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Descriptive Finding

The geographical patterns of birth seasonality in Australia

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Demographic Research: Volume 43, Article 40
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Abstract

BACKGROUND
Studies have shown how births exhibit seasonal patterns, with peaks and troughs in particular months and seasons. Most of this literature focuses on national-level patterns mainly in countries of the northern hemisphere.

OBJECTIVE
The aim of the paper is to describe key features of contemporary birth seasonality at a subnational scale across Australia.

METHODS
Data on births across the year by region for the 2001–2016 period were acquired from the Australian Bureau of Statistics. A Births Index was calculated to standardise for length of month and variations in birth numbers between regions. Choropleth maps and graphs were used to illustrate the geographical patterns.

RESULTS
Birth seasonality across Australia's regions is moderate but the patterns vary in a strongly clustered way. In northern and central latitudes of Australia, births are above-average early in the year (February to April), while in the southeast of the country they tend to be above-average in September and October.

CONCLUSIONS
The Australian results are consistent with physiological hypotheses that climate and environmental influences have a role in the seasonality of births. Hot and humid summers in northern Australia, and cold winters in the southernmost parts of the country, might be responsible for reducing the number of conceptions below their regional averages for the year.

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CONTRIBUTION

We demonstrate how birth seasonality across the regions of Australia has a strong climatic pattern that is consistent with physiological hypotheses.

1. Introduction

Seasonal variations in fertility have been observed in many countries. For example, in Sweden birth numbers peak in April and July, with much lower numbers of births in December (Dahlberg and Andersson 2018). In France, modest variation occurs throughout the year with slightly below-average birth numbers in March and December, and slightly above-average numbers in late September and early October (Régnier-Loilier and Divinagracia 2010). In Australia, seasonality is limited with small birth peaks in March and September and slightly below-average numbers of babies being born in December (ABS 2018; Mathers and Harris 1983). Seasonal patterns of births have been shown to vary across subgroups of the population. Notable differences in patterns have been observed for marital and nonmarital fertility (e.g., Régnier-Loilier and Divinagracia 2010), for births of different parities (e.g., Haandrikman 2004), for populations of different faiths (e.g., Friger, Shoham-Vardi, and Abu-Saad 2009), by mother's education level (e.g., Bobak and Gjonca 2001), and by mother's age (e.g., Dahlberg and Andersson 2018). Several studies have also demonstrated marked changes in the seasonality patterns over time (e.g., Cypryjański 2019; Compton and Tedds 2016), sometimes accompanied by a long-run reduction in the amplitude of seasonality (e.g., Régnier-Loilier and Divinagracia 2010; Cancho-Candela, Andrés-de Llano, and Ardura-Fernández 2007).

Apart from being of intrinsic interest to demographers, birth seasonality is important for a number of reasons. It is relevant in localities where there are large variations in birth numbers throughout the year because it will result in seasonal fluctuations in demand for maternity services. Birth seasonality is also related to infant disease epidemics (Martinez-Bakker et al. 2014), and it has been shown to be associated with longevity, with slightly longer lives lived by those born in late autumn and winter (Reffelmann et al. 2011). Month of birth has also been linked to a variety of other socioeconomic outcomes, including health, educational attainment, and income (Buckles and Hungerman 2013).

Explanations for birth seasonality commonly offered in the literature refer to various environmental and social/cultural factors (Lam and Miron 1991; Travato and Odynack 1993). Climate, temperatures, and photoperiod (length of daylight) are mentioned as possible influences on seasonal fluctuations in sexual activity, sperm quality, ovarian function, and pregnancy loss (Ellison 2008; Levitas et al. 2013). Ellison (2008) suggests that there is evidence that both ovarian function and early survival of the foetus are affected by energy levels and that these are lower in extreme climates. Levitas et al. (2013) have described seasonal variations in sperm counts and sperm motility in the United States concluding that the winter and spring semen patterns are compatible with increased fecundability and may be a plausible explanation of the peak number of deliveries during the autumn. For cultural and social influences, researchers have suggested a role for the socioeconomic composition of the population, religious calendars, the influence of holiday periods (especially at Christmas and New Year), marriage timing, and parental planning favouring births in certain months. However, the causes of birth seasonality are not fully understood.

Most studies of birth seasonality have focused on national scale trends, with only a few examining subnational patterns. They include Martinez-Bakker et al. (2014), who found that across the United States the peak month for births generally occurs around the middle of the year for more northerly states and later in the year for more southerly states. Trovato and Odynak (1993) examined 20th century births seasonality trends across the provinces of Canada, finding all provinces possessed fairly similar seasonal patterns. Above-average numbers of births occurred over March to July, with another peak in September reflecting Christmas/New Year conceptions.

This paper offers an overview of the subnational variation in seasonal birth patterns across Australia in the early 21st century. Given its wide range of latitudes and the associated heterogeneity of climates and environmental conditions, Australia presents a useful case study to assess the extent to which birth seasonality varies with climatic conditions.

2. Data and methods

Data on live births by SA4 region for the period 2001–2016 were acquired as a custom table order from the Australian Bureau of Statistics. SA4 regions comprise the standard ‘large’ subnational region type in the 2016 Australian Statistical Geography Standard (ABS 2016). Their populations are typically between 300,000–500,000 in metropolitan areas and 100,000–300,000 in nonmetropolitan parts of the country. There are 88 SA4 regions in total included in this study; one SA4 region, Other Territories, was excluded from the analysis due to its small population of only about 3,000 people. This region combines several small territories, such as Christmas Island and the Cocos Islands, which form part of Australia but do not belong to one of the states or mainland territories. Data for years prior to 2001 were not available on the same statistical geography.

The time reference of births refers to when the birth occurred, not the date of birth registration. Births for the latest two years of available data (2017 and 2018) are not included because registration delays mean the counts of births are incomplete, especially for the most recent months. All data were obtained as monthly births aggregated over years 2001–2016 to avoid small numbers. The births data is available in the additional files accompanying this paper.

To assess seasonality, numbers of births were converted to a Births Index I, calculated as the average daily number of births (B) in region j occurring in month m divided by the average daily number of births across the year y (with both numerator and denominator aggregated over all years of the study period) multiplied by 100:

$$I_m^j = \frac{B_m^j}{B_y^j} 100.$$

Values of the Births Index above 100 indicate above-average numbers of births for that month, while values under 100 indicate below-average numbers of births. Note that we have not standardised for the changing size of the female childbearing age population over time (where there is population growth, there will be a larger population at risk at the end of a year compared to the start). Because we aggregated births over a 16-year period, population growth from year to year is indirectly accounted for in rising birth numbers over time. The only remaining approximation is the effect of population change within a 12-month period, which is relatively minor.

We present our findings using choropleth maps and simple graphs. Digital boundary data for SA4 regions were obtained from the ABS website (ABS 2016) and maps were created in QGIS. Data on the latitude of SA4 regions consists of polygon centroids, obtained from tables accompanying the digital boundary data.

3. The seasonality of births in Australia

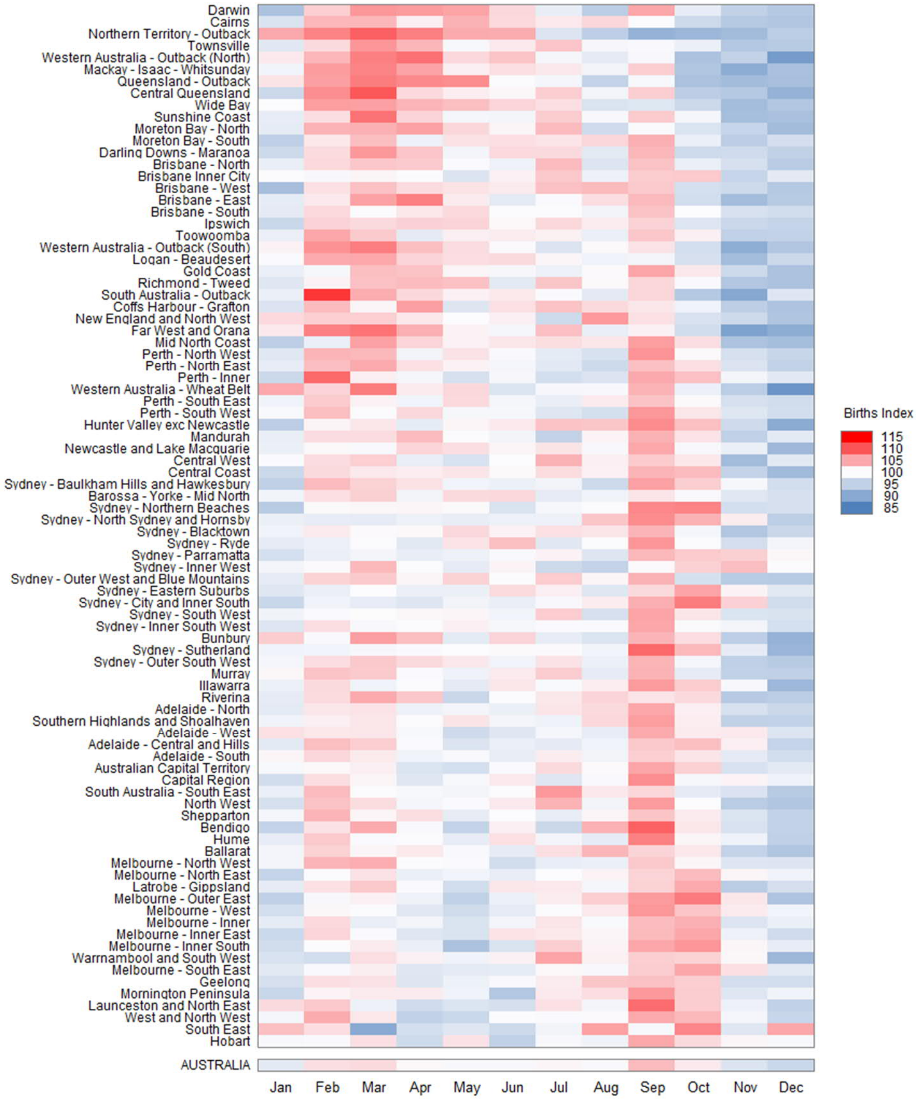
At the national level there is relatively little seasonal variation in fertility in Australia, with the Births Index at its lowest in December at 95.7 and highest in September at 103.9. At the regional scale, more seasonal variation is evident. The heatmap in Figure 1 illustrates the distribution of the Births Index by month across SA4 regions, with the regions ordered from north to south down the vertical axis. Note that because the majority of Australia's population lives in the southern half of the country, the vertical axis of the heatmap is not proportional to latitude, and only regions above the Sunshine

Coast (the 10th region from the top) have centroids positioned north of the latitude of the geographic centre[3] of Australia.

Overall, the seasonality is fairly modest, with only 0.5% of regional Birth Index values lying outside the 90–110 range. Figure 1 shows that the greatest variations from the annual average occur mostly around February/March (late summer and early autumn) and September/October (spring). Peak fertility in the northern half of Australia tends to occur early in the year in February, March, and April, while most regions in the south experience their peaks in September or October, which are the result of conceptions around Christmas and New Year. Some regions in the south, such as South Australia – Outback, Western Australia – Outback (South), and Far West and Orana (the remote western half of New South Wales), are inland or remote regions that also experience peak fertility early in the year. Almost all regions experience below-average numbers of births in November and December, while in June the number of births is close to the annual average for most regions and the variation between regions is also the lowest for any month.

[3] The Lambert gravitational centre of Australia (https://www.ga.gov.au/scientific-topics/national-location-information/dimensions/centre-of-australia-states-territories).

Figure 1: The distribution of the Births Index by month for SA4 regions



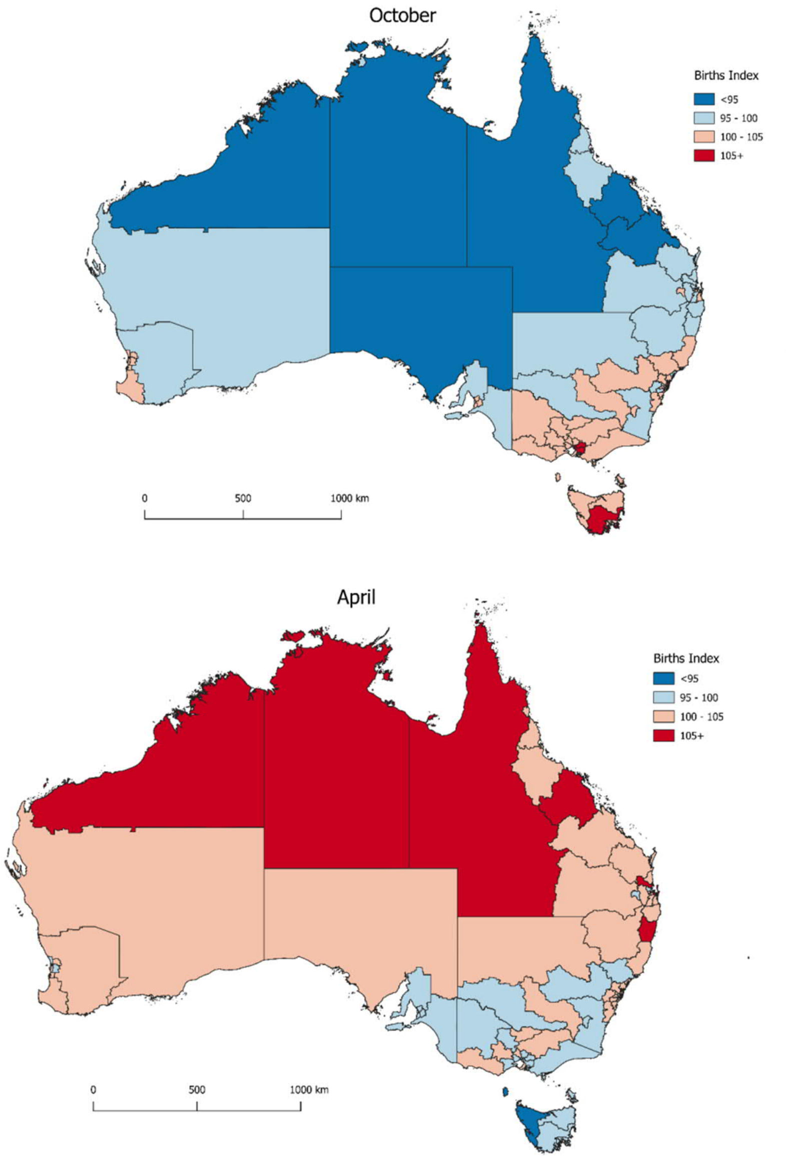
Source: Calculated from ABS births data.
Note: Regions are ordered from north to south down the vertical axis according to the latitude of regional centroids in ABS digital boundary data.

As suggested by Figure 1, geographical variations in the Births Index are greatest in autumn and spring. Figure 2 illustrates the geographical patterns of the Index in April and October, the middle months of autumn and spring, respectively. In October, above-average numbers of births occur in many parts of southern Australia, while in April the opposite is true, with northern Australia experiencing above-average births. The relationship is not perfect, but the majority of regions which experience above-average numbers of births in April have below-average births in October. These maps hint at conceptions being a little below average in northern and central Australia during the hot summer months (December to February), and below average in southern Australia during the cold winter months (June to August), especially in Tasmania[4].

Figure 3 presents the data from a different perspective by mapping the peak month of the Births Index across Australia. September is the most common month (38 regions), followed by March (18) and then October (11); no regions experience their peak births in January, November, or December. The darker the shading on the map, the later in the year the peak month occurs. As can be seen, across many northern and central regions of the country the peak births month occurs in late summer and autumn (February to April), reflecting conceptions in late autumn and winter (May to July) when these hot parts of Australia are less hot and humid. Further south a select few regions experience peaks in winter. Many southeastern regions of the mainland and Tasmania experience their highest fertility in spring (September and October), reflecting December and January conceptions when these southern regions are warmer. The geographical clustering is clearly strong, though not perfect. For example, one SA4 region of Melbourne experiences peak births in March while all other regions of the city have peaks in September or October.

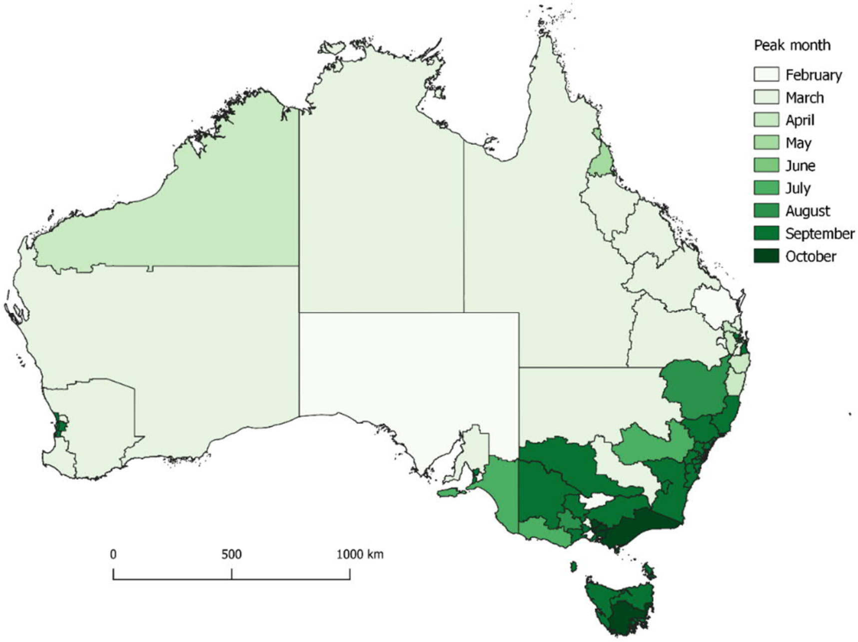
[4] The large island off the south-east coast of mainland Australia.

Figure 2: The Births Index by SA4 region in April and October



Source: Calculated from ABS births data.

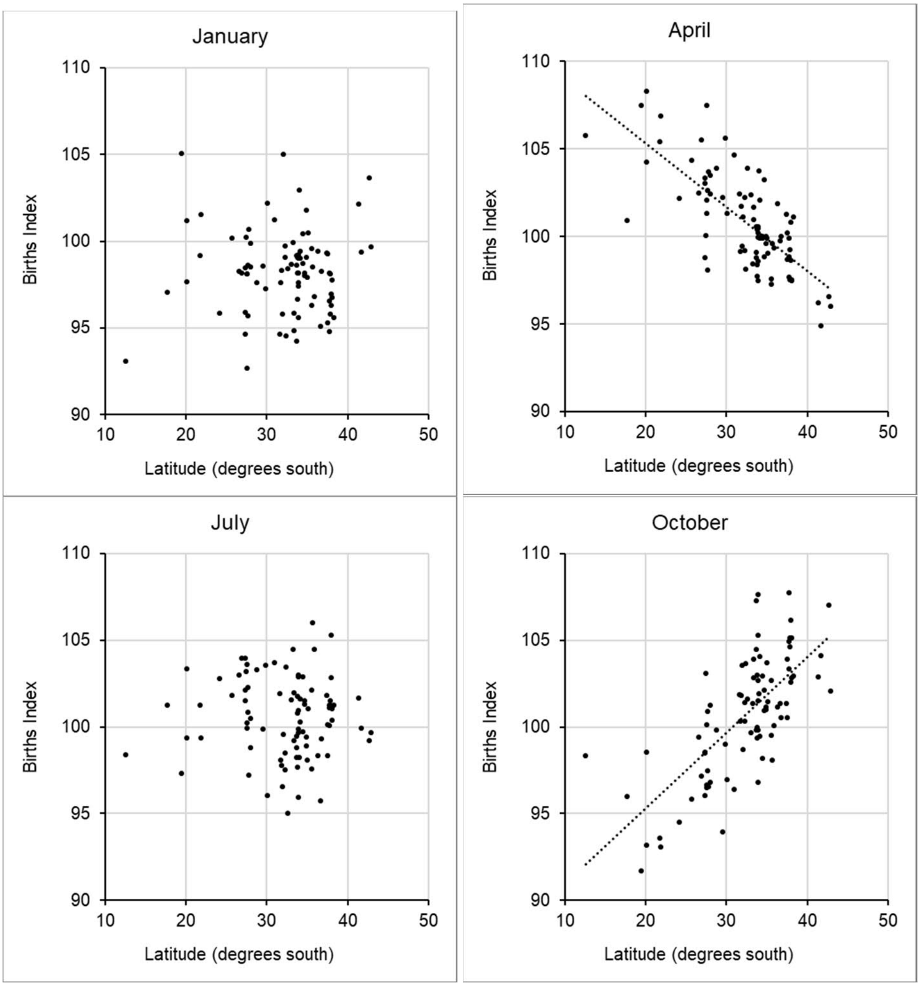
Figure 3: The peak month of the Births Index by SA4 region



Source: Calculated from ABS births data.
Note: No regions experience their peak births in January, November, or December.

The literature suggests a role for environmental factors in shaping birth seasonality patterns, including climate, temperature, and photoperiod (Ellison 2008; Levitas et al. 2013). Like Martinez-Bakker et al. (2014) we use latitude as a proxy for those variables. Figure 4 plots the association between latitude and the Births Index for the middle month of each season; these are also the months of the year with strongest and weakest associations with latitude. The number of births occurring in summer and winter has little association with latitude as shown by the graphs for January and July, but this is not the case in spring and autumn. The correlation coefficient of the Births Index with latitude is 0.71 in October ($r = 0.71$, 95% CI 0.58, 0.80) and –0.73 in April ($r = –0.73$, 95% CI –0.82, –0.62). The cross-over between above- or below-average births in spring and autumn is located at approximately 31 to 34 degrees south. The graphs in Figure 4 therefore hint at some influence of hot and cold weather in the seasonal patterns of births across Australia.

Figure 4: The association between the Births Index and latitude for SA4 regions for the middle month of each season



Source: Calculated from ABS births data.
Notes: January = summer, April = autumn, July = winter, October = spring. The centroid of the northernmost region of Australia is at about 13 degrees south and the southernmost about 43 degrees south. Across each season, OLS regressions were estimated with latitude a predictor of the Births Index in both April (b = –0.36, 95% CI –0.43, –0.29) and October (b = 0.44, 95% CI 0.34, 0.53). In April the R^2 was 0.54, and in October it was 0.50.

4. Discussion

This paper has presented data on the geographical variations in birth seasonality in contemporary Australia. An important point is that while at the national level there is only slight seasonality in births, at the regional scale more variation is evident. This is hardly surprising – for almost any social variable greater variety is observed as the spatial filter becomes finer.

Probably the most obvious finding of our brief presentation is the striking geographical clustering of birth seasonality in Australia – at least at the chosen SA4 scale. The maps in Figures 2 and 3 display patterns that are far from random. In autumn, births are above-average in northern and central latitudes of Australia, then as the year progresses births peak in more southern regions. It could well be that extremes of weather play some role in this seasonality: hot and sweaty summers in the north and centre of Australia, and cold winters in the southernmost regions, reduce the number of conceptions below the region's average for the year. Conceptions increase when the region experiences more comfortable weather relative to these very hot and cold seasons. This is consistent with Ellison's (2008) hypotheses on the effect of extreme climates on energy levels and hence upon ovarian function and early foetal survival.

The range of the Births Index throughout the year shows a weak relationship with latitude (not shown) in which northern regions generally experience the largest seasonal variations. Across the United States, Martinez-Bakker et al. (2014) found a similar relationship between birth seasonality range and latitude for the 1965–2008 period: US states nearer the equator generally had larger seasonal variations, though the association between the seasonal range and latitude was fairly weak. However, it is possible that the relationship in Australia may be more associated with remoteness or seasonal temperature ranges, as all large outback regions located far from Australia's major cities tend to have the largest seasonal variations in births.

There are almost certainly other factors at work, many of them social and cultural. The role of the Christmas/New Year holiday period is clearly revealed in Figure 1, showing a small September or October peak in births for most SA4 regions of southern Australia. Other influences worth exploring are the socioeconomic composition of regional populations, including employment type, educational qualifications, and ethnic and cultural background including Indigenous fertility patterns in northern and remote regions. The level of fertility and parity patterns may also be important. In addition, as Evans and Gray (2018) point out, characteristics of the local area may also be relevant to fertility, such as the state of the local labour market, housing affordability, and population density.

Of course, our study has some limitations. We focused on the geographical pattern of birth seasonality at one geographical scale (SA4 regions) for one time period in aggregate (2001–2016), and without any breakdown by population characteristics (education, parity, etc.). Our presentation also focused on just a few key features, and we did not provide a definitive explanation for the patterns. Further insights could be garnered beyond our descriptive analyses through various spatial econometric techniques to explore the determinants of the observed seasonality. In addition, from a historical and international perspective, it is important to point out that the seasonal variations in regional fertility shown here are mostly moderate, and for any month the Births Index rarely falls outside the range 90–110. Only a few regions experience relatively large amplitudes of seasonality, and they are generally outback and more remote regions (Figure 1). Nonetheless, we have revealed some interesting geographical patterns in birth seasonality in Australia that are ripe for more extended investigation.

5. Acknowledgments

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