian
	129 Other European
2 Māori	211 Māori
3 Pacific Peoples	300 Pacific Peoples nfd
	311 Samoan
	321 Cook Islands Maori
	331 Tongan
	341 Niuean
	351 Tokelauan
	361 Fijian
	371 Other Pacific Peoples
4 Asian	400 Asian nfd
	410 Southeast Asian nfd
	411 Filipino
	412 Cambodian
	413 Vietnamese
	414 Other Southeast Asian
	421 Chinese
	431 Indian
	441 Sri Lankan
	442 Japanese
	443 Korean
	444 Other Asian
5 Middle Eastern/Latin American/African	511 Middle Eastern
	521 Latin American
	531 African
6 Other Ethnicity	611 Other Ethnicity

Note: nfd = not further defined.

An alternative approach is to base the measurement of diversity not on *individuals*, but on *reported ethnicities*. By this approach, each reported ethnicity counts once within the measure of diversity (or residential sorting). Individuals who report multiple ethnic affiliations would therefore appear more than once within the calculation. However, this ensures that multiple-ethnic affiliation, and changes in multiple-ethnic affiliation over time, are captured within the measures of diversity and residential sorting. This is the approach that was adopted by Mondal et al. (2019).

The second and related issue for the measurement of ethnic diversity is what level of disaggregation to use. As noted in the literature review above, many New Zealand studies have used Level 1 of the Standard Classification of Ethnicities, including Maré et al. (2011) and related studies. Johnston et al. (2002) appear to have used Level 3 of the classification (or something closely related to it), while their subsequent studies have used either that classification or a more aggregated version of it. Mondal et al. (2019) used Level 2 of the classification, which is a mid-way point between the two classifications noted in Table 1 above. The problem with using highly aggregated broad ethnic groups as a classification is that this masks potentially important heterogeneity. Moreover, it ignores any ethnic diversity that arises when an individual affiliates to more than one ethnicity, where two or more of their reported ethnicities are captured within the same broader ethnic group. For instance, a person who affiliates with Fijian and Samoan would only be recorded in the Pacific group if the Level 1 classification is used.

To avoid ignoring potentially important ethnic heterogeneity, we adopt Level 3 of the Standard Classification of Ethnicities, as reported in Table 1 above. We acknowledge that some aggregation of substantively heterogeneous ethnic groups remains at that level of the classification (e.g. African, or Latin American, as single ethnic groups). However, we believe that this strikes an appropriate balance between capturing the heterogeneity across the population and ensuring that there are adequate cell sizes to be included in the analysis.

The third issue is which measure of diversity to adopt. A commonly used measure in the literature is the *fractionalisation index* (e.g. Alesina, Devleeschauwer, Easterly, Kurlat, & Wacziarg, 2003). As noted in the introduction, this index measures the probability that two randomly selected individuals do not have the same ethnicity. Let P_{ga} refer to the

population of group g in area a and $P_{\bullet a}$ to the population of area a. Mathematically, the fractionalisation index is then calculated as:

$$F_a = 1 - \sum_{g=1}^{G} \left(\frac{P_{ga}}{P_{\bullet a}}\right)^2 \quad (1)$$

A theoretically attractive measure is the *Shannon diversity index* from information theory (see Nijkamp & Poot, 2015). The Shannon diversity index S_a of area a is given by:

$$S_a = -\sum_{g=1}^{G} \left(\frac{P_{ga}}{P_{\bullet a}}\right) ln \left(\frac{P_{ga}}{P_{\bullet a}}\right) \quad (2)$$

This measure is also referred to as the Shannon-Wiener, Shannon-Weaver or *entropy index*. The index varies between zero (when there is only one ethnicity present) and a maximum of $\ln(G)$ when all G ethnicities have an equal number of members.[4] In order to easily compare populations that have coarse (small G) or fine (large G) classifications, the literature recommends the use of the Shannon evenness index, which divides S by $\ln(G)$.[5] This is the approach we adopt here. The *Shannon evenness index* for area a is given by:

$$SE_a = -\frac{\left(\sum_{g=1}^{G}\left(\frac{P_{ga}}{P_{\bullet a}}\right) ln\left(\frac{P_{ga}}{P_{\bullet a}}\right)\right)}{ln(G)} \quad (3)$$

In our specific application, G is equal to the five groups we use at Level 1 of the ethnicity classification, or the 37 ethnic groups we use at Level 3 (see Table 1). The fractionalisation index does not correct for the effect of varying the number of groups. However, Figure 1 shows that at the Level 1 ethnic classification, the upward trends in the fractionalisation and Shannon evenness indexes are very similar, although slightly diverging in the projections. We report our historical measures of ethnic diversity for each of New Zealand's sixteen regions, and for New Zealand as a whole, for each census from 1996 to 2013. This is based on census data for the aggregate number of people reporting each of the 37 Level 3 ethnicities in each region in each census.

In terms of projected future ethnic populations, the official Stats NZ national and subnational ethnic population projections are produced by means of a stochastic Bayesian cohort component method (e.g. Stats NZ, 2017). However, the data requirements of the method necessarily limit the

size of ethnic groups that can be projected. Stats NZ currently produces projections only for all Level 1 ethnic groups, and for the three largest Level 2 ethnic groups (Chinese, Indian and Samoan).

In this paper, we adopt an alternative population projections method, the *Hamilton-Perry method* (Hamilton & Perry, 1962), which can be applied to feasibly produce population projections for much smaller population groups. This method has recently been revived as a means of projecting small *area* populations and has been used in several applications recently in the USA (e.g. Baker, Swanson, Tayman, & Tedrow, 2017). For example, Swanson, Schlottmann and Schmidt (2010) use the method to produce population projections for 356 census tracts in Clark County, Nevada (total population approximately 1.4 million) for a 20-year projection horizon. They demonstrate that the method produces plausible results for small populations (see also Swanson & Tayman, 2017). We instead apply the method to project small *ethnic group* populations.

The Hamilton-Perry method, which is based on cohort change ratios, is deceptively simple. Essentially, using two census data sets five years apart, a *cohort change ratio (CCR)* is calculated for each five-year age-sex cohort. Each five-year age-sex cohort can then be projected forward based on this ratio. The exception is the age cohort 0–4 years, which is instead projected based on the *child:woman ratio (CWR)*, using the number of women aged 20–44 years. To illustrate, say that the population of a particular male group aged 5–9 years in the 1996 Census was 650, and the population of the corresponding male group in the 2001 Census, now aged 10–14 years, was 700. The CCR for the 10–14-year age group is 700/650 = 1.077. If the population of the male group aged 5–9 years in the 2001 Census was 620, then the projection for the population in that group aged 10–14 years in 2006 is 620*1.077 = 668. Similarly, if the number of women aged 20–44 in the 1996 Census was 2500, and the number of girls aged 0–4 in the 2001 Census was 500, then the CWR for girls is 500/2500 = 0.2. Thus, if the number of women aged 20–44 in the 2001 Census was 3000, the number of girls aged 0–4 in 2006 is then projected to be 3000*0.2 = 600.

In our case, we calculated CCRs for each five-year age-sex group for each of the 37 Level 3 ethnic groups, both nationally and individually for each region. CCRs were calculated for the most recent two inter-censal periods (2001–2006 and 2006–2013), and an average of the two was used for the projections model. Taking an average of the last two inter-censal periods

not only smooths the estimated CCRs, thereby removing some of the noise from the estimates, but also takes account of New Zealand's roughly ten-year international migration cycle, as described by Poot (2010). Similarly, we calculated CWRs for the same two inter-censal periods and averaged them for the projections model.

Despite the smoothing obtained by averaging across two inter-censal periods, some CCRs and CWRs remain implausibly high, or low. Therefore, following Swanson et al. (2010), we constrained the five-year CCRs to be between 0.9 and 1.25 and the five-year CWRs to be between 0.16 and 0.3. These constraints are necessary in order to avoid implausibly large changes in projected inter-censal populations, which could not be reasonably justified by underlying patterns in fertility, mortality and migration.

A concern could be raised about the *seven*-year inter-censal period being used for calculating the CCRs and CWRs for the most recent period (2006–2013). However, somewhat surprisingly, this does not pose an issue. Because the ratio is taken between two five-year age cohorts, it actually matters little that the ratio is taken seven years apart. While the individuals who are included in each cohort in these two successive census years will not be exactly the same, the assumption that the cohort of individuals included in the calculation at each census be the exact same cohort is not necessary for the Hamilton-Perry model to generate reasonable projections.[6]

We then used the smoothed and constrained CCRs and CWRs to project the population forward in five-year steps, using the 2013 Census usually resident population (CURP) as a base population. We projected all 37 Level 3 ethnic populations at the national level using the method described above, as well as all Level 3 ethnic populations at the regional level where the 2013 population of that ethnic group exceeded 150 members. This limits the extent to which our results are biased by small populations. For regional ethnic groups with fewer than 150 members, we assumed that they grow at the same rate as the national population of that ethnic group. We did not constrain the projected regional populations to sum to the projected national population of the same ethnicity. In the context of projecting summary diversity measures, this is not problematic.

We used the CURP as the base population as opposed to the estimated usually resident population (EURP), as there are no official EURPs produced for Level 3 ethnic groups nationally or subnationally – such population estimates are only produced by Stats NZ for the Level 1

ethnic groups. Given that the main difference between CURPs and EURPs relates to net census undercount, our projections will necessarily underestimate the population of each ethnic group. However, they can be interpreted as a projection of future CURPs, which are based on responses to the census ethnicity questionnaire. The proportional changes in the size of the population will be unbiased to the extent that future net census undercount, by age and ethnic group, is similar to net census undercount in the censuses between 2001 and 2013 that were used to estimate our CCRs and CWRs.[7] Similarly, the projected diversity measure will also be unbiased in that case.

Finally, we classified the regions into three groups – low diversity, medium diversity and high diversity – based on their past and future trajectories in terms of ethnic composition. As shown below, the three groups are distinct and the groupings are unambiguous, in the sense that regions in a lower-diversity group are not currently, and are never projected to be, more diverse than those in a higher-diversity group.

Ethnic diversity in New Zealand and its regions, 1996–2013

Table 2 presents the total ethnic responses by Level 3 ethnic group (as percentages of the total number of persons who stated at least one ethnicity) for New Zealand as a whole for each census from 1996 to 2013, along with the resulting Shannon evenness index. The largest ethnic group throughout this period is the New Zealand European group, although its dominance is decreasing; it represented over 72 per cent of recorded ethnic responses in 1996, but little more than 60 per cent in 2013. Māori are the second largest group, although the percentage of respondents who reported to be Māori has also decreased, from 15.1 per cent in 1996 to 13.2 per cent in 2013. In contrast, many other ethnic groups have increased substantially in size and proportion. For instance, Chinese increased from 2.4 per cent in 1996 to 3.8 per cent in 2013, Indian increased from 1.2 per cent to 3.4 per cent, and Filipino increased from 0.2 per cent to 0.9 per cent.

The Shannon evenness index does not show a clear trend, falling from 1996 to 2001, before increasing between 2001 and 2006, and then falling again between 2006 and 2013. This has resulted from large changes in the wording of the ethnicity question and the guidance provided for answers to this question in successive censuses. Several of the European

groups decreased substantially between 1996 (when they were separate options available to be selected on the census form) and 2001 (when they were not). One notable example is the case of the Dutch population (see van der Pas and Poot, 2011), where the percentage dropped from 1.37 per cent in 1996 to 0.77 per cent in 2001. However, the most dramatic decline was that of the British and Irish, from 11.74 per cent in 1996 to 2.16 per cent in 2001. The unusual shifts before and after 2006 largely arise from the behaviour of the 'Other Ethnicity' group. This group includes the 'New Zealander' category, which attracted a large number of responses in the 2006 Census, but fewer before or since. Table 2 does not contradict the 1996–2013 increase in the Shannon evenness index shown in Figure 1. It can be shown that if the Level 3 European ethnicity groups and 'Other Ethnicity' group are amalgamated, the evenness index shows a steady increase from 0.290, to 0.333 in 2001, 0.367 in 2006 and 0.406 in 2013. However, because we focus on projecting all Level 3 ethnic groups, we continue to work with all 37 ethnic groups in the remainder of the paper. We return to this point in the concluding section, as it creates a potential issue for the projection of the 'Other Ethnicity' population group.

Table 3 summarises the calculated Shannon evenness index, by region and for New Zealand as a whole, for each census from 1996 to 2013. The index values for 2013, nationally and by region, are also illustrated in Figure 2. As noted in the previous section and listing regions in descending order of diversity, we separate the regions into a high-diversity group (Auckland, Wellington, Waikato), a medium-diversity group (Bay of Plenty, Northland, Hawke's Bay, Manawatu-Wanganui, Gisborne, Canterbury, Otago, Nelson), and a low-diversity group (Taranaki, Marlborough, Southland, West Coast, Tasman). As at the national level, the Shannon evenness index values have bounced around for the regions. However, the general trend has been of increasing diversity, and the relative rankings of the regions have remained fairly consistent. The regions in the high-diversity group have been the three most-diverse regions since 2001 (Waikato was ranked fifth in 1996). The regions in the low-diversity group have been the five least diverse regions in every census, with one exception (Taranaki was ranked 11th in 2001). Note that only Auckland and Wellington have a diversity level consistently above the national average in all censuses from 1996 to 2013.

Table 2: Ethnic diversity (Level 3 total responses) in NZ, 1996–2013 (%)

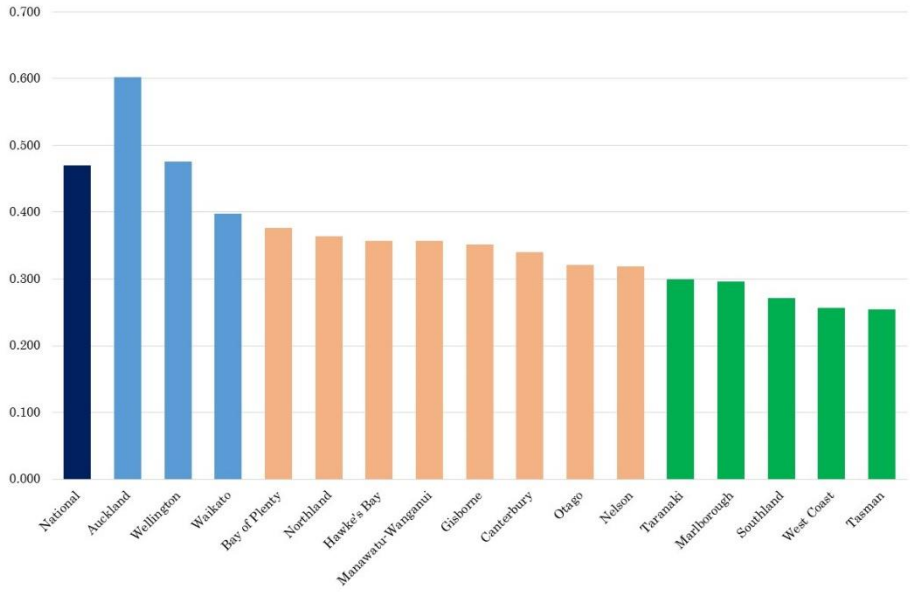
Ethnic Group	1996	2001	2006	2013
European nfd	0.07	0.60	0.50	0.58
New Zealand European	61.46	68.11	55.02	60.17
Other European nfd	0.88	0.01	0.00	0.00
British and Irish	10.02	1.96	2.33	2.33
Dutch	1.17	0.69	0.66	0.63
Greek	0.09	0.06	0.05	0.05
Polish	0.09	0.05	0.05	0.05
South Slav	0.22	0.15	0.13	0.12
Italian	0.12	0.07	0.07	0.08
German	0.33	0.23	0.25	0.28
Australian	1.32	0.52	0.61	0.50
Other European	1.23	1.23	1.57	1.79
Māori	12.88	13.29	13.06	13.21
Pacific Peoples nfd	0.01	0.02	0.02	0.02
Samoan	2.50	2.90	3.03	3.18
Cook Islands Maori	1.16	1.33	1.34	1.36
Tongan	0.77	1.03	1.17	1.33
Niuean	0.45	0.51	0.52	0.53
Tokelauan	0.12	0.16	0.16	0.16
Fijian	0.19	0.18	0.23	0.32
Other Pacific Peoples	0.12	0.17	0.19	0.24
Asian nfd	0.05	0.10	0.05	0.10
Southeast Asian nfd	0.00	0.01	0.01	0.03
Filipino	0.20	0.28	0.39	0.89
Cambodian	0.11	0.13	0.16	0.19
Vietnamese	0.07	0.09	0.11	0.15
Other Southeast Asian	0.23	0.27	0.35	0.47
Chinese	2.00	2.65	3.41	3.78
Indian	1.04	1.57	2.42	3.42
Sri Lankan	0.12	0.18	0.19	0.25
Japanese	0.18	0.25	0.28	0.31
Korean	0.31	0.48	0.71	0.67
Other Asian	0.06	0.09	0.20	0.28
Middle Eastern	0.23	0.35	0.40	0.45
Latin American	0.06	0.08	0.15	0.29
African	0.09	0.18	0.25	0.30
Other Ethnicity	0.03	0.02	9.96	1.50
Shannon evenness index	*0.424*	*0.380*	*0.492*	*0.470*

Note: The percentages refer to the number of census respondents who stated an ethnicity in the listed ethnic group as a percentage of the total number of census respondents who stated at least one ethnicity. The Shannon evenness index is based on the distribution of total responses.

Table 3: Shannon evenness index (Level 3 ethnicities), nationally and regionally, 1996–2013

Region	1996	2001	2006	2013
National	0.424	0.380	0.492	0.470
High-diversity regions				
Auckland	0.538	0.515	0.612	0.602
Wellington	0.458	0.400	0.499	0.476
Waikato	0.371	0.320	0.423	0.398
Medium-diversity regions				
Bay of Plenty	0.373	0.310	0.408	0.376
Northland	0.378	0.308	0.396	0.364
Hawke's Bay	0.346	0.293	0.395	0.357
Manawatu-Wanganui	0.342	0.281	0.387	0.357
Gisborne	0.357	0.307	0.379	0.351
Canterbury	0.308	0.245	0.381	0.340
Otago	0.292	0.222	0.355	0.321
Nelson	0.313	0.235	0.361	0.318
Low-diversity regions				
Taranaki	0.291	0.222	0.339	0.299
Marlborough	0.268	0.196	0.339	0.296
Southland	0.256	0.190	0.313	0.271
West Coast	0.246	0.175	0.307	0.257
Tasman	0.270	0.184	0.313	0.255

Figure 2: Shannon evenness index, 2013, based on ethnic classification at Level 3



Projected ethnic diversity in New Zealand and its regions, 2013–2038

Table 4 summarises the calculated Shannon evenness index, by region and for New Zealand as a whole, projected in five-year steps from 2013 to 2038. These projections, along with the historical index values presented in Table 3 in the previous section, are also illustrated in Figure 3 (nationally), while Figures 4–6 show the corresponding projected and historical index values for the high-diversity, medium-diversity, and low-diversity groups of regions, respectively. The trend both nationally, and in every region, is increased diversity over time. The Shannon evenness index nationally is projected to increase from 0.470 in 2013 to 0.624 in 2038 (and for comparison, as shown in Table 3, it was as low as 0.380 in 2001).

The relative rankings of the three groups of regions (high diversity, medium diversity, low diversity) remains stable, with none of the regions in a lower-diversity group overtaking any region in a higher-diversity group. However, the relative rankings *within* the medium-diversity group of regions are projected to change substantially. Within that group, the Shannon evenness index grows most quickly for the Canterbury, Otago and

Manawatu-Wanganui regions, and slower for the Gisborne and Bay of Plenty regions. In contrast, the relative rankings within the high-diversity and low-diversity groups are projected to remain stable over time.

Finally, we consider whether there is a projected *β*-convergence in the level of diversity between the regions over the period from 2013 to 2038. *β*-convergence is a term that was introduced in the literature on economic growth to describe the phenomenon in which the growth rate of income is inversely related to the level of income (see, for example, Rey & Montouri, 1999). If there is *β*-convergence, poor places grow faster than rich places and may eventually 'catch up'. In the present context and considering diversity instead of income, will the level of diversity of the medium- and low-diversity regions eventually 'catch up' with the level of diversity in the high-diversity regions? In relative terms, the low-diversity group is growing the fastest, with an average projected increase in their Shannon evenness index of 35.5 per cent over the period from 2013 to 2038. This compares with a 32.3 per cent increase for the medium-diversity group, and a 25.2 per cent increase for the high-diversity group. The correlation between projected percentage growth in diversity over the period and initial diversity is −0.496, again highlighting that the least-diverse regions will have the greatest percentage growth in diversity over the period to 2038. This suggests a high degree of projected *β*-convergence over time.

Table 4: Projected Shannon evenness index (Level 3 ethnicities), nationally and regionally, 2013–2038

Region	2013	2018	2023	2028	2033	2038
National	0.470	0.503	0.535	0.565	0.595	0.624
High-diversity regions						
Auckland	0.602	0.629	0.654	0.676	0.695	0.712
Wellington	0.476	0.504	0.532	0.557	0.582	0.607
Waikato	0.398	0.422	0.444	0.467	0.490	0.515
Medium-diversity regions						
Bay of Plenty	0.376	0.395	0.413	0.432	0.451	0.472
Northland	0.364	0.378	0.392	0.405	0.420	0.439
Hawke's Bay	0.357	0.374	0.391	0.407	0.424	0.443
Manawatu-Wanganui	0.357	0.385	0.412	0.438	0.465	0.493
Gisborne	0.351	0.364	0.376	0.388	0.401	0.416
Canterbury	0.340	0.372	0.404	0.435	0.467	0.501
Otago	0.321	0.353	0.384	0.415	0.446	0.478
Nelson	0.318	0.341	0.363	0.385	0.407	0.433
Low-diversity regions						
Taranaki	0.299	0.321	0.343	0.366	0.389	0.412
Marlborough	0.296	0.315	0.335	0.354	0.375	0.401
Southland	0.271	0.293	0.314	0.337	0.360	0.385
West Coast	0.257	0.274	0.291	0.308	0.327	0.349
Tasman	0.255	0.267	0.278	0.290	0.302	0.320

Figure 3: Shannon evenness index, 1996–2013 (historical) and 2018–2038 (projected) at the national level, based on ethnic classification at Level 3

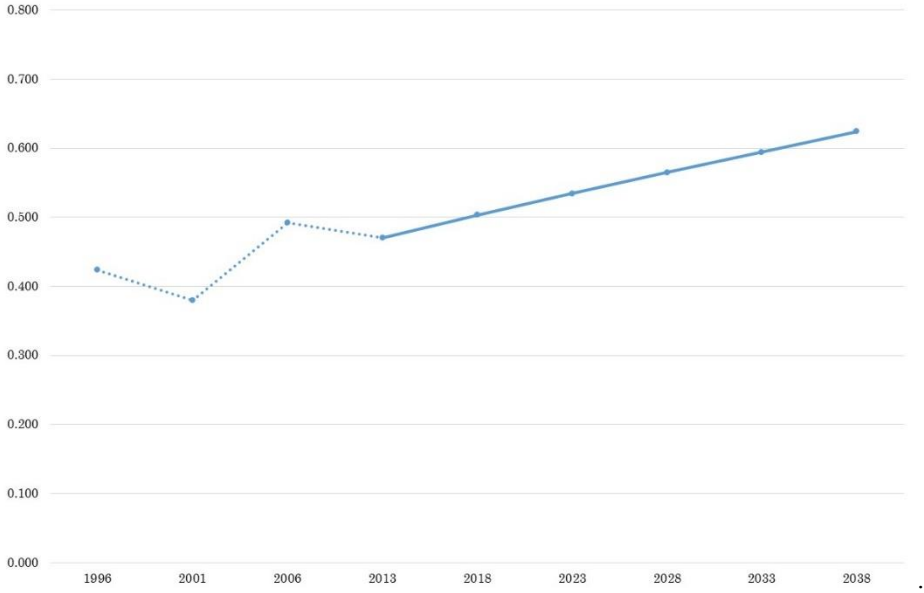
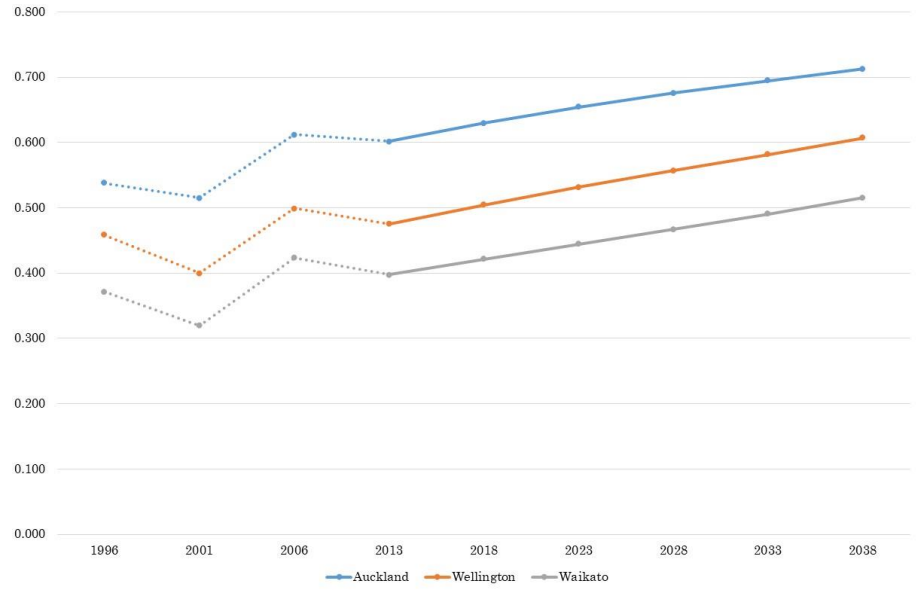


Figure 4: Shannon evenness index, 1996–2013 (historical) and 2018–2038 (projected) for the high-diversity group of regions



Note: The dashed lines are based on historical (census) data. The solid lines are based on projected data.

Figure 5: Shannon evenness index, 1996–2013 (historical) and 2018–2038 (projected) for the medium-diversity group of regions

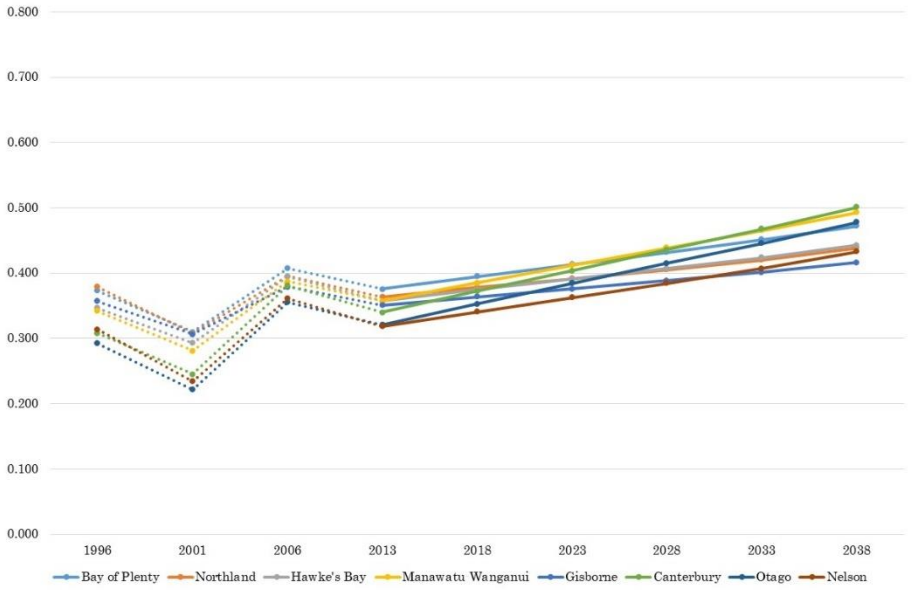
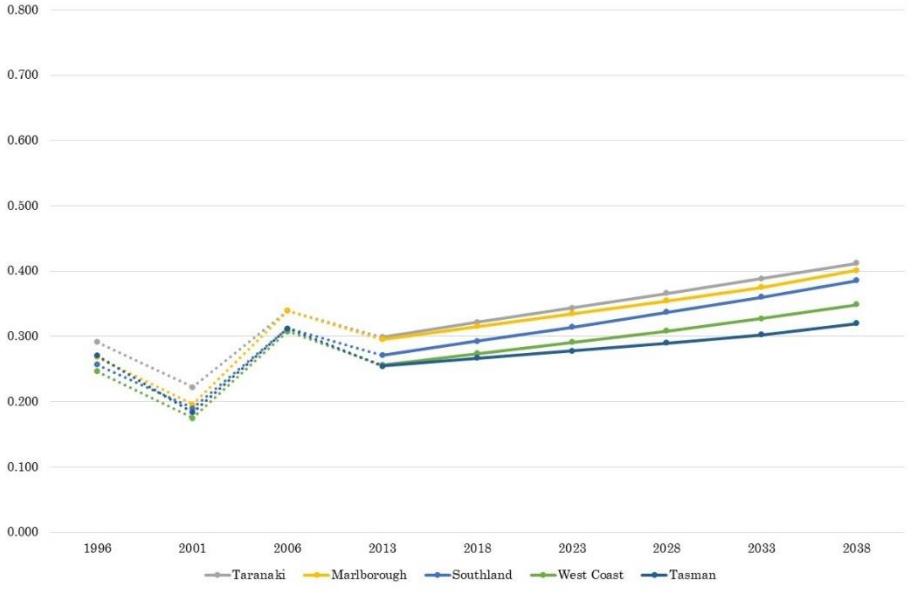


Figure 6: Shannon evenness index, 1996–2013 (historical) and 2018–2038 (projected) for the low-diversity group of regions



Note: The dashed lines are based on historical (census) data. The solid lines are based on projected data.

Discussion and conclusion

New Zealand is an incredibly ethnically diverse country. However, that diversity is not uniform across all regions of the country. In this paper, we show that the most populous and fastest-growing regions (Auckland, Wellington and Waikato) are also the regions that have the highest ethnic diversity, both historically and projected into the future. Moreover, the smaller, more-peripheral, and slowest-growing regions (Taranaki, Marlborough, Southland, Tasman and West Coast) have the lowest ethnic diversity, both historically and projected into the future. However, *all* regions are projected to increase in diversity over time and there is projected convergence in diversity, in that regions that had relatively low diversity in 2013 are the regions that are projected to increase in diversity faster in relative terms.

The greatest differences in projected paths of diversity are within the medium-diversity regions. Within this group, there is projected to be a substantial change in ranking between the regions. In particular, the Canterbury, Otago and Manawatu-Wanganui regions are projected to increase in diversity more quickly than the other regions in that group. While our analysis is silent on the specific *causes* of these future changes in diversity (other than through the historical mechanisms mathematically reflected in cohort change ratios), we note that those three regions have features in common with the high-diversity regions (Auckland, Wellington and Waikato). For instance, those regions have a relatively youthful population, driven in part by the existence of university campuses. University campuses not only increase the youthfulness of the population, which may provide some resistance to population ageing, but they also attract a more ethnically diverse population, including cohorts of international students. Should this indeed be a driver of diversity, the Bay of Plenty region, with its new university campus in Tauranga, might be expected to experience a trajectory of growing diversity that is steeper than that anticipated in our projections (in Figure 5). The trend in diversity will also strongly depend on future levels of international migration. The cohort change ratio method implicitly assumes that those levels will not be very different from those of the last decade. This will affect particularly the regions with international airports, specifically Canterbury and Otago, along with Auckland and Wellington, given that recent international

arrivals often reside initially in their first city of arrival. Hence, changes in international migration will drive changes in diversity more directly and forcefully in those regions in a way that small, more-peripheral regions, cannot easily replicate.

Our research has several limitations. First, changes in the framing of the ethnicity question within the census present a problem, both for the calculation and interpretation of historical data on diversity, and for ethnic population projections that rely on these historical data, such as those used in this paper. This problem is clearly more relevant at greater levels of disaggregation of the ethnicity data, as is apparent in comparing the past trends in diversity between Level 1 (in Figure 1) and Level 3 (in Figure 3). The historical trend in the Level 3 data should therefore be interpreted in light of the overall trend in the Level 1 data, and over-interpretation of the inter-censal changes in the Level 3 data should be avoided, as we have done in this paper. In terms of the ethnic population projections, the problems are largely mitigated by averaging over the last two inter-censal periods, and thus any issues associated with the large increase in the 'New Zealander' category in the 2006 Census are smoothed out.

Second, our analysis is largely descriptive and, as noted above, does not reveal the causal mechanisms underlying the historical or projected future changes in diversity. Moreover, there are likely to be intersecting changes in diversity by age and ethnicity at the subnational level. These present fruitful areas for future research.

Despite these limitations, our paper presents a first attempt to summarise both historical and projected future trends in ethnic diversity for New Zealand, both nationally and regionally, and using data at a higher level of ethnic disaggregation than previous research and official population projections. Given the known limitations of commonly used population-projections methodology for projecting small population groups, the method we adopt has great potential for future applications, especially following the final release of data from the 2018 Census (and contingent on the quality of the reported ethnicity data that are released). Understanding the future ethnic diversity of New Zealand is important for planning and policy purposes. Adopting appropriate tools to increase this understanding is vital. Our results demonstrate the usefulness of the approach in filling this knowledge gap.

Acknowledgements

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Notes

1 Census respondents can state more than one ethnicity. Of the 2013 Census population of 4.2 million, 4.0 million stated their ethnicity and provided a total of 4.5 million stated responses at the five-digit level (the highest level of disaggregation). Multiple response varies considerably across ethnic groups. More than half of Māori identified with two or more major ethnic groups. In other major ethnic groups, the proportions of people identifying with two or more major ethnic groups were as follows: Pacific peoples (37.2 percent), Middle Eastern/Latin American/African (16.8 percent), European (13.3 percent), and Asian (9.9 percent) (Statistics New Zealand, 2014b).

2 See, for example, Nijkamp and Poot (2015) for a review of these and other measures of diversity.

3 However, except for Māori, the majority of people do not do so yet. See also Endnote 1.

4 To allow calculation of D even in the case of there being groups who have zero members at some point in time, we define:

$$0*\ln(1/0)= \lim_{q\to 0}[\, q(\ln(1/q)] = 0.$$

5 In ecology, this index is known as *Pielou's Evenness Index* (Pielou, 1966).

6 We tested this extensively with both synthetic data and with New Zealand population data at the national level by single year-of-age. Essentially, the impact of international migration dominates all other causes of temporal volatility in CCRs (except for major changes in the ethnic classification for some groups, as discussed later). Taking the average CCRs and CWRs across two successive inter-censal periods removes much of the volatility.

7 Participation in the 2018 Census was lower than expected. Consequently, the 2018 Census data are being enhanced by administrative data to reduce the undercount to 1.4 percent. By comparison, the official census undercount in 2013 was 2.4 percent. Ethnicity is a 'priority 1' variable. While Stats NZ (2019) expects that the ethnicity data to be released are of high quality, an independent external review panel warns that data for Māori and Pacific groups may be of moderate quality. The prediction errors of 2018 ethnicity numbers generated by the cohort change ratio method will be analysed in a future paper.

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