Socio-economic groups moving apart: An analysis of recent trends in residential segregation in Australia's main capital cities

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Funding information
Ministerio de Economía y Competitividad, Grant/Award Number: ECO2017-82241-R; Brotherhood of St Laurence; University of Melbourne; Australian Research Council Centre of Excellence for Children and Families, Grant/Award Number: CE140100027; Xunta de Galicia, Grant/Award Number: ED431B2019/34; Fondo Europeo de Desarrollo Regional, Grant/Award Number: ECO2017-82241-R; Agencia Estatal de Investigación

Abstract
We study changes in the spatial distribution and segregation of socio-economic groups in Australia using a new data set with harmonised census data for 1991 and 2011. We find a general increase in residential segregation by education and occupation groups across the major capital cities in Australia. Importantly, these trends cannot be explained in general by changes in the demographic structure of groups and areas but rather by the rise in the over and underrepresentation of groups across areas. In particular, our analysis reveals clear diverging trends in the spatial configuration of high and low socio-economic groups as measured by their occupation and education. Whereas high-skilled groups became more concentrated in the inner parts of cities, the low-educated and those working in low-status occupations became increasingly overrepresented in outer areas. This pattern is observed in all five major capital cities, but it is especially marked in Sydney, Melbourne and Brisbane.

KEYWORDS
Australia, human capital, occupations, residential segregation

1 | INTRODUCTION

Social and economic transformations in many industrialised countries over the past 50 years have had very asymmetric effects on skill groups, widening inequalities between them. Various factors contributed to the deterioration of the relative position of low- and middle-skilled groups including skilled-biased technical change and the rise in returns to skill (Acemoglu, 2002), offshoring and the polarisation of labour markets (Goos, Manning, & Salomons, 2014) and the decline of labour market institutions (Fortin & Lemieux, 1997).

Similar to other Anglo-Saxon countries like the United States and the United Kingdom, since the 1980s, Australia’s labour markets have been characterised by an increasing polarisation, with a decline in middle skill and routine jobs, and a sharp increase in the number of casual jobs—from 15% in 1983 to 28% in 2002 (Campbell, 2004)—all of which disproportionately affected the low-skilled members of the workforce (Coelli & Borland, 2016). This shift in the structure of occupations came alongside an increase in the return to skill of the most qualified further contributing to inequalities between skill groups (Keating, 2003). These changes in labour markets were also reflected in housing markets, where the strong rise in housing prices negatively impacted the levels of housing stress and affordability of most vulnerable groups (Yates, 2008). We hypothesise that these compound inequalities have had consequences for the residential sorting of skill groups within Australian cities.
This paper aims to study changes in the spatial distribution of education and occupation groups in Australia’s major capital cities between 1991 and 2011 and its effect on residential segregation. Between 1991 and 2011, Australia experienced rates of economic growth outperforming most advanced economies (Reserve Bank of Australia, 2010). However, similar to other advanced industrialised countries, the increase in national and regional incomes over that period disproportionally benefited those at the top (Azpitarte, 2014; Wilkins, 2007). Examining the implications of postindustrial cities for the spatial sorting of skill groups is the primary purpose of this research.

For the analysis, we use the measurement framework proposed by Alonso-Villar & Del Río (2010)—which allows to quantify the segregation of a group in a multigroup context—and measures of overall segregation that are consistent with it (Frankel & Völjì, 2011; Silber, 1992; Theil & Finizza, 1971). Importantly for our purpose, this framework permits the analysis of segregation trends within cities while controlling for changes in the demographic structure of those cities. Specifically, it allows decomposition of the overall segregation in terms of the segregation experienced by population subgroups, as well as, the segregation of the geographical units that compose the city. This is critical to identify the groups and areas that became more or less segregated and also to quantify the contribution of demographic changes to segregation trends. We apply these measures to a newly created, harmonised data set based on census data, which allows the comparison of the spatial distribution of skill groups across comparable geographies at different levels in 1991 and 2011.

Our research contributes to previous literature in several ways. First, it departs from most works on residential segregation by accounting for the residential sorting of all the socio-economic groups simultaneously. This is so because we use multigroup segregation measures instead of binary measures based on pairwise comparisons, which facilitates comparisons among cities whereas considering the socio-economic diversity existing within them. Second, we measure residential segregation in Australia based on education and occupation groups, whereas most studies in this country focus on segregation by ethnicity or country of origin (Edgar, 2014; Jones, Jonhston, Forrest, Charlton, & Manley, 2018). Third, we use detailed local level data on education and occupation. By doing so, our empirical strategy departs from previous investigation on suburbanization of disadvantage in Australia (Pawson & Herath, 2015; Randolph & Holloway, 2005; Randolph & Tice, 2017), which identified disadvantaged areas using an aggregate index that conflates multiple indicators of local disadvantage and was therefore affected by an ecological fallacy (Goldie, Kakuk, & Wood, 2014) as not all individuals living in disadvantaged areas are disadvantaged individuals. Fourth, by looking at the geographical distribution of education and occupation groups, our analysis sheds some light on the underlying factors driving the suburbanisation of disadvantaged in Australian cities and the groups affected by it, thus expanding previous studies, which provide no insight on the socio-economic groups affected by the transformation of cities.

The paper is organised as follows. Section 2 describes the measurement framework, whereas Section 3 describes the new data set and the harmonisation process. In Section 4, we present the empirical findings including the map evidence for major capital cities. Section 5 concludes.

2 | MEASUREMENT FRAMEWORK

We use the framework proposed by Alonso-Villar and Del Río (2010), which allows decomposing the overall segregation of cities in terms of the segregation experienced by the different groups and the segregation of the areas that comprise the city. We study residential segregation from an evenness perspective—that is, the extent to which a group is unequally distributed across locations—as well as a representativeness perspective concerned with the extent to which the representation of groups in each location differs from the representation one would expect given the group’s weight in the overall population.

To quantify the segregation of any given group, $g$, we use two indices:

$$D_g = \frac{1}{2} \sum_{l} \frac{n_l^g}{N_l} \ln \left( \frac{n_l^g}{N_l} \right),$$

and

$$\Phi_g = \sum_{l} \frac{n_l^g}{N_l} \ln \left( \frac{n_l^g}{N_l} \right).$$

where $N_l^g$ is the size of demographic group $g$, $P$ represents total population, $n_l^g$ is the number of individuals from group $g$ in location $l$, and $p_l$ is the population size of location $l$.

These indices are equal to 0 if the group is evenly distributed across locations, that is, when the group’s population share in each location matches its share in the whole population. The higher the degree of unevenness of the group, the higher the value of these indices. The maximum value of $D_g$ is $1 - \frac{N_g}{P}$, whereas that of $\Phi_g$ is $\ln \left( \frac{N_g}{P} \right)$, which can be higher than 1. The measure $D_g$, proposed by Moir and Selby-Smith (1979) in the binary case and explored by Alonso-Villar and Del Río (2010) in a multigroup context, has a clear interpretation. It measures the proportion of group $g$’s individuals that would have to move to another location to be evenly distributed across space. Both indices satisfy standard properties in the segregation literature, but whereas $\Phi_g$ satisfies the Pigou–Dalton transfer principle, $D_g$ does not. We use the two measures to assess the sensitivity of our results to the formulation of the index.

The indices $D_g$ and $\Phi_g$ of group’s segregation are related to the measures of overall segregation IP and M used in multigroup settings:

$$IP = \frac{1}{2} \sum_{g} \sum_{l} \frac{n_l^g}{P} \ln \left( \frac{n_l^g}{N_l} \right),$$

and

$$M = \sum_{g} N_l^g \left( \sum_{l} \frac{n_l^g}{N_l} \ln \left( \frac{n_l^g}{N_l} \right) \right).$$

The IP index, proposed by Silber (1992), is a generalisation of the well-known index of dissimilarity to the multigroup case and corrects some of its shortcomings. Consistent with the index $D_g$, the measure
\( IP \) represents the proportion of individuals that would have to change residential location so that all groups are evenly distributed across locations. The mutual information index, \( M \), first proposed by Theil and Finizza (1971), has also been claimed to be a suitable measure to quantify residential segregation (Kramer & Kramer, 2018). It measures the extent to which the average skill-based entropy (or uncertainty) of the spatial units departs from the maximum entropy that the skill composition of the population permits. Both \( IP \) and \( M \) are equal to 0 if there is no segregation and they take positive values otherwise. The maximum value of \( IP \) is \( \sum_{g} \frac{N^g}{P} (1 - \frac{N^g}{P}) \) and that of \( M \) is \( \sum_{g} \frac{N^g}{P} \ln(\frac{N^g}{P}) \), which can be above 1 (Del Río & Alonso-Villar, 2019).

As shown in Alonso-Villar and Del Río (2010), the indices \( IP \) and \( M \) can be decomposed as follows:

\[
IP = \sum_{g} \frac{N^g}{P} D^g, \tag{5}
\]

and

\[
M = \sum_{g} \frac{N^g}{P} \Phi^g. \tag{6}
\]

That is, if the total population is divided into several mutually exclusive groups, overall segregation as measured by \( IP \) and \( M \) equals the weighted average of the segregation of the groups according to \( D^g \) and \( \Phi^g \), respectively, with weights equal to the groups’ shares in the population.

In addition to its decomposability by population subgroups, the measure \( M \) can also be decomposed in terms of locations, which makes it particularly suitable for quantifying the contribution of each spatial unit to overall segregation. Following Alonso-Villar and Del Río (2010) and Frankel and Volij (2011), the index \( M \) can be expressed as

\[
M = \sum_{l} \frac{P_l}{P} \Psi_l, \tag{7}
\]

where

\[
\Psi_l = \sum_{g} \frac{N^g_l}{P_l} \ln \left( \frac{\frac{N^g_l}{P_l}}{\frac{N^g}{P}} \right). \tag{8}
\]

The index \( \Psi_l \) quantifies the level of segregation of any area, \( l \), by looking at the level of under and overrepresentation of the different groups in that area. If the share of each demographic group in a location is similar to the one that the group has in the city as a whole, then the value of \( \Psi_l \) will be close to zero. In contrast, if the groups’ representation in that location differs substantially from the one that would be expected given their shares in the city’s population, then the area will be characterised by large values of \( \Psi_l \). Expression 7 implies that overall segregation is equal to the weighted average of the segregation of its areas as measured by the \( \Psi_l \) index.

3 | DATA

We draw on publicly available socio-economic and geocoded data. Data on education and occupations come from the 1991 and 2011 Basic Community Profiles (BCPs) compiled by the Australian Bureau of Statistics (ABS). These profiles include count data on residents’ characteristics at various regional levels. We focus on the population aged 15 and older.

To ensure the comparability of geographies and variables across years, we constructed a harmonised data set that allows meaningful comparisons of the spatial distribution of groups in 1991 and 2011. Table 1 provides descriptive information on the variables and spatial units used in the analysis. The boundaries of the main capital cities are based on capital statistical division (SD) spatial units of the Australian Statistical Geographical Classification (ASGC) and were drawn from the ABS (2011, p. 12), which defines them “after consultation with planners, to contain the anticipated development of the city for a period of at least 20 years.” This wide interpretation of a city, or even extended versions, is commonly employed in Australian studies (Baum, Haynes, van Gellecum, & Han, 2006; Pawson & Herath, 2015; Bill & Andrew, 2014). In what follows, we explain the main features of the harmonisation process; further details are presented in the Appendix included in the Supporting Information.

3.1 | Education

Data on education for 1991 were coded using the ABS Classification of Qualifications (ABSCQ), whereas in 2011, they were recorded using the Australian Standard Classification of Education (ASCED). The two classifications differ in the number of categories (eight in ABSCQ and six in ASCED), and to create a classification comparable across years, we used the correspondence file provided by the ABS (2001), which allows us to create four highly comparable categories—bachelor’s degree and above, diploma and advance diploma, certificate level and no postschool qualification.

3.2 | Occupations

Occupations for 1991 were classified using the first edition of the Australian Standard Classification of Occupations (ASCO1), whereas data for 2011 were recorded using the Australia and New Zealand Standard Classification of Occupations (ANZSCO). Both classifications divide occupations into eight categories ranging from high-status occupations, such as managers and professionals, to low-status occupations, including labourers and machinery workers. No direct correspondence between the ASCO1 and ANZSCO has been produced to date. Following the recommendation from the ABS, we used the correspondence between the ASCO1 and the second edition of the same classification (ASCO2) and the correspondence between the ANZSCO and ASCO2 classifications produced by the ABS.

We triangulated the available correspondences to create the most comparable albeit imperfect harmonised classification of occupations for 1991 and 2011. On the basis of the results from the triangulation analysis, we decided to create a parsimonious classification with only three categories. The first category, top, includes high-skilled
| Key demographic and geographical variables | Sydney 1991 | Sydney 2011 | Melbourne 1991 | Melbourne 2011 | Brisbane 1991 |
|-------------------------------------------|-------------|-------------|----------------|----------------|--------------|
| Population aged 15 and over               | 2,791,997   | 3,548,421   | 2,386,067      | 3,214,529      | 1,038,188    |
| Education groups                          |             |             |                |                |              |
| Bachelor's degree and above               | 267,190 (11.2) | 856,094 (27.2) | 228,246 (10.9) | 762,965 (26.5) | 80,723 (8.8) |
| Diploma and advance diploma               | 147,913 (6.2) | 318,523 (10.1) | 122,219 (5.9)  | 281,698 (9.8)  | 54,797 (6.0) |
| Certificate level                         | 394,170 (16.5) | 537,612 (17.1) | 289,477 (13.9) | 477,359 (16.6) | 132,962 (14.6) |
| No postschool qualification               | 1,585,096 (66.2) | 1,436,007 (45.6) | 1,446,343 (69.3) | 1,361,683 (47.2) | 645,218 (70.6) |
| Occupation groups                         |             |             |                |                |              |
| Top                                       | 395,011 (27.0) | 800,498 (39.6) | 326,149 (26.5) | 696,749 (37.6) | 127,776 (23.7) |
| Middle                                    | 795,052 (54.3) | 952,908 (47.1) | 661,669 (53.7) | 896,606 (48.3) | 302,625 (56.2) |
| Bottom                                    | 272,903 (18.7) | 269,449 (13.3) | 243,907 (19.8) | 261,715 (14.1) | 108,557 (20.1) |
| Geographies                               |             |             |                |                |              |
| Statistical local areas (SLAs)            | 45          | 64          | 58             | 79             | 222          |
| Statistical subdivisions (SSDs)           | 14          | 14          | 18             | 16             | 9            |
| SLAs median size                          | 52,048      | 61,144      | 39,461         | 47,743         | 3,861        |
| SLAs (harmonised)                         | 45          | 53          | 201            |                |              |
| SSDs (harmonised)                         | 14          | 16          |                |                | 9            |
| TABLE 1 | Key demographic and geographical variables |
|---------|---------------------------------|
|         | Brisbane 2011 | Adelaide 1991 | 2011 | Perth 1991 | 2011 |
| Population aged 15 and over | 1,588,025 | 817,266 | 964,061 | 885,353 | 1,328,901 |
| Education groups | | | | | |
| Bachelor's degree and above | 328,014 (22.9) | 59,632 (8.2) | 177,200 (20.3) | 73,453 (9.4) | 268,524 (22.6) |
| Diploma and advance diploma | 129,020 (9.0) | 44,216 (6.1) | 74,527 (8.6) | 53,549 (6.8) | 115,801 (9.8) |
| Certificate level | 285,592 (19.9) | 111,194 (15.3) | 172,809 (19.8) | 128,178 (16.4) | 243,766 (20.6) |
| No postschool qualification | 692,724 (48.3) | 510,475 (70.4) | 446,279 (51.2) | 526,768 (67.4) | 557,533 (47.0) |
| Occupation groups | | | | | |
| Top | 333,196 (34.7) | 97,774 (23.8) | 179,845 (33.4) | 111,363 (24.8) | 276,668 (34.0) |
| Middle | 477,653 (49.8) | 229,573 (55.9) | 273,710 (50.8) | 253,596 (56.5) | 411,482 (50.6) |
| Bottom | 148,576 (15.5) | 83,429 (20.3) | 85,399 (15.8) | 83,827 (18.7) | 124,404 (15.3) |
| Geographies | | | | | |
| Statistical local areas (SLAs) | 221 | 32 | 55 | 33 | 37 |
| Statistical subdivisions (SSDs) | 11 | 4 | 4 | 5 | 5 |
| SLAs median size | 5,371 | 30,206 | 32,955 | 21,399 | 29,392 |
| SLAs (harmonised) | 201 | 25 | 31 | 5 |
| SSDs (harmonised) | 9 | 4 | 5 | | |

Notes: The numbers in parentheses correspond to the share of the education and occupation groups represented by each category.
occupations and comprises Categories 1 and 2 of the ASCO1 and ANZSCO classifications. The second category, *middle*, comprises a range of middle-skilled occupations such as technicians, trades, clerks and sales workers included in Categories 3–6 of ASCO1 and ANZSCO. The third category, *bottom*, comprises Categories 7 and 8 of the two classifications, which include occupations at the bottom of the skill distribution such as drivers, machinery operators and labourers. The parsimonious classification was motivated by our interest in low- and high-skilled groups and also by the large correspondence found between top and bottom categories of the classifications. Note that the occupation variable only includes information for those who were working on the Census date, therefore excluding the unemployed and economically inactive groups. Census data on labour force status included in the BCPs allow the construction of the census counts of unemployed and inactive residents in each geography in 1991 and 2011. However, the integration of those two groups in the occupation hierarchy is problematic given our interest in spatial social gradients, as it is not a priori clear how to rank them with respect to the occupational categories, especially the economically inactive, which comprises a wide range of socio-economically diverse groups. Supplementary analyses combining the census counts on occupations, unemployment and economically inactive were performed to evaluate trends in the segregation of the unemployed and economically inactive. While trends for those groups will be discussed in Section 4, those supplementary analyses are not reported. Importantly, integrating the unemployment and economically inactive groups into the segregation analysis does not alter the results for occupational categories reported here and which are the focus of our discussion.

### 3.3 Geographical units

We used information on three geographical units: statistical local area (SLA), statistical subdivision (SSD) and SD. Data on the first two were used to identify the two spatial levels employed in the analysis, whereas the latter allowed us to delimit Australia’s main capital cities. SLAs are general purpose spatial units and constitute the smallest building block of the main structure of the ASGC used in 1991 and 2011 censuses. SLAs aggregate into SSDs, which are socially and economically homogenous regions with identifiable links between their inhabitants (ABS, 2011, p. 8). We identified Australia’s main capital cities with the capital city SD of each state. Capital city SDs represent the city in a wider sense and are the most stable spatial units within each state.

The number of SLAs in Australia’s major capital cities rose from 390 in 1991 to 456 in 2011, an increase largely caused by the subdivision of SLAs over that period. The boundaries of the SLAs in 2011 in general do not coincide with those in 1991 because of changes to the boundaries of the local government areas, which constitute the building blocks of the SLAs. To create comparable areas, we proceeded as follows. Taking 1991 as the reference year, we matched every SLA from that year with the one covering the same area in 2011. For those cases in which a one-to-one match was not possible, we amalgamated the minimum number of contiguous SLAs required to construct a comparable unit. This often required the aggregation of SLAs of 2011 to match a SLA of 1991 whose territory had been partitioned. In some cases, however, creating a harmonised region also required the amalgamation of SLAs from 1991.

Of the 390 SLAs of 1991, for about 71% (278 SLAs), it was possible to find a perfect match with one SLA from 2011. About 13% of the SLAs from 1991 (50 SLAs) were split into two or more SLAs of 2011 whose union covered the same area as the SLA from 1991. The remainder 16% of 1991 SLAs (62 SLAs) did not fall in any of the two previous categories and were amalgamated to construct a spatial unit comparable to a unit or aggregation of units from 2011. The harmonisation of geographies resulted in 355 harmonised SLAs covering the same territory in 1991 and 2011. A description of the harmonised units of each capital city is provided in the harmonised SLAs file in the Supporting Information.

## 4 Residential segregation by socio-economic status in Australia

### 4.1 Changes in overall segregation between 1991 and 2011

Table 2 shows our estimates of overall residential segregation for 1991 and 2011 when using the harmonised SLAs as the geographical unit of analysis, the smallest unit for which data are available. Results for the IP index reveal a general increase in segregation across the main capital cities. Although observed for both education and occupation, the rise was particularly intense in terms of education, ranging from 36% in Adelaide to 75% in Brisbane. Results for the M measure are quantitatively and qualitatively very similar to those of the IP index. The increase in segregation is also found when segregation is measured using SSDs rather than SLAs (see Table SB1), which shows the robustness of our findings to the geographical unit of analysis.

In 2011, Sydney and Melbourne were the cities with the highest level of segregation in terms of both education and occupation, followed by Brisbane, which had the largest increase over the period. The IP index indicates that, in 2011, 12.9% (resp. 11.3%) of the population in Sydney would have to relocate for the city to eliminate residential segregation by education (resp. occupation). The lowest segregation values are in Perth (requiring moving 9.6% and 8.5% of its population) and Adelaide (9.7% and 8.9%).

### 4.2 Segregation of socio-economic groups and locations

We examine the contribution of socio-economic groups and locations to the rise in segregation exploiting the decomposability properties of the IP and M measures. These allow us to evaluate whether the increase in segregation stemmed from changes in the residential
patterns of disadvantaged or advantaged groups. Table 3 provides estimates of the residential segregation of each group at the SLA level as measured by the $D^g$ and $\Phi^g$ indices. As discussed in Section 2, these measures are consistent with the measures of overall segregation $IP$ and $M$, which can be expressed as the weighted average of the $D^g$ and $\Phi^g$, respectively.

Figures on Table 3 reveal diverging trends between skill groups. The groups with lower education levels (i.e., those with a certificate or with no postschool qualification) became more segregated as their levels of overrepresentation and underrepresentation across SLAs rose between 1991 and 2011. The rise in the unevenness of the low educated happened across all capital cities. In contrast, the degree of unevenness of the highly educated diminished between 1991 and 2011 in all cities, although that group displayed the highest level of segregation of all groups in both years. For example, the measure $D^g$ for Sydney in 2011 indicates that 20.1% of people with bachelor’s degrees would have to change their residential location to have an even distribution across SLAs, whereas the percentage for the other groups ranges between 6.8% and 13.4%. Importantly, these trends for education groups are not sensible to the choice of segregation measure ($D^g$ or $\Phi^g$) or the geographical unit used for the analysis. 11

Results for occupations tell a similar story to those obtained for education, with clear diverging trends for low- and high-status groups. Thus, while residential segregation rose for individuals working in bottom occupations, it decreased for those in top occupations whatever the index used.12 Individuals in top and bottom occupations were equally segregated in 1991, but by 2011, those in bottom occupations had become the most segregated group, especially in Sydney and Melbourne. Thus, according to $D^g$, in 2011, 23.3% and 14%, respectively, of workers in bottom and top occupations living in Sydney would have to change place of residence to have no segregation, whereas in 1991, these percentages were 17.4 and 15.6. Those working in middle occupations experienced the highest increase in segregation of all groups in all major cities, although their level of segregation was still far below that of the other two groups by 2011.13

These results suggest that the rise in overall segregation in Australia’s main capital cities was, at least partially, driven by the rise in the residential segregation of low-skill groups defined in terms of education and occupation. However, this analysis does not consider changes in the demographic size of the areas and the population shares of the groups. The interplay between demographic changes and the spatial distribution of the groups is something that we explore in Section 4.3.

In addition to the decomposability by groups, trends in cities’ overall segregation as measured by $M$ can be linked to the changes in the levels of segregation of the different areas within those cities. As shown in the methods section, the index $M$ can be decomposed in terms of the index $\Psi_l$ that quantifies the segregation of any area looking at the under and overrepresentation of the different groups residing there.

Figure 1 shows, on the vertical axis, the segregation level of each SLA as measured by index $\Psi_l$ and, on the horizontal axis, the distance

| TABLE 2 | Overall segregation (indices $IP$ and $M$), SLA level |
|---------|------------------------------------------------------|
| $IP$ index | Sydney | Melbourne | Brisbane | Adelaide | Perth |
| Education | | | | | |
| 1991 | 0.086 | 0.077 | 0.068 | 0.072 | 0.062 |
| 2011 | 0.129 | 0.118 | 0.119 | 0.097 | 0.096 |
| $\Delta$ (%) | 50.0 | 51.9 | 75.0 | 36.1 | 53.2 |
| Occupation | | | | | |
| 1991 | 0.092 | 0.090 | 0.082 | 0.086 | 0.074 |
| 2011 | 0.113 | 0.113 | 0.103 | 0.089 | 0.085 |
| $\Delta$ (%) | 22.8 | 24.4 | 25.6 | 3.5 | 14.9 |
| $M$ index | Sydney | Melbourne | Brisbane | Adelaide | Perth |
| Education | | | | | |
| 1991 | 0.033 | 0.029 | 0.029 | 0.029 | 0.024 |
| 2011 | 0.053 | 0.045 | 0.051 | 0.039 | 0.035 |
| $\Delta$ (%) | 60.6 | 55.2 | 75.9 | 34.5 | 45.8 |
| Occupation | | | | | |
| 1991 | 0.037 | 0.035 | 0.033 | 0.035 | 0.026 |
| 2011 | 0.044 | 0.043 | 0.040 | 0.033 | 0.027 |
| $\Delta$ (%) | 18.9 | 22.9 | 21.2 | –5.7 | 3.8 |

Source: Authors’ calculation.
| Dg Index (consistent with IP) | Education | Sydney 1991 | 2011 Δ (%) | Melbourne 1991 | 2011 Δ (%) | Brisbane 1991 | 2011 Δ (%) | Adelaide 1991 | 2011 Δ (%) | Perth 1991 | 2011 Δ (%) |
|-----------------------------|-----------|-------------|-------------|----------------|-------------|---------------|-------------|---------------|-------------|-------------|-------------|
| Bachelor's degree           | 0.261     | 0.201       | −23.0       | 0.256          | 0.2         | −21.9         | 0.276       | 0.236         | −14.5       | 0.289       | 0.204       | −29.4       |
| Diploma                     | 0.146     | 0.068       | −53.4       | 0.149          | 0.052       | −65.1         | 0.127       | 0.068         | −46.5       | 0.153       | 0.072       | −52.9       |
| Certificate                 | 0.079     | 0.134       | 69.6        | 0.09           | 0.141       | 56.7          | 0.074       | 0.116         | 55.4        | 0.063       | 0.098       | 55.6        |
| No postschool               | 0.052     | 0.097       | 86.5        | 0.04           | 0.077       | 90.0          | 0.036       | 0.075         | 108.3       | 0.041       | 0.059       | 43.9        |
| Δ (%)                       |           |             |             |                |             |               |             |               |             |             |             |             |

| Φg Index (consistent with M) | Education | Sydney 1991 | 2011 Δ (%) | Melbourne 1991 | 2011 Δ (%) | Brisbane 1991 | 2011 Δ (%) | Adelaide 1991 | 2011 Δ (%) | Perth 1991 | 2011 Δ (%) |
|-----------------------------|-----------|-------------|-------------|----------------|-------------|---------------|-------------|---------------|-------------|-------------|-------------|
| Bachelor's degree           | 0.19      | 0.112       | −41.1       | 0.173          | 0.103       | −39.9         | 0.227       | 0.149         | −34.4       | 0.238       | 0.126       | −47.1       |
| Diploma                     | 0.058     | 0.013       | −77.6       | 0.062          | 0.007       | −88.7         | 0.05        | 0.014         | −72.0       | 0.068       | 0.017       | −75.0       |
| Certificate                 | 0.019     | 0.053       | 178.9       | 0.025          | 0.055       | 120.0         | 0.019       | 0.039         | 105.3       | 0.013       | 0.029       | 123.1       |
| No postschool               | 0.007     | 0.026       | 257.1       | 0.005          | 0.017       | 240.0         | 0.004       | 0.017         | 325.0       | 0.005       | 0.009       | 200.0       |
| Δ (%)                       |           |             |             |                |             |               |             |               |             |             |             |             |

| Dg Index (consistent with IP) | Occupation | Sydney 1991 | 2011 Δ (%) | Melbourne 1991 | 2011 Δ (%) | Brisbane 1991 | 2011 Δ (%) | Adelaide 1991 | 2011 Δ (%) | Perth 1991 | 2011 Δ (%) |
|-----------------------------|------------|-------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|-------------|-------------|
| Top                         | 0.156      | 0.14        | −10.        | 0.15          | 0.145       | −3.3          | 0.153       | 0.142         | −7.2        | 0.167       | 0.126       | −24.6       |
| Middle                      | 0.032      | 0.057       | 78.1        | 0.032         | 0.056       | 78.1          | 0.029       | 0.048         | 65.5        | 0.03        | 0.044       | 50.0        |
| Bottom                      | 0.174      | 0.233       | 33.3        | 0.169         | 0.218       | 29.0          | 0.145       | 0.193         | 32.4        | 0.148       | 0.156       | 5.4         |
| Δ (%)                       |           |             |             |                |             |               |             |               |             |             |             |             |

| Φg Index (consistent with M) | Occupation | Sydney 1991 | 2011 Δ (%) | Melbourne 1991 | 2011 Δ (%) | Brisbane 1991 | 2011 Δ (%) | Adelaide 1991 | 2011 Δ (%) | Perth 1991 | 2011 Δ (%) |
|-----------------------------|------------|-------------|-------------|---------------|-------------|---------------|-------------|---------------|-------------|-------------|-------------|
| Top                         | 0.072      | 0.052       | −27.8       | 0.067         | 0.053       | −20.9         | 0.073       | 0.057         | −21.9       | 0.081       | 0.05        | −38.3       |
| Middle                      | 0.003      | 0.01        | 233.3       | 0.003         | 0.009       | 200.0         | 0.003       | 0.007         | 133.3       | 0.003       | 0.006       | 133.3       |
| Bottom                      | 0.087      | 0.143       | 64.4        | 0.078         | 0.13        | 65.4          | 0.067       | 0.108         | 59.7        | 0.069       | 0.082       | 18.8        |

Source: Authors' calculation.
of the SLA to the corresponding city centre (in km). The centre is defined as the centroid of the city's inner SLA and distance to the centre is the distance from that point to each SLA's centroid. The graph pools all the SLAs from the main capital cities, with the dark and light grey dots representing, respectively, the SLAs in 1991 and 2011. The chart also includes the average level of segregation—computed using a local polynomial estimator of order two with bandwidths determined by a rule-of-thumb optimal bandwidth selector—and the 95% confidence interval around that average.

The figure provides insights into the increase in segregation in Australia in recent decades. Levels of segregation increased, on average, across most distance ranges although the increase was far from uniform. Concretely, the largest growth in segregation occurred in central and outer areas of the cities. This is consistent with the U-shaped pattern in the graphs where segregation first decreases and then increases with the distance to the centre. Although already evident in 1991, the U-shaped pattern of segregation has become more salient in recent decades with central and
outer locations becoming more segregated, especially in the case of education. In 2011, SLAs located 20 km far from the centre had the lowest levels of segregation (by either education or occupation groups) with segregation increasing when moving to outer areas. The segregation level of areas that are 70 km far from the centre was not very different from that of areas located within a 5- to 10-km ring.

To further investigate the relationship between segregation and location, we estimated the following ordinary least squares (OLS) econometric model that allows the identification of non-linear relationships between segregation and distance to the city centre:

\[ L\text{Seg}_l = \alpha + \beta_1 \text{Dist}_l + \beta_2 \text{Dist}_l^2 + X_l \theta + \epsilon_l, \]  

(9)

where \( L\text{Seg}_l \) is the measure of local segregation in area \( l \), \( \text{Dist}_l \) denotes the distance from the city centre, and \( \epsilon_l \) is an i.i.d. error term. The model also controls for differences across cities using five dummy variables (one for each city) that are included in the vector \( X_l \) and take value 1 when the area belongs to the city and 0 otherwise.

Ordinary OLS regression models may yield biased and inefficient estimations in the presence of spatial dependence in the data (Martin, 1974). Thus, in addition to OLS models, we also estimated spatial lag and spatial error models that account for spatial correlation in the data (Anselin, 1988; Anselin, Syabri, & Kho, 2006). The spatial lag model incorporates a spatially lagged-dependent variable on the right-hand side of the equation, \( \rho \text{WSeg} \), where \( \rho \) is the parameter of spatial autocorrelation and \( W \) is a matrix of spatial weights. The spatial error model allows for correlation in the error term of the model, which is assumed to be \( \epsilon = \lambda W \epsilon + u \), where \( \lambda \) is a parameter capturing the extent of autocorrelation, \( W \) is the spatial weight matrix, and \( u \) is a vector of i.i.d. errors.

Table 4 shows the estimation results from the three models for 1991 and 2011. Models were estimated using the \( D^2 \) and \( \Phi^2 \) indices of local segregation yielding very similar results, so only the results for \( \Phi^2 \) are reported here. For the spatial models, rook-based contiguity weights of order one were used in the regressions. The estimated coefficients of the dummy variables for the capital cities suggest no significant differences between cities and are not reported here for the sake of space but are available upon request. In all regressions, Brisbane was used as reference category because it is the city with the largest number of SLAs.

The estimated measures of spatial autocorrelation (\( \rho \) in the spatial lag model and \( \lambda \) in the spatial error model) are positively and statistically significant (\( \rho < .01 \)), which indicates the presence of spatial dependencies for both education and occupation segregation. In all the OLS and spatial models, the estimated coefficients for \( \text{Dist} \) and \( \text{Dist}_l^2 \) are, respectively, negative and positive suggesting an inverted U-shaped relationship between distance from the city centre and local segregation for both education and occupation. Consistent with the graphical evidence in Figure 1, the U-shaped pattern became pronounced in 2011 as indicated by the larger absolute value of the coefficients for both \( \text{Dist} \) and \( \text{Dist}_l^2 \) in 2011 than in 1991. Interestingly, the coefficients for \( \text{Dist}_l^2 \) are statistically significant at the highest level of 1 per cent (\( p < .01 \)) only in the regressions for 2011, which indicates that the large levels of local segregation of outer areas in Australian cities are a recent development that was not present back in 1991.

4.3 Demographic changes versus spatial segregation changes: A counterfactual analysis

When evaluating trends in residential segregation within cities, it is important to account for the changes in the demographic structure of those cities. Thus, from an evenness perspective, overall segregation may increase over time because either the relative size of the most segregated groups grows, or the segregation levels of some groups increase, or because of a combination of both factors. Analogously, from a representativeness perspective, an increase in overall segregation may be caused by an increase in the population share of those locations in which some groups are highly over or underrepresented, by an intensification of the over and underrepresentation of groups in some locations or by a mix of these factors.

Results in previous section showed that the period 1991–2011 was characterised by a growing segregation of low-skilled groups within Australian cities. Parallel to this, there were important changes in the demographic composition of those cities. In particular, cities witnessed a spectacular increase in the number of highly educated individuals, with the proportion of individuals with bachelor’s degrees more than doubling in all capital cities (see Table 1 in Section 3). In contrast, the share of residents with no postschool qualification dropped about 20 percentage points in all cities. Changes in the occupational structure of cities mirror those in education. There was a marked drop in the number (and shares) of workers in middle and bottom occupations and a sharp increase in the number (and weight) of those in top occupations, especially in Sydney and Melbourne.

To evaluate the contribution of demographic changes to segregation trends, we turn to counterfactual analysis. We focus on the measure \( M \), which has the advantage of being decomposable in terms of both the segregation of groups and regions—Equations 6 and 7.

To evaluate the role of demographic and segregation factors, we undertake two counterfactual analyses because, when moving from 1991 to 2011, we can follow two paths depending on whether we first change the groups’ sizes or the groups’ segregation levels. These two paths lead to the following decompositions:

\[ M_{11} - M_{91} = (M_{11} - M_{\text{seg 91 pop 91}}) + (M_{\text{seg 91 pop 91}} - M_{91}), \]  

(10)

demographic factor segregation factor

\[ M_{11} - M_{91} = (M_{11} - M_{\text{seg 91 pop 91}}) + (M_{\text{seg 91 pop 91}} - M_{91}). \]  

(11)

segregation factor demographic factor
### TABLE 4  Models for the relationship between segregation and distance from the city centre

| Models for local segregation | OLS               | Spatial lag          | Spatial error          |
|------------------------------|-------------------|----------------------|------------------------|
|                              | 1991 coeff.       | 2011 coeff.          | 1991 coeff.            | 2011 coeff. |
| **Education**                |                   |                      |                        |             |
| Distance                     | $-0.001^{**} (0.0004)$ | $-0.004^{**} (0.0005)$ | $-0.0006^{**} (0.0003)$ | $-0.002^{**} (0.0003)$ |
| Distance ²                   | $0.00001^{*} (0.00001)$ | $0.00005^{**} (0.00001)$ | $0.000006 (0.000004)$ | $0.00002^{**} (0.000005)$ |
| City dummies                 | Yes               | Yes                  | Yes                    | Yes         |
| Spatial autocorrelation      |                   |                      |                        |             |
| $R^2$                        | 0.064             | 0.185                | 0.677^{**} (0.041)     | 0.679^{**} (0.039) |
|                              |                   |                      | 0.691^{**} (0.040)     | 0.724^{*} (0.037)  |
| **Occupation**               |                   |                      |                        |             |
| Distance                     | $-0.001^{**} (0.0005)$ | $-0.002^{**} (0.0004)$ | $-0.001^{*} (0.0004)$ | $-0.001^{**} (0.0004)$ |
| Distance ²                   | $0.00001 (0.0001)$ | $0.00002^{**} (0.00001)$ | $0.000001 (0.00001)$ | $0.00001^{*} (0.00001)$ |
| City dummies                 | Yes               | Yes                  | Yes                    | Yes         |
| Spatial autocorrelation      |                   |                      |                        |             |
| $R^2$                        | 0.073             | 0.092                | 0.457^{**} (0.056)     | 0.563^{*} (0.049)  |
|                              |                   |                      | 0.477^{*} (0.055)      | 0.583^{*} (0.048)  |

Notes: ** and * denote coefficient significantly different from 0 with 1% and 5% confidence level, respectively. Standard errors are reported in parentheses. Abbreviation: OLS, ordinary least squares.
Decomposition 10 breaks down the change in overall segregation in two components: one that results from the difference between overall segregation in 2011 and overall segregation in the counterfactual assuming groups' shares as in 1991 and groups' segregation as in 2011 (labelled demographic factor) and a second component given by the difference between overall segregation in that counterfactual and the actual overall segregation in 1991 (labelled groups' segregation factor). In the decomposition given by (11), the demographic factor is given by the difference between overall segregation in the counterfactual (with groups' shares as in 2011 and groups' segregation as in 1991) and overall segregation in 1991, whereas the groups' segregation factor is the difference between overall segregation in 2011 and overall segregation in the counterfactual. The contribution of demography (resp. groups' segregation) to the change in overall segregation between 1991 and 2011 is defined as the mean of the two demographic (resp. groups' segregation) factors divided by the total change.

To explore whether the change in overall segregation between 1991 and 2011 stems from changes in the group composition of the SLAs (segregation factor) or in the shares these areas account for (demographic factor), we also build two counterfactual distributions: one in which we keep unaltered the SLAs' shares whereas the composition of each area moves from that in 1991 to that in 2011; and another in which the representation of the groups within each SLA is the factor that remains unchanged whereas the areas' shares change.

Table 5 provides the results of the decompositions by groups and regions. Changes in the relative size of education groups unambiguously contributed to the increase in residential segregation by education (the demography factor contributes positively to explain the change, which ranges between 113% and 233% depending on the city). The sharp increase in the prevalence of highly educated individuals who tend to be more unevenly distributed than other groups (as shown in Table 3) certainly lies behind this result. If segregation levels of education groups were as in 1991 and their demographic shares as in 2011 ($M_{seg = 91; pop = 11}$), the $M$ index would have increased much more than it actually did, which indicates that changes in the groups' segregation levels between 1991 and 2011 contributed to prevent the rise in overall segregation. The decline in the unevenness of the most educated is a factor clearly pushing in that direction.

In contrast, the value of the counterfactual $M_{seg = 11; pop = 91}$ is greater than $M_{91}$, suggesting a positive contribution of groups' segregation to the increase in overall segregation, likely reflecting the increase in the segregation of low-educated groups documented above. As mentioned earlier, the contribution of a factor to the change in overall segregation was calculated as the mean contribution of the factor in the two counterfactual analyses. In the case of the segregation factor, this average turns out to be negative, reflecting the larger magnitude of the negative contribution of the segregation factor in one of the decompositions.

The analysis thus suggests that although individuals with bachelor's degrees experienced a decrease in segregation, as shown in Section 4.1, this highly segregated group grew so much during this period that it made overall segregation rise. This effect was reinforced by the rise in the unevenness of those with low education.

If we look instead at residential segregation by occupation, we find that in Sydney, Melbourne and Brisbane, segregation increased mainly because occupation groups became more unevenly distributed across regions (although changes in the groups' sizes played also a role). Thus, for example, in Sydney, 83.4% of the change came from changes in the groups' segregation levels and 16.6% from demographic changes.

The reason why segregation by occupation increased in all the cities over the period was that individuals working in middle and bottom occupations were more unevenly distributed in 2011 than they were in 1991 (as shown in Table 3). However, the levels of segregation of middle occupations by 2011 were relatively small compared with those of the most segregated occupation and education groups. On the other hand, the demographic weight of the bottom occupation group, a group who in 2011 had segregation levels similar to those of the most highly educated group, decreased over the period. Thus, a combination of changes in both the groups' weights and the groups' unevenness would help explain why segregation by education rose more than segregation by occupation.

Both in the case of education and occupation, the decomposition by regions shows that the increase in overall segregation in Sydney, Melbourne, Brisbane and Perth can only be explained by an intensification in the over and underrepresentation of the groups within SLAs. The demographic factor is either negative or slightly positive, which indicates that the driver of the segregation rise in these cities was not the growth of SLAs with segregation issues. The situation in Adelaide is similar to that in the other cities when exploring segregation by education. However, this city has a different evolution than the others when socio-economic status is proxied by occupation. The decomposition by regions suggests that the overall segregation reduction in Adelaide arose mainly from changes in the relative size of the regions (68.3%), although changes in the over and underrepresentation of the groups within regions also played a role (31.7%).

### 4.4 | Which groups are located where?

To further shed light on the changes in the spatial distribution of low and high skill groups, we examine the degree of over and underrepresentation of the groups across SLAs. To show the level of representation of any group $g$ in location $l$, we use the location quotient, $r_{gl} = \frac{g_{gl}/G_{gl}}{P_{gl}/P_{gl}}$, which compares the size of the group in location $l$ with that in the overall population and constitutes the main building block of the index $Φ^d$ (see Section 2). We distinguish five levels of representation based on the quintiles of the distribution of $r_{gl}$ in 1991 computed at city level pooling information on all groups (education or occupation) and SLAs.\textsuperscript{16} A group is very underrepresented in a given SLA if $r_{gl} ≤ P_{20}$, underrepresented if $P_{20} < r_{gl} ≤ P_{40}$, represented at the expected level if $P_{40} < r_{gl} ≤ P_{60}$, overrepresented if $P_{60} < r_{gl} ≤ P_{80}$, and very overrepresented if $r_{gl} > P_{80}$.

Figures 2-4 show the level of representation of occupation groups across SLAs, for both 1991 and 2011, in the cities in which
### TABLE 5  Actual and counterfactual M values and decompositions by groups and regions

| Segregation by education | Counterfactuals groups | Segregation by groups | Counterfactuals regions | Segregation by regions |
|-------------------------|------------------------|------------------------|-------------------------|------------------------|
|                         | $M_{91}$ $M_{11}$ $\Delta$ (%) | $M_{seg = 11; pop = 91}$ $M_{seg = 91; pop = 11}$ | Segregation (%) | Demography (%) | $M_{seg = 11; pop = 91}$ $M_{seg = 91; pop = 11}$ | Segregation (%) | Demography (%) |
| Sydney                  | 0.033 0.053 60.30 | 0.039 0.064 $-13.27$ 113.27 | 0.053 0.032 110.84 $-10.84$ |
| Melbourne               | 0.029 0.045 53.61 | 0.031 0.058 $-35.42$ 135.42 | 0.044 0.030 147.93 $-5.07$ |
| Brisbane                | 0.029 0.051 77.57 | 0.032 0.062 $-18.00$ 118.00 | 0.053 0.027 110.79 $-7.93$ |
| Adelaide                | 0.029 0.039 32.86 | 0.024 0.059 $-133.45$ 233.45 | 0.039 0.029 104.13 $-4.13$ |
| Perth                   | 0.024 0.035 46.98 | 0.022 0.048 $-65.35$ 165.35 | 0.038 0.023 115.55 $-15.55$ |

| Segregation by occupation | Counterfactuals groups | Segregation by groups | Counterfactuals regions | Segregation by regions |
|---------------------------|------------------------|------------------------|-------------------------|------------------------|
|                          | $M_{91}$ $M_{11}$ $\Delta$ (%) | $M_{seg = 11; pop = 91}$ $M_{seg = 91; pop = 11}$ | Segregation (%) | Demography (%) | $M_{seg = 11; pop = 91}$ $M_{seg = 91; pop = 11}$ | Segregation (%) | Demography (%) |
| Sydney                   | 0.037 0.044 18.28 | 0.046 0.042 83.44 16.56 | 0.045 0.037 113.34 $-13.34$ |
| Melbourne                | 0.035 0.043 21.84 | 0.045 0.038 94.50 5.50 | 0.043 0.034 103.77 $-3.77$ |
| Brisbane                 | 0.033 0.040 22.23 | 0.039 0.037 61.91 38.09 | 0.042 0.030 134.47 $-34.47$ |
| Adelaide                 | 0.035 0.033 $-5.24$ | 0.032 0.039 247.43 $-147.43$ | 0.035 0.034 31.67 68.33 |
| Perth                    | 0.026 0.027 4.63 | 0.026 0.030 $-131.39$ 231.39 | 0.030 0.025 243.37 $-143.37$ |

Source: Authors' calculation.
FIGURE 2  Representation of occupation groups in each statistical local area (SLA), Sydney
**FIGURE 3** Representation of occupation groups in each statistical local area (SLA), Melbourne
FIGURE 4 Representation of occupation groups in each statistical local area (SLA), Brisbane
segregation by occupation increased the most over the period: Sidney, Melbourne and Brisbane (the charts for Perth and Adelaide are shown in the Supporting Information).\textsuperscript{17} The charts reveal important changes in the spatial distribution of skill groups. Interestingly, we find evidence of a growing concentration of high-skilled occupations in inner city locations across all five cities, as suggested by the increase in the number of inner SLAs coloured in dark red on the maps. In 1991, those working in top occupations had a representation larger than the expected (i.e., above the share the group has in the city) in 71% of the 132 SLAs within a 10-km ring of the centre. By 2011, this percentage had risen to 92% (121 out of 132 SLAs).

In contrast, the charts provide clear evidence of the outward displacement of people working in middle and bottom occupations consistent with a growing underrepresentation of those groups in central locations. The percentage of SLAs within a 10-km ring where bottom occupations are under or very underrepresented rose from 67% to 92%, with similar trends found for those in middle occupations (from 55% to 83%).

The reconfiguration of the inner cities came accompanied by substantial changes in the social and economic mix of middle and outer regions. Most salient among them is the large increase in the overrepresentation of people working in bottom and middle occupations in suburban and peri-urban areas. In 1991, those working in bottom (middle) occupations were very overrepresented in 42 (46) of the 100 capital cities’ SLAs located more than 20 km far from the centre, and by 2011, that number had grown to 59 (78).

These findings shed light on the underlying factors driving, and the socio-economic groups affected by, the suburbanization of disadvantage in Australia’s major capital cities documented in Randolph and Tice (2017) and Pawson and Herath (2015). Thus, the large increase in the overrepresentation of bottom and middle occupations in suburban would explain the growing concentration of disadvantage in areas 20 km far from the centre reported in Randolph and Tice (2017). In contrast with other occupations, those working in top occupations became more underrepresented in middle and outer areas as evidenced by the increase in the number of light-coloured outer SLAs.

The diverging pattern of skill groups is observed in the five cities although is particularly evident in Sydney, Melbourne and Brisbane. In Sydney, the concentration of high-status occupations occurred in the northwest and inner ring parts, expanding the area where those occupations were already overrepresented in 1991. These areas coincide with the highly advantaged areas identified in Baum, Haynes, van Gellecum, and Han (2006) using data for 2001. The rise in the overrepresentation of top occupations was particularly evident in the southern parts of the inner city. Bottom and middle occupations became increasingly overrepresented in southwest suburbs and outer areas. Similar to Sydney, top occupations in Melbourne and Brisbane became increasingly overrepresented in the inner cities. By 2011, bottom and middle occupations in Melbourne were clearly overrepresented in the northwest and southeast suburban and peri-urban areas of the city. In Brisbane, middle occupations became more overrepresented in the northern and southern parts of the city.

5 | CONCLUSIONS

Over the past two decades, Australia has not only witnessed economic growth but also a rise in income inequality (Australian Council of Social Services, 2015). The economic gains of the country during this buoyant period have benefited more those at the top of the income distribution, which has had important consequences in terms of poverty (Azpitarte, 2014), especially for those with low education attainments (Wilkins, 2007). Vulnerability in one dimension usually involves difficulties in others, which explains why Australian lower income households are four (five) times more likely to face precarious housing (employment) than higher income households (Beer, Bentley, & Bake, 2016). Income inequality among individuals tends to translate into spatial inequalities, especially if advantaged and disadvantaged groups locate in differentiated neighbourhoods (Hunter, 2003) and public intervention is limited (Randolph & Tice, 2017).

Using information from a newly created data set on individuals’ occupation and education, this paper has documented an increase in residential segregation by socio-economic status in Australian major capital cities (Sydney, Melbourne, Brisbane, Adelaide and Perth) between 1991 and 2011, a pattern in line with what has occurred in European capital cities in recent years (Marcicicak, Musterd, van Ham, & Tammaru, 2016). To our knowledge, this is the first paper documenting residential segregation by education and occupation in Australia, a country where most literature has focused on segregation by ethnicity or ancestry.

Unlike most scholarship on socio-spatial inequalities within Australian cities (Pawson & Herath, 2015; Randolph & Tice, 2017), this paper has paid attention to the concentration of not only the bottom social group but also the top and middle ones. Living in a low socio-economic neighbourhood reduces individuals’ opportunities and development, whether it is due to a lower school quality, higher exposure to crime or weaker job networks (Rothwell & Massey, 2015). The concentration of social advantage may foster inequalities even further because human capital externalities and access to desirable amenities are likely to occur in places where highly educated individuals are overrepresented (Diamond, 2016). The clustering of skill advantage may have important consequences for not only the low-skill groups but also the middle-skill groups.

Measuring overall segregation using multigroup indices that account for the simultaneous concentration of all the groups (low-, high-, and middle-skill groups) has allowed us to provide a summary statistic of the phenomenon’s magnitude. Quantifying the extent of segregation for each group separately has permitted us to show from which group “isolation” comes. In addition, our counterfactual analysis has allowed us to explore whether the rise in segregation was the result of demographic changes or instead the consequence of skill groups moving apart more intensively.

Our research has shown that segregation is not only a pervasive phenomenon (requiring that between 8.5% and 12.9% of individuals in a city change their residential location to remove segregation) but also one that has intensified over this period. The increase in residential segregation is particular intense when looking at education, with a
rise of about 50% or above in Sydney, Melbourne, Perth and Brisbane and of roughly 35% in Adelaide.

Our analysis has also revealed that the rise in segregation by occupation groups cannot be explained by demographic changes but rather by an intensification of the over and underrepresentation of groups across locations. Regarding education, we have shown that whereas the highly educated groups are in general the most unevenly distributed in space, the rise in segregation was mostly driven by an increasing segregation of the low-skill groups and the growth of the highly skilled. Isolation of high social groups being higher than that of low social groups is a pattern also detected in North American and European cities (Bischoff & Reardon, 2014; Marciniacz, Musterd, van Ham, & Tammaru, 2016) for other socio-economic indicators.

The analysis given here indicates that whereas the least skilled groups became increasingly overrepresented in middle and outer areas of the cities, the most qualified and those in top occupations became more concentrated in the inner parts. The increasing concentration of low-skill groups in Australian suburban areas is in line with the suburbanization of poverty documented for Australia, the United States and the United Kingdom in recent years (Bailey & Minton, 2018; Kneebone & Garr, 2010; Pawson & Herath, 2015; Randolph & Tice, 2017), although our analysis has moved beyond documenting the spatial patterns of the various skill groups.

ACKNOWLEDGEMENTS
We acknowledge financial support from the Ministerio de Economía, Industria y Competitividad, the Agencia Estatal de Investigación, the Fondo Europeo de Desarrollo Regional (ECO2017-82241-R) and Xunta de Galicia (ED431B2019/34). Francisco acknowledges support from the Australian Research Council Centre of Excellence for Children and Families over the Life Course (CE140100027) and the University of Melbourne, and the Brotherhood of St Laurence.

CONFLICT OF INTEREST
The authors have no conflict of interest to declare.

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ENDNOTES
1 When using binary measures, like the dissimilarity index, in a context with more than two groups, scholars often compare each disadvantaged group with the most advantaged one (e.g., in the case of segregation by race/ethnicity, each minority group is compared with Whites). Other studies compare only the bottom and top socio-economic groups (Tammaru, Marciniacz, Aunap, van Ham, & Janssen, 2019) or each group against the rest of the population (Maloutas & Spyrellis, 2019; Marciniacz, Musterd, van Ham, & Tammaru, 2016).
2 Specifically, they use the Socio-Economic Index for Areas (SEIFA) produced by the Australian Bureau of Statistics applying principal compo-
14 For the harmonised SLAs that resulted from the amalgamation of SLAs, the distance was computed as the weighted average of the distances to the city centre from each of the centroids using the size of the SLA as weights.

15 For the estimation of the local polynomial, we used the Ipoly Stata command where each SLA was given a weight equal to its population size.

16 The percentiles $P_{0.5}$, $P_{0.6}$, $P_{0.7}$ and $P_{0.8}$ are shown in Table SB3. In the five cities, the median ($P_{0.5}$) is very close to 1 (expected representation).

17 The results for education are very similar and are available upon request.

REFERENCES

ABS – Australian Bureau of Statistics. (2001). Australian Standard Classification of Education (ASCED) 2001. Canberra: ABS.

ABS – Australian Bureau of Statistics. (2011). Australian Standard Geographical Classification (ASGC) 2011. Canberra: ABS.

ABS – Australian Bureau of Statistics. (2016). Socio-economic indexes for areas (SEIFA). Technical paper, Cat no. 2033.0.55.001. Canberra: ABS.

Acemoglu, D. (2002). Technical change, inequality, and the labor market. Journal of Economic Theory, 146(1), 1–38.

Anselin, L. (1988). Spatial econometrics: Methods and models. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Anselin, L., Syabri, I., & Kho, Y. (2006). GeoDa: An introduction to spatial data analysis. Geographical Analysis, 38(1), 5–22.

Australian Bureau of Statistics. (2011). Australian Standard Geographic Classification. Canberra: ABS.

Australian Bureau of Statistics. (2016). Socio-economic indexes for areas (SEIFA). Technical paper, Cat no. 2033.0.55.001. Canberra: ABS.

Beer, A., Bentley, R., & Bake, E. (2016). Neoliberalism, economic restructuring and policy change: Precarious housing and precarious employment in Australia. Urban Studies, 53(8), 1542–1558.

Bill, R., & Andrew, T. (2014). Suburbanizing Disadvantage in Australian Cities: Sociospatial Change in an Era of Neoliberalism. Journal of Urban Affairs, 36(sup1), 384–399. https://doi.org/10.1111/jua.12108

Bischoff, K., & Reardon, S. (2014). Residential segregation by income, 1970-2009. In J. Logan (Ed.), Diversity and disparities: America enters a new century. New York: The Russell Sage Foundation.

Campbell, I. (2004). Casual work and casualisation: How does Australia compare? Labour and Industry: A Journal of the Social and Economic Relations of Work, 15(2), 85–111.

Coelli, M., & Borland, J. (2016). Job polarisation and earnings inequality in Australia. The Economic Record, 92(296), 1–27.

Del Rio, C., & Alonso-Villar, O. (2019). On measuring segregation in a multigroup context: Standardized versus unstandardized indices. ECINEQ (Society for the Study of Economic Inequality) Working Paper 2020–561.

Diamond, R. (2016). The determinants and welfare implications of workers’ diverging location choices by skill: 1980-2000. American Economic Review, 106(3), 479–524.

Edgar, B. (2014). An intergenerational model of spatial assimilation in Sydney and Melbourne, Australia. Journal of Ethnic and Migration Studies, 40(3), 363–383.

Fortin, N. M., & Lemieux, T. (1997). Institutional changes and rising wage inequality: Is there a linkage? Journal of Economic Perspectives, 11(2), 75–96.

Frankel, D., & Volij, O. (2011). Measuring school segregation. Journal of Economic Theory, 146(1), 1–38.

Goldie, X., Kakuk, I., & Wood, G. (2014). Two tales of a city: Detecting socioeconomic disadvantage in an ‘advantaged’ Australian urban centre. Australian Geographer, 45(4), 521–540.

Goos, M., Manning, A., & Salomons, A. (2014). Explaining job polarization: Routine-biased technological change and offshoring. American Economic Review, 104(8), 2509–2526.

Hunter, B. H. (2003). Trends in neighbourhood inequality of Australian, Canadian, and United States of America cities since the 1970s. Australian Economic History Review, 43(1), 22–44.

Jones, K., Johnston, R., Forrest, J., Charlton, C., & Manley, D. (2018). Ethnic and class residential segregation: Exploring their intersection—A multilevel analysis of ancestry and occupational class in Sydney. Urban Studies, 55(6), 1163–1184.

Keating, M. (2003). The labour market and inequality. The Australian Economic Review, 36(4), 374–396.

Keeble, E., & Garr, E. (2010). The suburbanization of poverty: Trends in metropolitan America, 2000 to 2008. Washington: Brookings Institute.

Kramer, R., & Kramer, P. (2018). Diversifying but not integrating: Entropic measures of local segregation. Tijdschrift voor Economische en Sociale Geografie, 110, 251–270. https://doi.org/10.1111/tesg.12306, forthcoming.

Maloutas, T., & Spyrellis, S. N. (2019). Segregation trends in Athens: The changing residential distribution of occupational categories during the 2000s. Regional Studies, 54, 462–471. https://doi.org/10.1080/00343404.2018.1556392, forthcoming.

Marcinczak, S., Mustard, S., van Ham, M., & Tammaru, T. (2016). Inequality and rising levels of socio-economic segregation: Lessons from a pan-European comparative study. In T. Tammaru, S. Marcinczak, M. van Ham, & S. Mustard (Eds.), Socioeconomic segregation in European capital cities: East meets west (pp. 358–382). London: Routledge.

Martin, R. L. (1974). On spatial dependence, bias and the use of first spatial differences in regression analysis. Area, 6(3), 185–194.

Moir, H., & Selby-Smith, J. (1979). Industrial segmentation in the Australian labour market. Journal of Industrial Relations, 21, 281–292.

Pawson, H., & Herath, S. (2015). Dissecting and tracking socio-spatial disadvantage in an urban area. Geografie Tijdschrift voor Economische en Sociale Geografie, 36(1), 7–30. https://doi.org/10.1111/juaf.12108

Randolph, B., & Tice, A. (2017). Relocating disadvantage in five Australian cities, 2004-16: Extent, processes and nature. Urban Geography, 39(6), 892–915.

Baum, S., Haynes, M., van Gellecum, Y., & Han, J. H. (2006). Advantage and disadvantage across Australia’s extended metropolitan regions: A typology of socioeconomic outcomes. Urban Studies, 43(9), 1549–1579.

Beer, A., Bentley, R., & Bake, E. (2016). Neoliberalism, economic restructuring and policy change: Precarious housing and precarious employment in Australia. Urban Studies, 53(8), 1542–1558.

Bill, R., & Andrew, T. (2014). Suburbanizing Disadvantage in Australian Cities: Sociospatial Change in an Era of Neoliberalism. Journal of Urban Affairs, 36(sup1), 384–399. https://doi.org/10.1111/jua.12108

Bischoff, K., & Reardon, S. (2014). Residential segregation by income, 1970-2009. In J. Logan (Ed.), Diversity and disparities: America enters a new century. New York: The Russell Sage Foundation.

Campbell, I. (2004). Casual work and casualisation: How does Australia compare? Labour and Industry: A Journal of the Social and Economic Relations of Work, 15(2), 85–111.

Coelli, M., & Borland, J. (2016). Job polarisation and earnings inequality in Australia. The Economic Record, 92(296), 1–27.

Del Rio, C., & Alonso-Villar, O. (2019). On measuring segregation in a multigroup context: Standardized versus unstandardized indices. ECINEQ (Society for the Study of Economic Inequality) Working Paper 2020–561.

Diamond, R. (2016). The determinants and welfare implications of workers’ diverging location choices by skill: 1980-2000. American Economic Review, 106(3), 479–524.

Edgar, B. (2014). An intergenerational model of spatial assimilation in Sydney and Melbourne, Australia. Journal of Ethnic and Migration Studies, 40(3), 363–383.
Wilkins, R. (2007). The changing socio-demographic composition of poverty in Australia: 1982–2004. *Australian Journal of Social Issues, 42*(4), 481–501.

Yates, J. (2008). Australia’s housing affordability crisis. *The Australian Economic Review, 41*(2), 200–214.

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Additional supporting information may be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Azpitarte F, Alonso-Villar O, Hugo-Rojas F. Socio-economic groups moving apart: An analysis of recent trends in residential segregation in Australia’s main capital cities. *Popul Space Place*. 2021;27:e2399. [https://doi.org/10.1002/psp.2399](https://doi.org/10.1002/psp.2399)