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Comparing changing age-specific fertility across the United Kingdom using Lexis diagrams

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ABSTRACT

Within the constituent parts of the United Kingdom (UK) there are many differing demographic characteristics which are not routinely researched and understood. Among these characteristics are age-specific fertility rates (ASFRs) which differ between the constituent countries of the UK. This paper aims to address a gap in the fertility literature by using the Lexis diagram to explore fertility trends within the UK. This work explores differing ASFRs using Lexis diagrams to allow for detailed analysis, interpretation and display of changes in fertility that have occurred. Lexis diagrams have not previously been used in the analysis of fertility for the constituent parts of the UK, yet are ideal for making such fine-grained comparisons as they show age at birth, year of birth and cohort trends simultaneously. The essence of this paper is the exploration of trends in fertility in the constituent countries of the UK for the period (1950-2008). The analysis is simple in terms of the output, with a gradient of colours showing contrasting high and low rates in the period of interest. The research shows that there are subtle differences between the constituent countries of the UK and over time a gradual convergence may be occurring.

KEYWORDS

EDITORIAL NOTE

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COMPARING CHANGING AGE-SPECIFIC FERTILITY ACROSS THE UNITED KINGDOM USING LEXIS DIAGRAMS

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1 INTRODUCTION

This paper aims to provide a more detailed analysis of age-specific fertility trends for the United Kingdom (UK) than previously available, using the Lexis diagram. The essence of this paper is the exploration of trends in fertility by single year of age in the constituent countries of the UK for sections of the period from 1950 to 2008. Although there has been, as will be shown, some research on the fertility in different parts of the UK, there has not been any such work comparing the constituent countries making up the UK. This paper addresses this by using the Lexis diagram to compare age-specific fertility rates (ASFRs) in the different countries making up the UK; England and Wales, Scotland and Northern Ireland. The strength of the Lexis diagram approach is a wealth of data can be displayed in a compact manner. Analysis of the single diagram produced is intuitive and makes comparisons straightforward. The methodology involved requires various calculations but none more complex than addition, subtraction, multiplication and division. Clear from the analysis are trends over long time periods; age, period or cohort effects can be observed.

2 EMPIRICAL BACKGROUND – FERTILITY ACROSS THE UNITED KINGDOM

Within the literature on fertility in the UK there has been a limited amount of work studying variations in fertility within the constituent parts of the UK. Many studies prefer to take a cross-national comparative perspective by comparing other European countries (Rendall et al., 2009; Rendall et al., 2005: Sobotka, 2004) and fertility of specific groups, teenage fertility, for example (Rendall, 2003). Among the few papers which have considered fertility at a smaller geographic scale is that by Tromans et al. (2008), which looked at the degree to which changing trends in fertility in England have been evenly distributed. In the main, literature has been concerned with using some of the more powerful demographic techniques available to understand the key drivers of changing fertility, for example postponement of fertility (Berrington, 2004) and social class influences (Buxton et al. 2005). This is justified, yet work like that by Tromans et al. (2008) on changing fertility in England and Wales is also useful for demographers and policy makers.

It is often the case that the fertility of England and Wales is accorded attention and sometimes assumed to be representative of the UK as a whole (e.g. Sigle-Rushton, 2008), yet there are widely reported differences between England and Wales when compared with Northern Ireland and Scotland. For example, Northern Ireland has a Total Fertility Rate (TFR) which is persistently higher than that of England and Wales, while Scotland has a TFR which, since the late 1970s, has shown a 'distinctive path' (Wilson and Rees, 2003). In Northern Ireland the result of the higher fertility rate has been a younger and faster growing population than the other parts of the UK. The TFR in Northern Ireland remained above the replacement rate of 2.1 for some 20 years after the decline below replacement in England and Wales in 1973 (NISRA, 2009; Dunnell, 2007). In 2008 the TFR returned to replacement level from the lowest ever recorded TFR in the province in 2002 (Matheson, 2009). Ruddock et al. (1998) discussed the trend towards increasing numbers of births outside of marriage in Northern Ireland, yet within the UK context rates in Northern Ireland are much smaller. Other research looking at fertility in Northern Ireland by Graham (1995) identified trends in the demography of Northern Ireland using census data, as well as research by Compton (1985), who looked at correlates with fertility rates. A gap in the literature is the dearth of studies exploring the higher fertility of Northern Ireland in relation to other parts of the UK.

Fertility in Scotland, like Northern Ireland, has not been understood in the context of the other constituent parts of the UK. This is despite the differences in fertility between Scotland and Northern Ireland and England and Wales. In Scotland the fertility rate has been the lowest within the UK constituent countries. This has led to calls for a 'population policy' and has perhaps, in part at least, motivated initiatives such as 'Fresh Talent' which aims to retain recent graduates in Scotland (Houston et al. 2008). Until the late 1970s Scotland exhibited a higher fertility rate than England and Wales but now has a distinctively lower trajectory (Wilson and Rees, 2003; Armitage and Babb, 1996).

In sum, there are distinctive trajectories for fertility in each of the countries composing the UK. England and Wales show similar overall trends, although a slightly higher teenage fertility rate in Wales can be identified (Sigle-Rushton, 2008). Northern Ireland has a higher TFR than has been the case in England and Wales or

Scotland. In contrast to England and Wales, and particularly Northern Ireland, Scotland has the lowest TFR of the UK constituent countries. Although the overall TFRs are a helpful starting point for comparison, it is worth considering changing ASFRs as these show the age groups driving the period differences at the aggregate level as well as the degree to which there are similarities and differences across the UK.

3 RESEARCH AIM

Given the differences in the characteristics and the overall TFRs for different parts of the UK outlined in the previous section, it is worth exploring these differences in more detail. In this study, the main aim is to understand differences in fertility 'profiles' within the constituent countries of the UK by exploring the changing fertility of women by year and age simultaneously across the constituent parts of the UK.

The Lexis diagram is suitable in this context, as it allows the identification of differences between the individual countries making up the UK in a more detail. Using ASFRs for the constituent parts of the UK, underlying trends in each country will become clearer. Additionally, it is possible to calculate the degree of similarity and dissimilarity between the parts of the UK. Again, by using the ASFRs, a ratio figure which compares two rates is calculated to show the overall degree of similarity or dissimilarity.

4 DATA AND METHOD

4.1 DATA

Table 1 shows the data collected for analysis; the source of the data and the time period for analysis. The raw data itself was sourced from the Office for National Statistics (ONS), The General Register Office for Scotland (GROS) and the Northern Ireland Statistics and Research Agency (NISRA). The raw data are births and the mid-year female population for England and Wales and Scotland, although for Northern Ireland the ASFR has already been calculated across all years of interest.

Data Description	Source	Years
England and Wales mid-year female population	ONS	1963-2007
England and Wales births	ONS	1963-2007
Scotland mid-year female population	GROS	1950-2008
Scotland births	GROS	1950-2008
Northern Ireland Age Specific Fertility Rates	NISRA	1977-2008

Table 1: Data sources for ASFRs

4.2   CALCULATING AGE-SPECIFIC FERTILITY RATES

The calculation of ASFRs is a straightforward process. An ASFR shows the rate at which people of a particular age are having children. The rates are comparable across the childbearing age ranges and unaffected by differences in the numbers of women in a particular birth cohort and age-sex composition changes. "An age-specific birth rate is defined as the number of births to women of a given age group per 1,000 women in that age group." (Shryock and Siegel, 1976, p.278). The combined ASFRs give the Period Total Fertility Rate. However, this is a synthetic figure and, as it is cross-sectional, its representativeness for births occurring in a year has been questioned because of the increasing age at first birth and trends to later fertility (Bongaarts, 2002; Sobotka, 2004).

Using the data (see Table 1) ASFRS were calculated for single years of age every year. The age-specific fertility rate is defined in Hinde (1998, p.100) as:

$$fx = \frac{\text{births in year } t \text{ to women aged } x \text{ last birthday at the time of birth}}{\text{mid-year population of women aged } x \text{ last birthday}}$$

The numerator is the births in the calendar year to women in the whole year, while the denominator is the mid-year population of women aged x at their last birthday.

To calculate the ASFRs for England and Wales and Scotland, divide the number births for each age group by the number of females in the population in that age group. For example, the ASFR for females age 20 years, in England and Wales in 1990 is 70.13. This is calculated by dividing the number of births to women aged 20

in 1990 in England and Wales (26,580) by the number of women aged 20 years in 1990 in England and Wales (378,996.5), then multiplying by 1,000 (26,580 / 378,996.5 * 1,000 = 70.13). The same ASFR for Scotland is 64.67 (2,589 / 40,031 *1,000 = 64.67).

To get the rate ratio for England and Wales over Scotland we divide one (70.13) (England and Wales) by the other (64.67) (Scotland) and then get the comparison figure (70.13/64.67=1.08).

4.3 USING RATE RATIOS TO COMARE AGE-SPECIFIC FERTILITY RATES ACROSS COUNTRIES

To compare the individual fertility rates the rate ratio for two countries can be used. This gives a single number for each age and year which shows the difference in fertility between countries. It is constructed by taking the corresponding ASFRs and dividing them as described previously. This rate ratio shows the difference between countries. If the rate ratio is 1 both countries have the same ASFR, where it is greater than 1 the ASFR is higher in the numerator country, and where less than 1 the ASFR is higher in the denominator country. Using these ratios in the Lexis diagrams shows where there is a greater or lesser degree of similarity or dissimilarity between the single year age groups, by year, in each country. A final step before visualising the figures using the software is to smooth the data using the geometric mean. This takes the values of the surrounding cells (two above and two below), to avoid highlighting errors or anomalies that detract from the overall pattern. For example, supposing a unadjusted ASFR for a 25 year old, this data would be smoothed by averaging the ASFR for 23-27 year olds, give a smoothed ASFR.

4.4 LEXIS DIAGRAMS

The transformation of the raw data and the preliminary analysis was carried out in the statistical software R (R Development Core Team, 2008), Lexis Software and Microsoft Excel. The demographic data which was collected and the subsequent dataset created allow a Lexis diagram to be drawn. The Lexis diagram has been referred to as "one of the most useful technical devices of demography" (Alho and Spencer, 2005; p.17). To interpret the Lexis diagrams a brief explanation of what it

represents is needed. For every Lexis diagram, there is a standard format whereby the horizontal axis refers to year (e.g. 1980) and the vertical axis refers to age groups (e.g. age 30 years). The Lexis diagram is a series of coloured cells, organised in columns and rows. This means that age effects are apparent as horizontal lines of the same colour, cohort effects are identifiable as diagonally upwardly sloping lines of similar colour and period effects are shown as vertical columns of a similar colour. Lexis diagrams are "shaded contour maps that represent an array of demographic data over three dimensions" (Gjonca, 2005; p.11). In this instance, each cell of the Lexis diagram represents an ASFR ratio, which is then colour coded. The magnitude which corresponds to the colour is shown in a legend. The simplicity of the Lexis diagram is that in a single diagram a wealth of data is conveyed through coloured cells. Moreover, the reader can identify age, period and cohort effects. The colour of each cell shows the ratio of fertility rates.
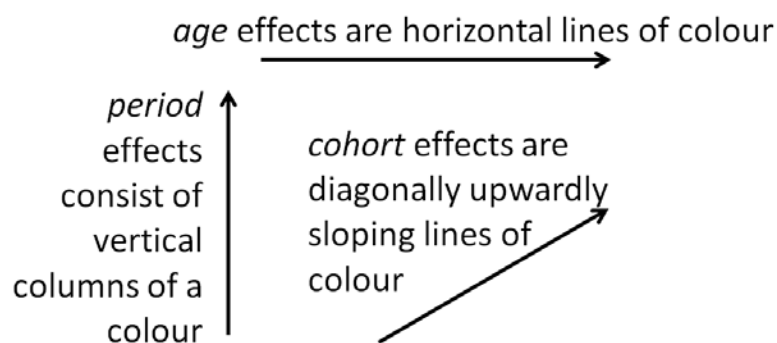

Figure 1: Interpreting Lexis Diagrams - Age, Period and Cohort Effects

5   RESULTS

First, this section discusses aggregate Total Fertility Rates (TFRs) for each country. Secondly, ASFRs in each of the constituent countries of the UK are discussed and thirdly, comparison diagrams (rate ratios) are analysed.

5.1   TOTAL FERTILITY RATES IN THE UK

Briefly, we give an overview of the main trends in the period 1970 – 2008. Figure 2 shows the TFR for the constituent parts of the UK. It is noticeable that there are

differences, with the exception of England and Wales which are very similar. This in part explains the grouping of England and Wales in the analysis in the next section – there are modest differences between England and Wales compared to differences between the former, Scotland and Northern Ireland. Scotland experiences analogous TFRs for most of the period, with a gradual drift downwards to become the country with the lowest TFR in the UK. Northern Ireland, on the other hand, is clearly different. It has experienced a much higher TFR until the early nineties. Possible reasons include cultural and religious differences to the rest of the UK and the history of this region (Mullholland, 2002). What can be seen is a convergence towards a comparable TFR across all constituent countries around the year 2000. What this study aims to explore further is a more fine-grained analysis of the age-specific trends behind the aggregate figures.
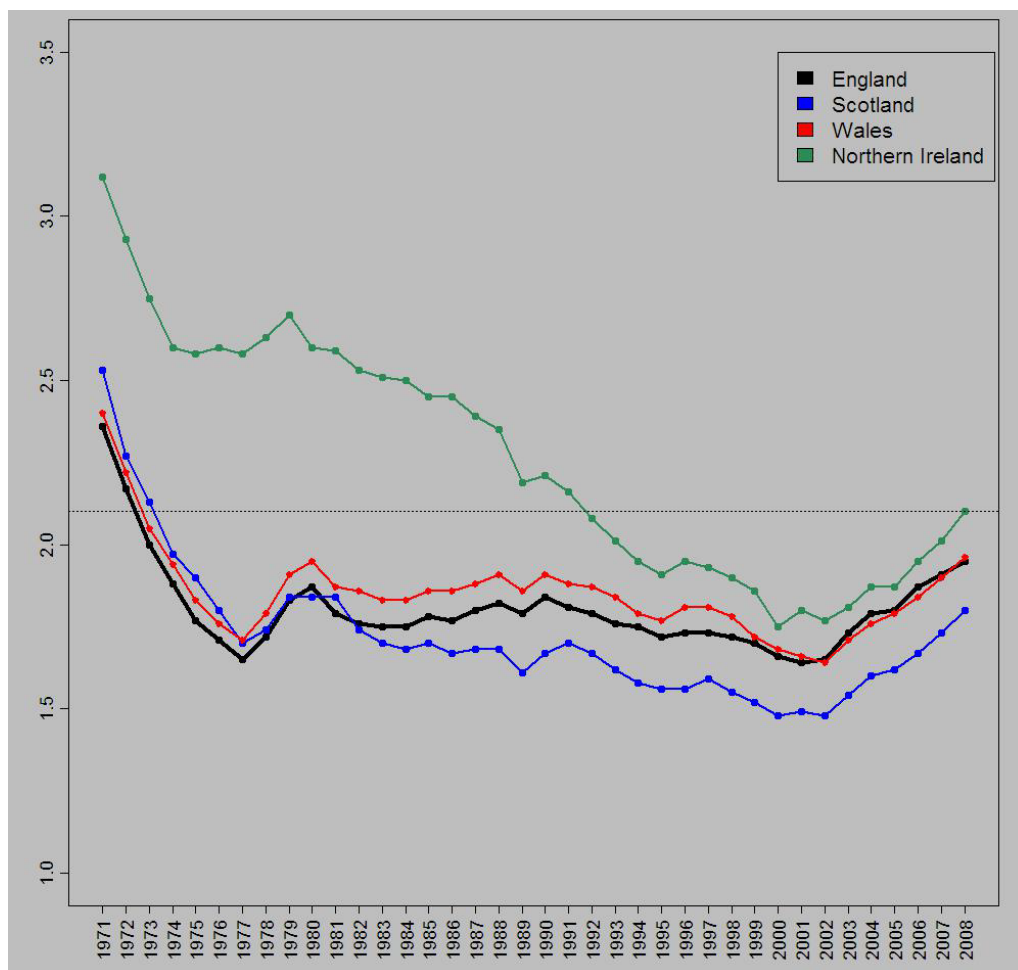

Figure 2: Total Fertility Rates, 1971-2008 consitutent countries of the United Kingdom

Source: Authors own analysis of ONS, GROS and NISRA data (2010).

5.2 AGE-SPECIFIC FERTILITY RATES

Single-year, ASFRs for all available years were calculated for each part of the UK. Figures 3, 4 and 5 show the results for England and Wales, Scotland and Northern Ireland respectively. As with many official statistics, England and Wales have been amalgamated.

England and Wales (see Figure 3) has the lowest intensity of fertility in the key childbearing age – the twenties. It also appears that the high ASFRs of over 140 per 1,000 from 1955-1975 among those aged 20-30 gradually reappear towards the end of the study period (2004 onwards). All the diagrams in this section illustrate the rising age at first birth occurring in all countries. The stepped pattern in the graphs towards the top right of the diagrams shows the increasing age at birth. Figure 3 shows that for England and Wales the rise since around 1970 has been persistent and in the late 1990s looks to have accelerated, with an upwards turn in the 'steps'. However, we can see that fertility among those aged 30 years or over has only increased to a limited degree. The diagram suggests that the fertility of those in their thirties averages about 40-60 for the whole period.
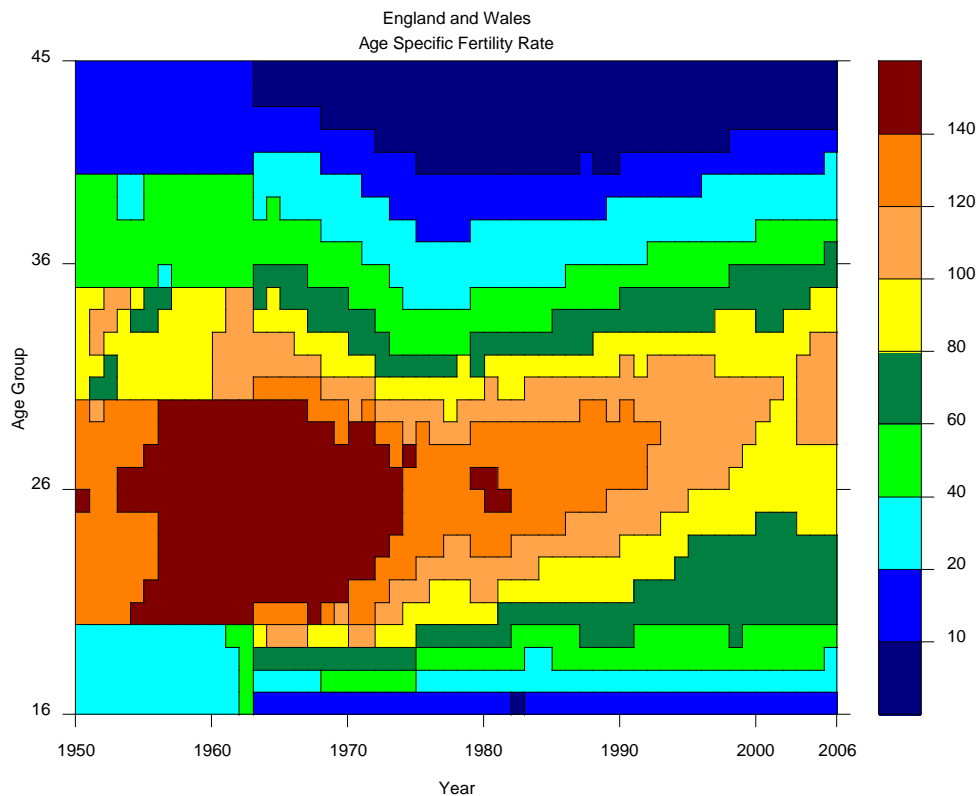
Figure 3: ASFRs for England and Wales

Source: Authors own analysis of ONS data (2010).

Although there are some similarities between England and Wales and Scotland (Figure 4) in the overall pattern, there are some noticeable differences. In terms of similarities it is notable that, like England and Wales ASFRs for those in their twenties declined in the early 1970s, at the transition to the most recent period of 'below-replacement fertility'. The main difference between England and Wales and Scotland is the higher intensity of childbearing among women in their twenties and the degree to which this has persisted through time. In Scotland there is a higher intensity of childbearing among those in their twenties throughout the period after 1980, apart from a decline to below 100 per 1,000 around the turn of the millennium. This lowest intensity in the age group coincides with the record lowest Total Fertility rate (the sum of ASFRs) which was 1.6 in 2001 (see Figure 2). The most recent data available suggests that there has been an increase in the fertility of women in this group – shown by the orange colour in the extreme right of the diagram. Trends among women in their thirties and teenagers are broadly similar to England and Wales (shown at the upper and lower extents of the diagram). For the older age groups (over 40 years), the pattern is surprisingly similar in Scotland when compared to England and Wales. This should be reflected in the comparison diagrams.
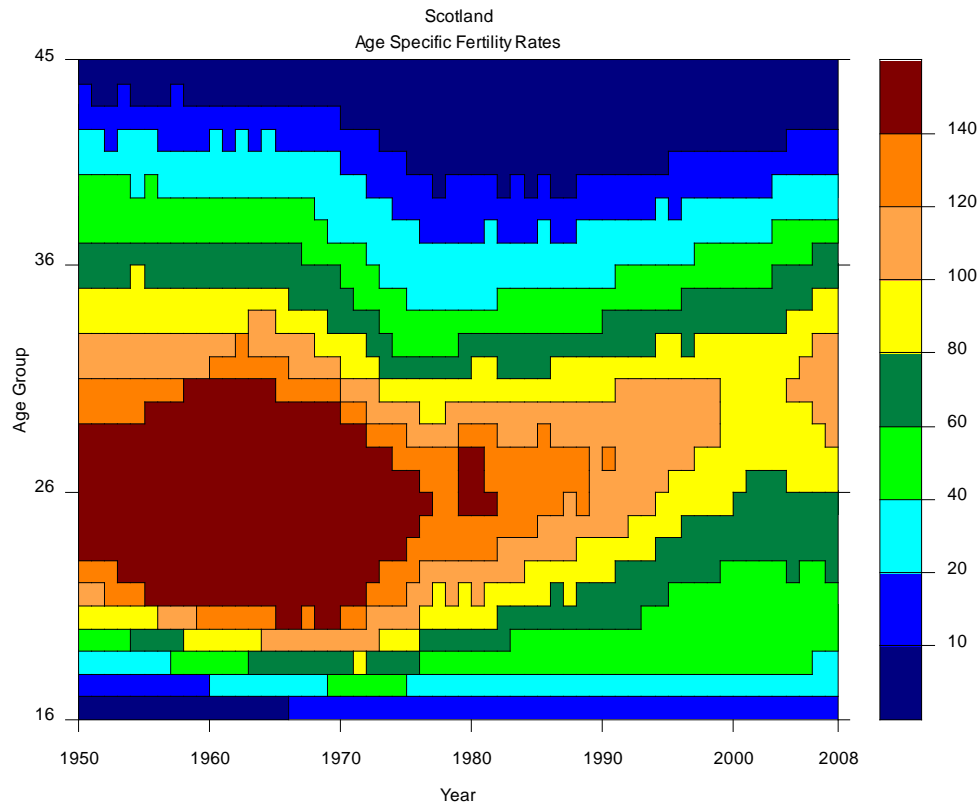
Figure 4: ASFRs for Scotland

Source: Authors own analysis of GROS data (2010).

Northern Ireland (see Figure 5) has a very strong intensity of fertility among those in their twenties and thirties. At the beginning of the timeframe there is an age group in excess of ten years (those aged approximately 22-34 years) where the intensity of childbearing is 100 plus per 1,000. Through time the number of years for which there is such intensity narrow, with the lowest number of years with a fertility rate in the top category being around 2001 (as for Scotland). The main trend by age group has been towards a weakening of fertility in the early twenties. Rates have fallen through the period. In the period since 2000 there seems to have been a stabilisation of rates among those in their mid-twenties with persistence of the 100 plus per 1,000 rates as well as an increase in intensity for those in their early thirties. In addition to the increases in the highest intensity in the early thirties in the diagram there has also been an increase in the intensity of fertility in the 50-75 and 75-100 per 1,000 categories. It is possible that some of this increase could arise from a delay to first births among those in their twenties around 2000 and movement to the early thirties age groups around 2008. For all three diagrams it is fair to say that there has been a delaying of childbearing over the study period.
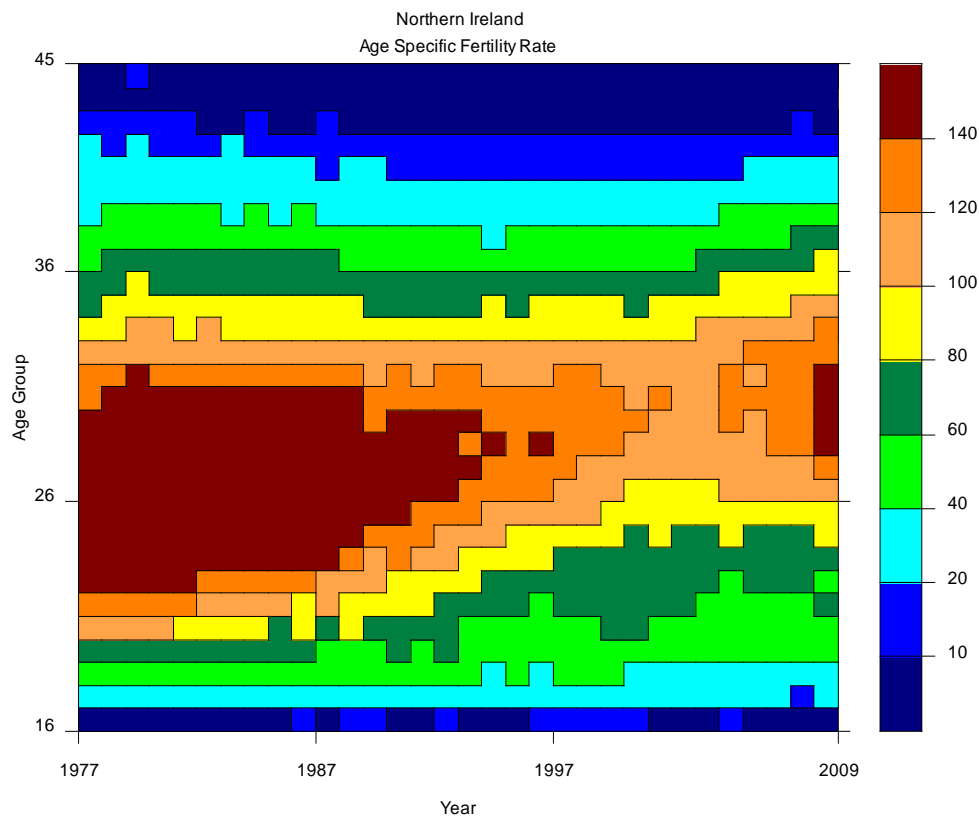
Figure 5: ASFRs for Northern Ireland

Source: Authors own analysis of NISRA data (2010).

5.3 COMPARING AGE-SPECIFIC CERTILITY RATES USING LEXIS DIAGRAMS

Using Lexis diagrams it is also possible to make comparisons of the ASFRs. By taking the ASFRs for those women of a certain age in a particular year and dividing the rate for one country by the corresponding rate in the same age group and year in another country, it is possible to compare and contrast rates. For this work it is necessary to compare years where there is data available in both countries (i.e. for Northern Ireland there is only data from 1977 whereas for England data goes back further, yet comparisons can only be made from 1977). The difference between the countries is shown by the colour gradient.

The first comparison diagram, Figure 6, shows the similarity between England and Wales and Scotland. The range 0.9 to 1.1, denoted by the colours blue-green and light green, form a large part of the Lexis diagram. The differences mainly occur in the pre-1970 period, where Scotland is has a higher fertility rate. However, the

opposite is true among older women from 1990 onwards and to a lesser extent for those in their early twenties from 1995-2005.

The diagram showing England and Wales over Northern Ireland, Figure 7, shows a more interesting pattern, in that there are fewer similarities between the two countries (note the oranges). The youngest ages at birth are consistently higher in England and Wales than Northern Ireland, suggesting a higher rate of teenage pregnancies in England and Wales compared to Northern Ireland. The more interesting pattern is that ASFRs in Northern Ireland are higher (i.e. rate ratio less than 1) for almost all other age groups. The most extreme examples occur during the late 1970's and 1980's when, for those women aged 35 years or older, the ASFR is double for Northern Ireland compared to England and Wales.

Comparison of Scotland over Northern Ireland (Figure 8), shows a similar pattern to England and Wales over Northern Ireland, as one would expect since England and Wales and Scotland are broadly similar. Cohort effects are very clear (upwardly diagonal colours), with successive cohorts conforming to a more uniform rate. There are some extreme rates for those cohorts over 35 years in the 1977-1997 period, with double the ASFRs in Northern Ireland compared to Scotland for most of the period. The other point of note is the higher teenage fertility rate in Scotland compared to Northern Ireland.
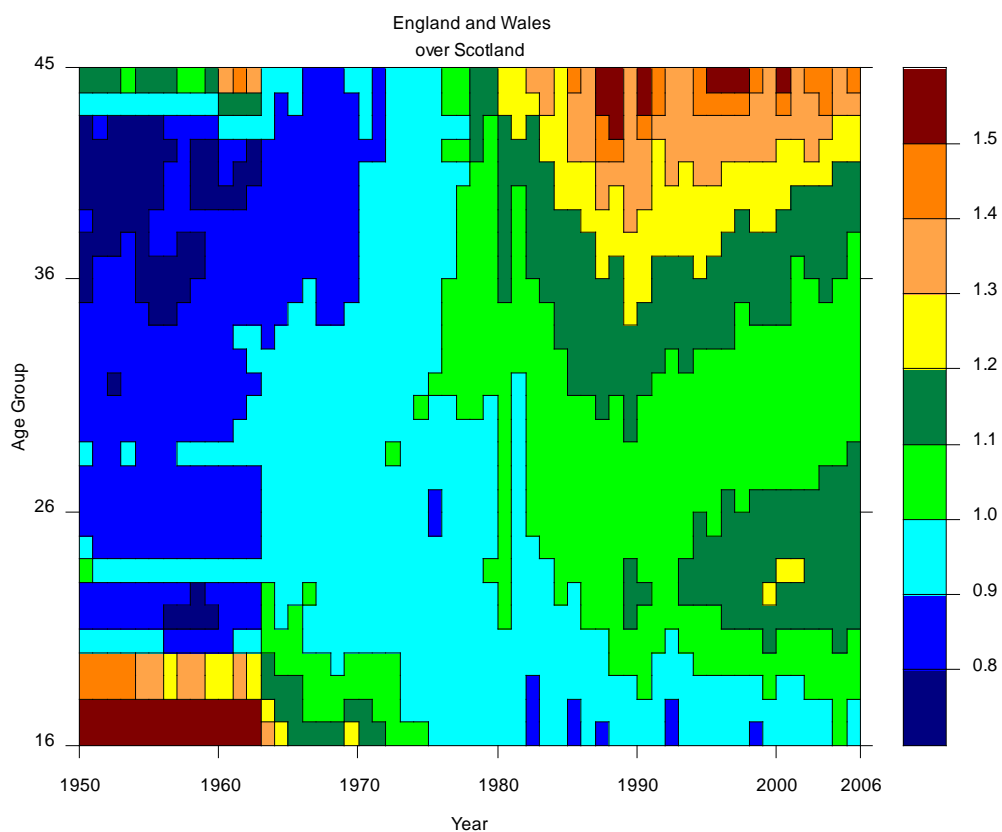
Figure 6: England and Wales over Scotland
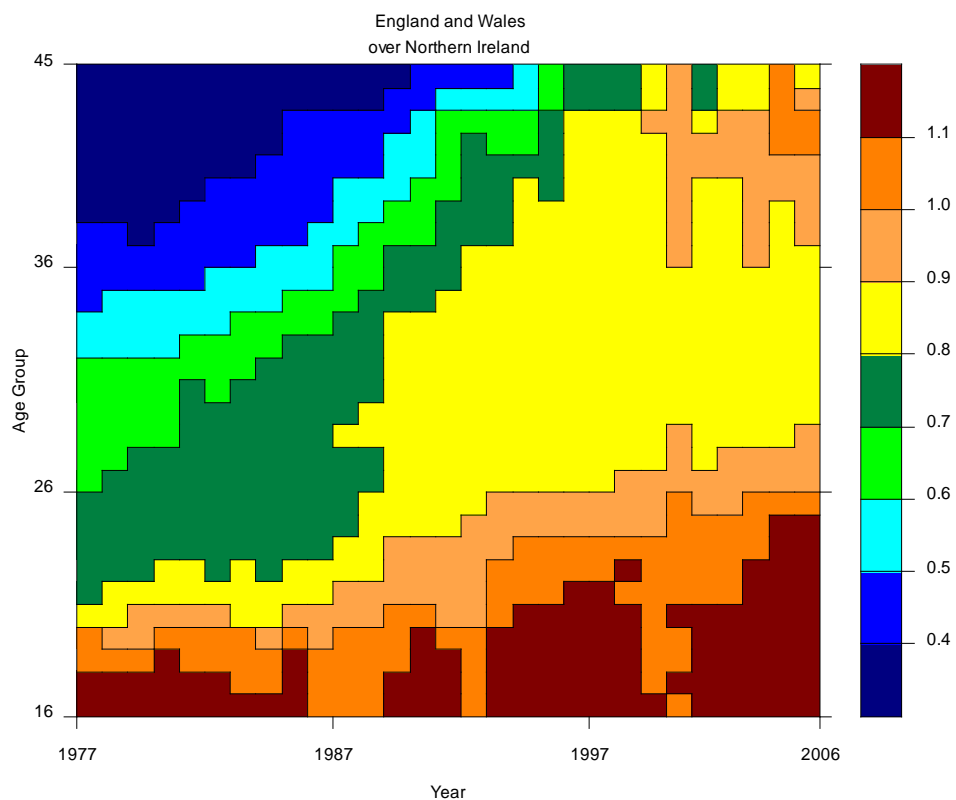
Source: Authors own analysis of ONS and GROS data (2010).

Figure 7: England and Wales over Northern Ireland
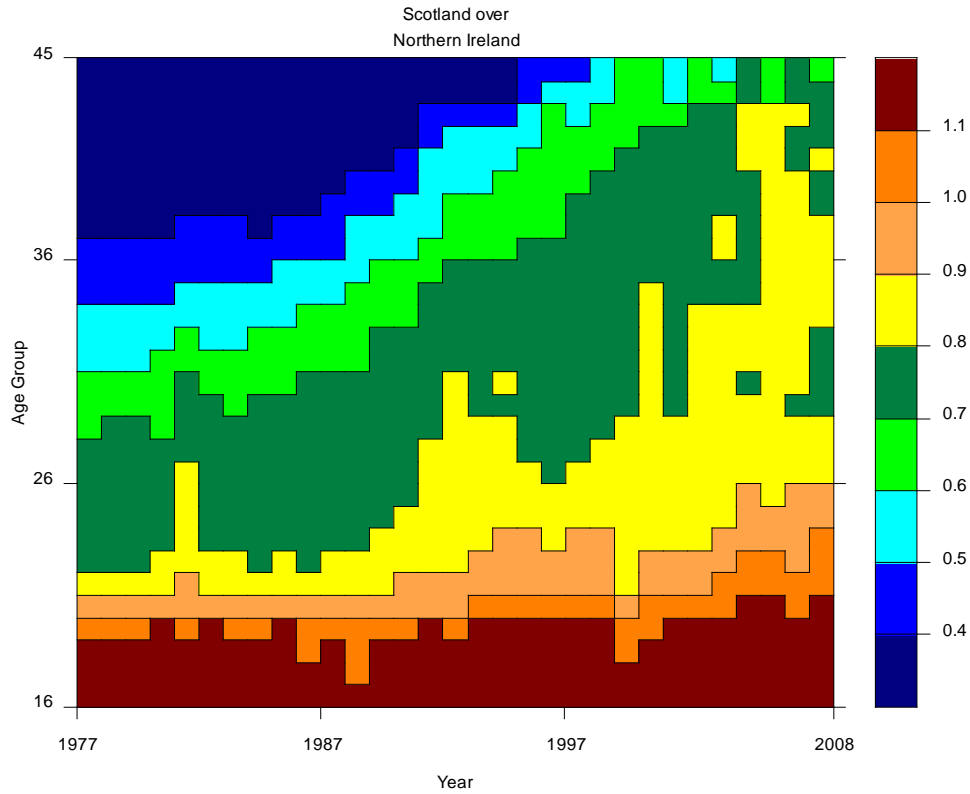
Source: Authors own analysis of ONS and NISRA data (2010).

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Figure 8: Scotland over Northern Ireland

Source: Authors own analysis of GROS and NISRA data (2010).

6 DISCUSSION

The present study has explored fertility differences within the UK using Lexis Diagrams. The similarity in fertility by year and age for Scotland and England and Wales is striking. Between the years 1970-80, there is very little difference, mirroring the overall aggregate (TFR) (Figure 2). After this point we can see that the divergence between Scotland and England and Wales began among those women over the age of 35 years after 1980. This could reflect either Scottish women having fewer children, or conversely English and Welsh women of this age having more children. This suggests that lower Scottish fertility is related to the fertility of women over 35 years.

Northern Ireland comparisons highlight its somewhat different fertility experience in comparison to Great Britain. The results suggest that there is a similarity among fertility rates in Great Britain, and a possible convergence which could be related to the fertility of women over 35 years in Northern Ireland. A notable exception to the pattern of consistently higher Northern Irish fertility is that teenage

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fertility is the opposite of what is expected from the TFR, it is lower than for Great Britain. Further research could focus on the reasons behind the pattern between Great Britain and Northern Ireland shown in this paper. A further area of research could be to explore why there is a difference between Scottish and English and Welsh women at older ages more recently; postponement and subsequent realisation of fertility might be different between these two areas.

7   CONCLUSION

The main strength of the Lexis diagram approach is the wealth of data that can be displayed or compared in such a compact manner. Using the Lexis diagram, the complex nature of the data is kept without confusion, while remaining compact enough for the reader to view all the available data. The method has shown that differences between countries can be illuminated not just on aggregate, but in a much finer grained manner, disaggregated by age and year. Age, period and cohort analyses are possible from one figure. This offers an enhanced and more detailed approach, using all the data available, illuminating underlying trends. An important result is that Scotland, England and Wales are very similar in terms of fertility at almost all ages from 1970 onwards. The only exceptions are the increasing ASFRs of older women (over 40 years) from 1980 onwards in England and Wales. Northern Ireland has a distinct fertility experience to Great Britain; lower teenage pregnancy rates and almost universally higher ASFRs for all ages over 20 years compared to Scotland, ages over 25 years compared to England and Wales respectively. Moreover, there seems to be a convergence taking place between all three country groupings. Over time the ASFRs seem to be becoming more similar. Applying the Lexis diagram to fertility data in the UK has proven to be a worthwhile exercise in identifying differences between the constituent parts of the UK in more detail than has previously been the case. This descriptive analysis provides a basis for future research and has shown important similarities, but also noteworthy differences in fertility trends over time that the aggregate analysis may miss.

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