The rise and fall of a multi-modal fertility curve

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The fertility curve, a plot of age-specific fertility rates for women aged 15 to 50, is generally assumed to be roughly bell-shaped, with a single mode. Across the developed world, the curve has evolved from being left-skewed (especially for first births) to being more symmetric, and the mode has been getting later, as women are moving to a later entry into motherhood. The fertility curve has also been getting wider as the variability of age of entry into motherhood is increasing. However, a change in shape from a smooth mono-modal curve towards a bi- or multi-modal curve has rarely been investigated with empirical data. This paper presents some initial findings, from a European perspective. It is mainly descriptive but points to further work which could usefully be carried out.

Literature review

The investigation of bi-modal fertility curves has most commonly taken the approach of investigating mathematical models which can best describe these complex curves. Recent studies include Peristera and Kostaki (2007), Mazzuco and Scarpa (2011) and Bermúdez *et al* (2012). Their work was in response to the observation that there has been a trend towards irregular fertility curves, and in particular the development of an early 'shoulder', initially seen in the English-speaking world - the UK, Ireland, New Zealand, Australia and the United States (Chandola, Coleman and Hiorns,1999 and 2002). A bi-modal fertility curve has also been seen in a developing world context -South Africa (Garenne *et al*, 2001).

It is interesting to note that an early pre-modal bulge had developed in the Netherlands in the 1970s, but it had subsequently faded and a smooth mono-modal distribution had re-established itself by the 1990s (Coleman and Garssen, 2002). Studying the United States, Sullivan (2005) discovered that there had been a bimodal distribution of first birth rates, if Type 1 hazard/exposure rates were studied, rather than the more commonly used Type 2 age-specific rates. Interestingly, this bi-modal distribution developed during the 1990s, reaching its apex by the mid-1990s and then faded again by the end of the decade.

The explanation for an irregular fertility curve is primarily that there are two co-existing sub-populations which have different behavioural norms. The women who enter motherhood early and cause the early shoulder have been considered most likely to be immigrants (Bongaarts and Sobotka, 2012), young women having unplanned and pre-marital children (Garenne *et al*, 2001; Coleman and Garssen, 2002); and/or racial, socio-economic, or educationally disadvantaged minorities (Sullivan, 2005).

Data

The data used in this analysis are from the Human Fertility Database (http://www.humanfertility.org). Birth order specific data are used, primarily focussing on first births, although summary graphs of second order births are also presented. At the present time, fifteen European countries have biological birth order data in the HFD. These include eight in Eastern Europe and seven in Western Europe. Comparisons are made between these two regions, reflecting the conclusion drawn by Frejka (2012) that they are at different points in their fertility transitions.

An important decision was whether to study period fertility curves or cohort curves. The development of the pre-mode bulge was first noticed when studying period data. However, further examination of cohort curves revealed that the development of the early shoulder was even more pronounced if examined from a cohort perspective; therefore this analysis focuses on cohort data.

The problem with cohort data is that fertility curves covering the complete reproductive span are not available until women reach 50; in other words, in 2010 only full curves are available for the 1960 cohort of women. However, a new modelling procedure has been described by Myrskylä, Goldstein and Cheng (2013), which continues the trend for each age-specific rate over the previous 5 years for a further 5 years before freezing it. In this paper we have applied this method to obtain fertility curves up to age 40 (Figures 1-4). As we focus on the early part of the fertility curve, then with the latest data from 2010 we can study all cohorts up to those born in 1980, who were therefore 30 in 2010, the current maximum modal age for first births.

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Presentation of results

To summarise the trends in development of the fertility curves, four sets of graphs are presented; Figures 1 and 2 for first birth fertility rates; Figures 3 and 4 for second birth fertility rates. Figures 1 and 3 show the classic representation of the fertility curves for cohorts of women born in 1968, 1971, 1974, 1977 and 1980. Figures 2 and 4 are a 3-dimensional representation of the full set of fertility curves for all cohorts from 1968-1980. The countries have been ordered according to the approximate stage of evolution of their ASFR fertility curve, transitioning from a uni-modal left-skewed curve with a very young modal age (Russia) to, once again, a uni-modal curve with a much later modal age (the Netherlands).

Looking at the curves (Figure 1) we see that several countries of Western Europe (Portugal to Finland) already had a very clear bulge or plateau covering the 21-25 year age range for the 1968 cohort. This 'bulge' then developed across the region over successive cohorts, from Sweden through to Bulgaria. Only in Russia has this nascent early shoulder not developed yet.

The Eastern European countries started with a fertility schedule completely different from Western Europe: the fertility curves were all uni-modal for the 1968 cohort, with a sharp intensity of entry in motherhood at age 20-21, after which the rates dropped off sharply. The cohorts born during the following decade then adapted extremely rapidly to later western fertility norms. In this transition the early rump separated from the later rump, which grew strongly in importance. This transition is illustrated well graphically with the 3-dimensional plots (Figure 2).

Comparing different countries and seeing how the curves seem to develop over time, we propose an ordering of the 15 countries as to how far along the process each is currently at: see Table 1. However, each country has a unique fertility curve and each is evolving slightly differently.

Table 1 Countries ordered by approximate stage of evolution of ASFR1 fertility curve

1	Russia
2	Bulgaria
3	Lithuania
4	Estonia
5	Slovakia
6	Hungary
7	Czech Republic
8	Slovenia
9	Sweden
10	Portugal
11	Norway
12	Finland
13	Switzerland
14	Austria
15	Netherlands

Through the course of the transition, a 'saddle' between the two modes is seen in many cases (Bulgaria through Sweden): this is the stage when the early mode has declined in intensity, but the later mode is only just starting to develop (Figure 2). This 'saddle point' is also clearly visible in the 2-dimensional plots (Figure 1), as the crossover age point with most stability in fertility rates across cohorts. In most countries the fertility rate for around the mid-20s has stayed almost constant, the exact age being specific to each country.

Also birth order 2?

The previous discussion covers first births only; an interesting question is whether higher order births also show this development of an early bulge, or not. Interestingly, the answer is - not to the same extent. The modal age has moved up, and strongly so for the Eastern European countries. In the process, a similar 'saddle' is seen in the 3-D plots (Figure 4) as was seen for first births. However, the 2-D plots do not show the same intensity of development of a bi-modal fertility curve.

It would appear that across Europe, both East and West, the modal age of second births is moving towards a rather narrow age range of 30-32. This is the case even for countries where the modal age of first birth remains quite low. For example, in Russia the modal age for first births for the 1980 cohort was 21; however, for this same cohort, the modal age for a second birth is likely to be 30 (in 2010, the latest year for which data are available, the 1980 cohort had only just reached age 30).

The graphs in Figure 3 show that the transition from a early mode to a later mode is much smoother for second births than for first births and the development of a bi-modal distribution is much less marked. The fall in peak rates progresses in tandem with an increase in width of the fertility curve and the new, later, schedule of timing of second birth then steadily establishes itself. There is not the same apparent split into two sub-populations (early and late adopters of the new timing norms) as is seen in the case of the first birth schedule transition.

Is there any suggestion of a third mode developing?

One could hypothesise that a third mode might develop, of women entering motherhood later in their 30s, perhaps in association with the uptake of assisted reproductive technologies. However, there is as yet little evidence of this happening in any country, not even in the countries with the latest fertility schedules. However, for the fertility rates for the mid- to late-30s have been projected and so time will tell whether this could happen, especially if there is a 'catching up' process after postponements caused by the recession.

Immigrants as the explanation?

Several explanations of the early bulge have previously been put forward. A growing proportion of immigrants arriving in a country with early childbearing norms is one (Bongaarts and Sobotka, 2012). In this initial investigation, this single factor is investigated as a possibility. Table 2 lists the proportion of young adults (aged 18-29) who were not born in the country where they were surveyed, using data from the 2002 and 2010 waves of the European Social Survey. If this were a major explanatory factor, then we would expect the countries with the highest proportion of immigrants to have the most noticeable humps. The data refute this hypothesis. The Western European countries have a significantly higher proportion of immigrants compared to the Eastern European countries. In the case of Norway and especially Switzerland it is a growing proportion. However, it is the Eastern European countries which have seen the most noticeable development of a bi-modal fertility curve over the past decade.

Table 2 Proportion of young people (19-29) who were not born in the country

	2002	2010
Austria	10.2	NA
Bulgaria	0.0**	1.8
Czech Rep	0.0	0.1
Estonia	4.5*	3.1
Finland	5.2	5.8
Hungary	1.3	3.2
Lithuania	NA	NA
Netherlands	7.4	6.1
Norway	7.3	11.8
Portugal	9.3	8.2
Russia	7.2**	4.2
Slovakia	1.8*	1.0
Slovenia	5.5	3.2
Sweden	11.7	9.2
Switzerland	13.9	23.0

* data from 2004

** data from 2006

Effect on TFR1

In seeking to account for the recent rise in TFRs, a number of explanations have been proposed. A combination of two factors has been proposed by McDonald and Kippen (2011) and Frejka (2012): a stabilisation of young fertility rates, combined with an increase in older age fertility. Together these lead to a widening of the fertility curve. What this investigation has shown is that it is not simply a widening of the fertility curve that has occurred, but essentially a splitting of the female population into two sub-populations, one 'stuck' (at least for a while) with an early schedule and the second following an increasingly later schedule. An important question is how quickly, if at all, the early fertility 'hump'

will now fade away and merge again into a uni-modal curve – and if this will cause the width of the fertility to shrink, and with it bring down the TFR1. The experience of the Western European countries, which seem to be furthest along in the transition, suggests that the width of the fertility curve will continue to grow.

Further work

The study of the evolution of the shape of the fertility curves has rarely been tackled. There is ample scope for further work. Looking at the question both from a mathematical standpoint or a sociological one, the question of how and why the populations of many different countries apparently split into two sub-populations following different norms is worth investigating. The next question is whether these divisions will subside or remain. Who belongs to which subgroup? Are they differentiated by education, socio-economic status, or urban/rural or racial attributes? Or is the fundamental difference their access to and use of contraceptives? It is very interesting to note that the evolution of the fertility curves for second births shows a more subdued development of a bi-modal distribution, but in general a rather smooth transition from an early to a later, wider schedule.

Conclusion

The majority of countries in both Eastern and Western Europe have developed a pre-modal 'bulge', 'shoulder' or at least a small 'kink' in recent years. Some, particularly in Eastern Europe, have gone on to develop a distinctly bi-modal distribution. Although the expected evolution is far from clear, as yet, it seems likely that this early bulge will slowly disappear and a uni-modal distribution will once again establish itself, although with a much greater width than before. As the width of the fertility curve is defined as the standard deviation of mean age at (first) birth, then this greater variability of timing of entry into motherhood is the driving force in this process.

The transition from communism to the market economy after 1989, with the subsequent economic stresses, the breakdown of social norms and (presumably) the increasing availability of modern contraceptives, clearly had a dramatic impact on successive generations of women in the eastern bloc. It would appear that in the transition from early childbearing norms to a later schedule, a sub-section of the population got 'left behind' in the process, and this led, at least for a while, to the development of a bi-modal distribution. The experience of some western countries, such as the Netherlands, would suggest that this process then continues and the early bulge slowly disappears again. The countries of Europe seem to be at different points in this evolution.

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Figure 1: ASFR1 curves for 1968-1971-1974-1977-1980 cohorts

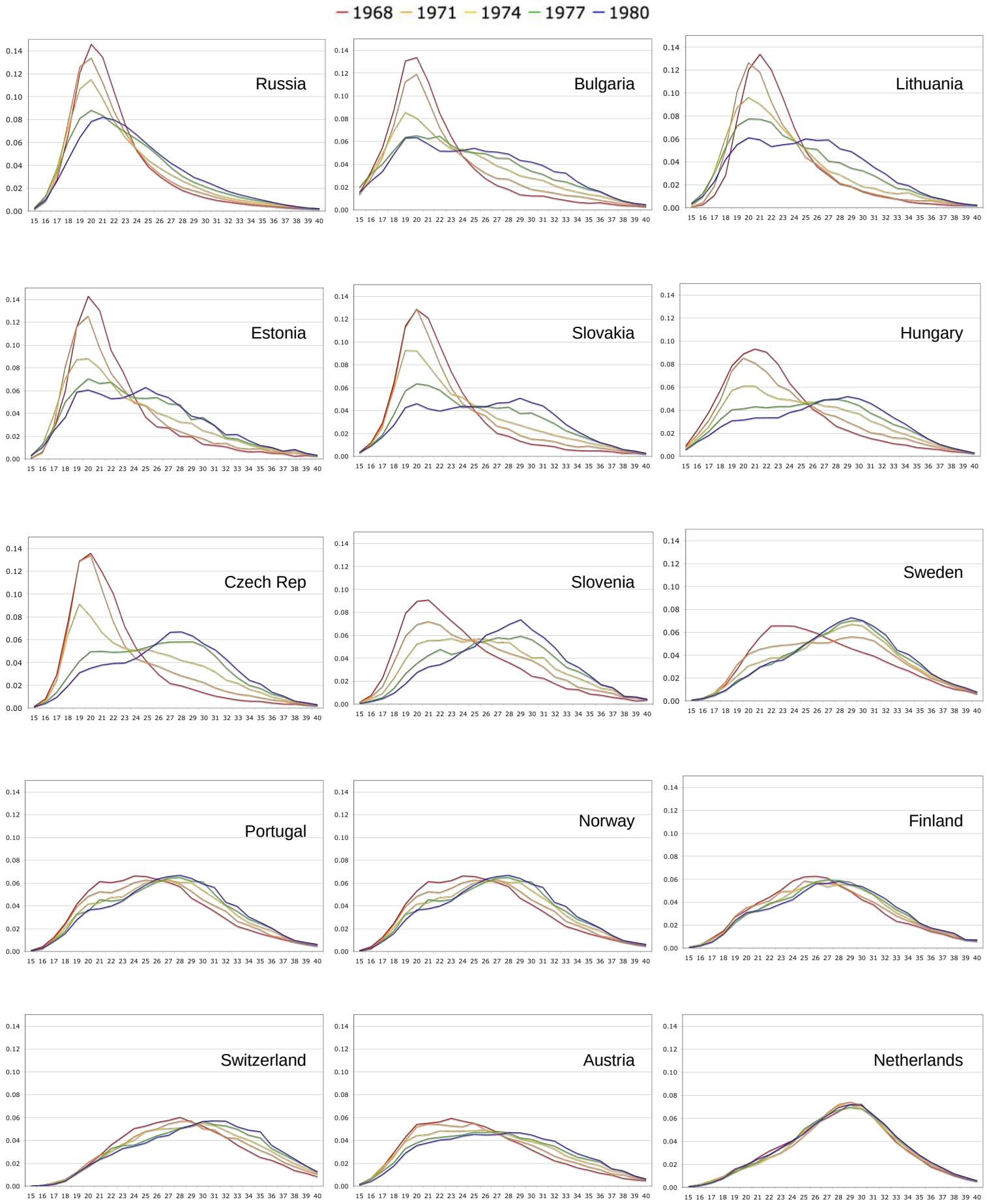

Figure 2: ASFR1 curves for 1968-1980 cohorts

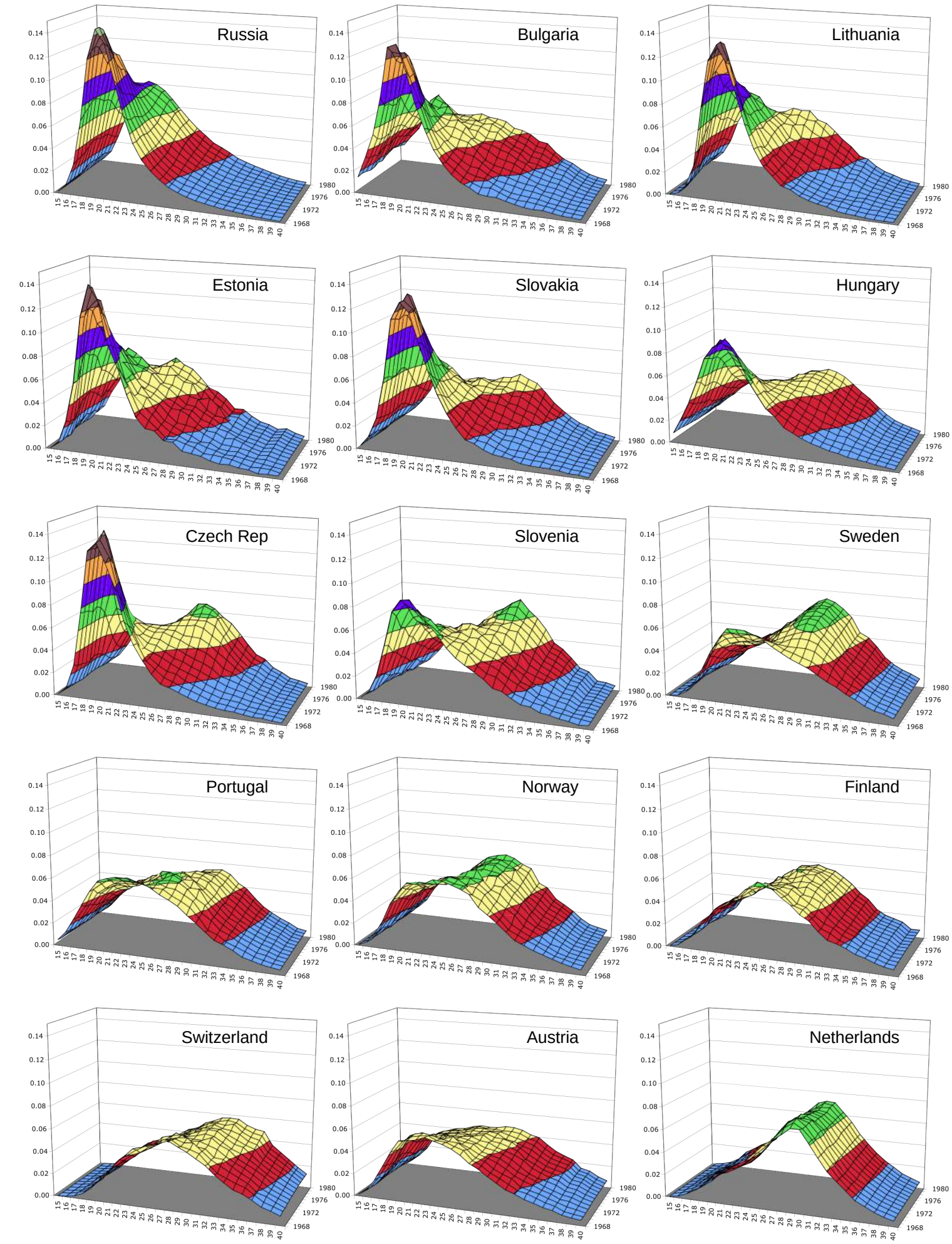

Figure 3: ASFR2 curves for 1968-1971-1974-1977-1980 cohorts

Note different vertical scale to Figure 1

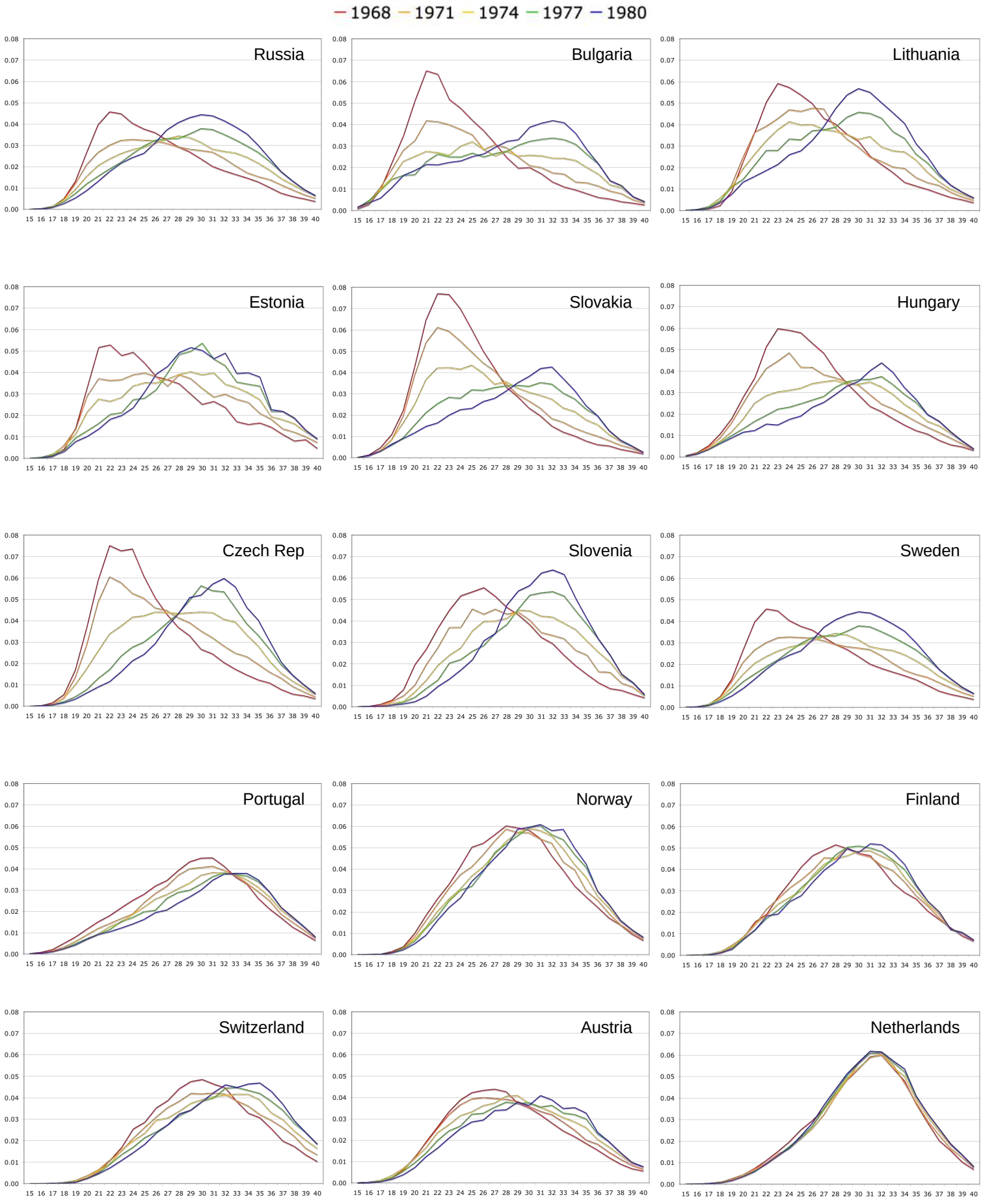

Figure 4: ASFR2 curves for 1968-1980 cohorts