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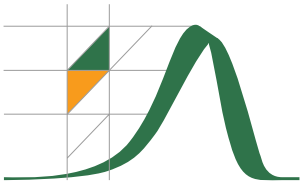
COHORT FERTILITY DECLINE IN LOW FERTILITY COUNTRIES: DECOMPOSITION USING PARITY PROGRESSION RATIOS

KRYŠTOF ZEMAN, ÉVA BEAUJOUAN, ZUZANNA BRZOZOWSKA AND TOMÁŠ SOBOTKA



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Abstract

This study provides a systematic analysis of parity components of the cohort fertility decline in 32 low-fertility countries in Europe, North America, Australia and East Asia. We decompose the change in cohort fertility in each country among women born between 1940 and 1970 using parity progression ratios (PPR) derived mostly from census, register data, and large-scale surveys. We are also interested in how the effect of the changing parity progression ratios varied across broader regions and whether it was different in countries reaching very low completed fertility. The fall in fertility was mostly driven by reductions in the progression ratios to third and higher-order births in the first stage of 1940 to 1955 cohorts. Among women born between 1955 and 1970 fertility decline slowed down in most regions. This second stage of the cohort fertility decline analysed here is also distinguished by its regional diversity. The main distinction can be drawn between Central and Eastern Europe, where fertility decline was driven primarily by falling second birth rates and the German-speaking countries, Southern Europe, and East Asia, where the fall in first birth rates (and the corresponding rise in childlessness) had a stronger influence.

Keywords

Low-fertility countries, cohort fertility, family size, parity progression ratios, fertility decline, Europe, very low fertility, childlessness, decomposition

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Cohort Fertility Decline in Low Fertility Countries: Decomposition Using Parity Progression Ratios

Kryštof Zeman, Éva Beaujouan, Zuzanna Brzozowska and Tomáš Sobotka

1 Introduction

The long-term decline in cohort fertility rates across developed countries has been widely documented (Frejka and Calot 2001, Frejka 2008, Myrskylä et al. 2013). Among women born around 1940, who were in prime reproductive years towards the end of the post-war baby boom, the completed fertility rate was between 1.9 and 2.5 children per woman in most European countries and in Japan, between 2.5 and 2.7 children per woman in Australia, New Zealand and the United States, and yet higher in South Korea and Singapore. In contrast, women born three decades later, around 1970, had on average less than two children in all developed countries, except in Australia, France, New Zealand, Norway, the United States and a few smaller European countries (Council of Europe 2005, Frejka et al. 2010, Sobotka et al. 2015, Van Bavel et al. 2015, Human Fertility Database 2016). This fall in fertility was accompanied by a continuous decline in the share of large families with three and more children, and, especially in the younger birth cohorts, by increasing proportions of women without children and with one child (e.g. Schoen 2006, Frejka and Sardon 2007, Frejka 2008, Frejka et al. 2010, Sobotka 2017, Beaujouan et al. 2016, Human Fertility Database 2016, Van Bavel et al. 2015).

So far, no systematic analysis has been conducted on how the changes in parity-specific components of fertility contributed to the decline in cohort completed fertility rates (*CFR*) in low-fertility countries. Previous research indicates that studying parity-specific changes in fertility is key for understanding fertility declines (Ní Bhrolcháin 1987, Barkalov 1999), especially in post-transitional fertility regimes (Wilson 2013). While the fall in third and higher-order birth rates certainly dominated the shift from a relatively high to around-replacement fertility, the declining first and second birth rates may have become more prominent drivers of this decline when cohort fertility reached around two children per woman and below. This expectation is in line with Frejka's (2008) analysis, which found that decreasing progressions to first and second births played a key role in fertility declines among European women born after 1955. Billari and Kohler (2004: 171) suggested that a pattern of "lowest-low" fertility in Europe is characterised by "a low probability of progression after the first child (but not particularly low levels of first-birth childbearing)". However, many factors including family policies, economic uncertainty, family size norms and preferences, and population heterogeneity may have affected the importance of specific parities in the cohort fertility decline to low levels. As a result, low-fertility countries vary considerably in their parity composition (Frejka and Sardon 2007, Sobotka 2013).

In this study we analyse the role of changing first[1], second, and third and higher-order birth rates in driving the decline in completed fertility in 32 low-fertility countries in Europe, North America, Australia and East Asia including Singapore[2]. Specifically, we decompose the change in cohort fertility in each country among women born between 1940 and 1970[3] using parity progression ratios (*PPR*) derived mostly from censuses, register data, and large-scale surveys containing a question on the number of children ever born. We focus on women aged 43 or older at the time the data were collected, who had by then almost completed their childbearing. By adopting a cohort perspective we do not need to discuss timing distortions that have strongly affected period fertility indicators in most developed countries in the last four decades (Billari and Kohler 2004, Bongaarts and Sobotka 2012).

We are also interested in how the effect of the changing parity progression ratios varied across cohorts and countries, and whether it was different in countries with very low completed fertility. Consequently, we address the following questions and hypotheses, discussed in more detail in Section 2:

- *Differences between cohorts:* In the 1940–1955 cohorts we expect that the fertility decline has been by and large driven by the shrinking importance of higher-order births, manifested by falling progression ratios to third and later births. In contrast, among the younger cohorts born in 1955–1970, the decline in progression to first and second birth would become an important driver of the reduction in their fertility.
- *Differences between wider regions:* Are there systematic regional differences in parity-specific patterns of cohort fertility decline, mirroring broader regional differences in fertility trends and in the institutional factors affecting them?
- *Shift to very low cohort fertility levels:* We pay particular attention to countries which experienced a fall in completed fertility below 1.75 children per woman. Can we identify systematic differences between countries and regions in parity-specific pathways to very low cohort fertility?

[1] Parity progression ratio to first birth and childlessness are complementary so we use the terms "declining parity progression ratio to first birth" and "increasing childlessness" interchangeably. Next to "parity progression ratios" we also use term "parity-specific transition rates".

[2] Although most of richer Asian countries and territories with a longer history of low fertility are in East Asia (Japan, Hong Kong, South Korea, Taiwan), Singapore belongs to South-east Asia. For simplicity, we label this culturally similar set of countries as "East Asia", following the example of Frejka et al. (2010).

[3] The youngest cohort covered in this paper differs by country, depending on data availability. It ranges from the 1965 cohort (data for Switzerland) up until the 1971 cohort (data for England and Wales and Finland). Most countries (19 out of 32) are covered up to the 1967 or 1968 cohorts. For simplicity, we label the youngest cohort covered across countries as the 1970 cohort or, alternatively, as the late 1960s cohorts. Table A1 in Appendix provides more details on available data.

2 Background: Post-Baby Boom Fertility Decline(s)

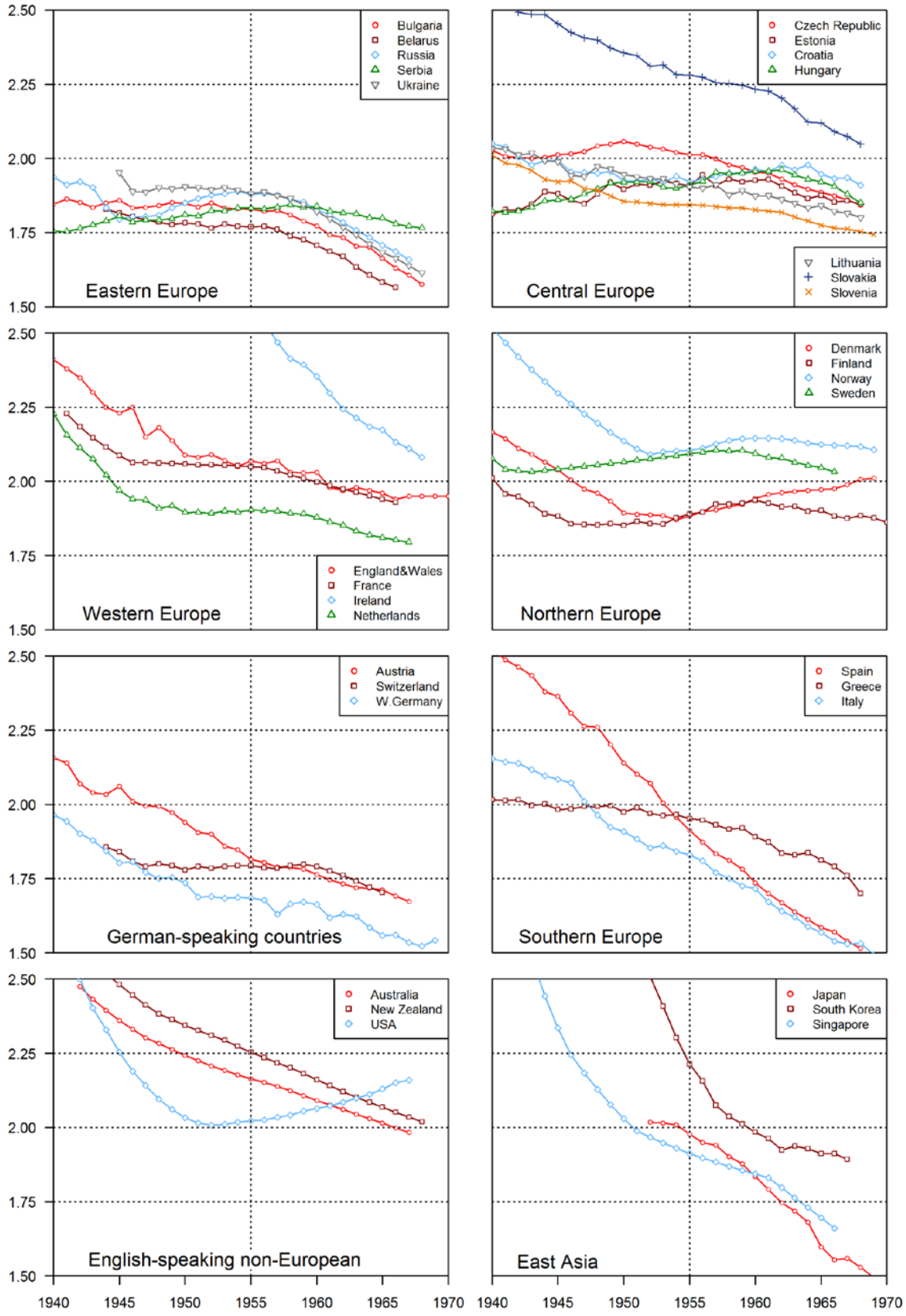
2.1 Regional Diversity in Cohort Fertility Trajectories

Among women born in the 1940s to 1960s, completed fertility in the developed countries moved towards or below two children on average, following various trajectories. Most typically, it declined continuously (e.g. in Italy, Spain, Slovakia or South Korea), but it also showed U-shaped trend (especially in the United States and Denmark) or inverted U-shaped trajectory (e.g. in Hungary), with timing of the changes varying across countries (Frejka and Calot 2001, Sardon 2006a, 2006b, Frejka et al. 2010, Myrskylä et al. 2013). In the early 1970s cohorts, fertility ranged from 1.4–1.5 children per woman in Spain, Italy, Ukraine and Germany to slightly above 2.0 in France, the United States and Sweden (Sobotka et al. 2015).

Figure 1 illustrates this diversity for women born between the 1940s and 1970s in low-fertility countries, grouped in eight broader regions (this grouping is adopted throughout this paper; see Table A1 in Appendix for the full list of countries and regions). In Western and Northern Europe, fertility declined most among women born in the 1940s, and the decline slowed down or ceased among women born in the 1950s and 1960s. In Austria, Germany and Switzerland, the three predominantly German-speaking countries in Europe, cohort fertility continued declining, reaching the lowest level of 1.5 in Germany in the late 1960s cohorts. The fall in fertility was even sharper (and from higher initial values) in Southern Europe, with women in Italy and Spain born in 1970 having on average fewer than 1.5 children. In contrast, most former state-socialist countries of Central and Eastern Europe experienced low cohort fertility at 1.8–2.0 children per woman already in the 1940 cohort, but subsequently saw their cohort fertility stable or even slightly rising up until the late 1950s cohorts; women born in the 1960s have reduced their family size. Among the countries studied here, Slovakia was major exception from the broader regional pattern, with a higher initial level above 2.5 children per woman.

The English-speaking countries outside Europe retained higher fertility than most other rich countries. The United States saw a swift downfall in fertility in the 1940s cohorts, followed by a stabilisation and a gradual increase among women born in 1955–1970, whereas Australia and New Zealand experienced continuous, but less pronounced fertility declines. In East Asia, Japan stands out for reaching a low fertility around two children per woman already among women born in the 1930s (Frejka et al. 2010; not available in our data). Relatively stable cohort fertility among women born in 1940–1955 was followed by a renewed fertility decline among the younger cohorts, with women born in 1970 reaching one of the lowest cohort fertility levels globally: 1.46. Singapore experienced a fast transformation from large family size (above 3 children per woman in the 1940 birth cohort) to very low fertility, reaching in the 1960s cohorts similar values as Japan. South Korea, starting at a high level of 3.9 children per woman born in 1940, appears to have followed a similar trajectory of fertility decline as Singapore, with a "lag" of about ten cohorts.

Figure 1 Completed cohort fertility in featured low-fertility countries grouped by broader regions, women born 1940–1970.



2.2 A Two-Stage Change in Cohort Fertility

With simplification, cohort fertility developments among women born in 1940–1970 can be divided into two stages. In the first one, among women born between 1940 and 1955, most reductions were seen in the higher-parity births. In the second stage, among women born between 1955 and 1970, the decreasing progressions to first and second child seem to have played the main role (Billari and Kohler 2004, Frejka 2008), although their contribution is likely to differ by region. We adopt this two-stage perspective of the post-war cohort fertility decline in our study and frequently refer to these two stages when discussing fertility developments in different countries and regions.

The two stages of fertility decline are anchored in the cultural, economic and social development of the post-war societies of the developed countries. In the West of Europe and in the English-speaking non-European countries the generation of women born in 1940–1955 grew up in times of unprecedented economic prosperity, saw a sharp rise in their labour force participation (although often on a part-time basis), experienced sexual freedom given by the effective hormonal contraception, and initiated the socio-cultural changes described as the second demographic transition (Van de Kaa 1987, Lesthaeghe 2010, Bonvalet et al. 2014). In the East of Europe, a vast majority of women worked full time. Women in most countries had only a limited access to the contraceptive pill and they relied heavily on abortion (Stloukal 1999). With the exception of rapidly rising divorce rates, the new family behaviours and values spreading in the West remained marginal in Central and Eastern Europe (Sobotka 2016).

Both in the East and the West, the early baby boomers remained rather traditional in terms of gender roles and task division within the family: women were perceived as secondary earners responsible for the housework and, in the West, expected to quit or largely reduce their paid work once children were born (McDonald 2000). In East Asia, gender and family relations changed very slowly, but the region was experiencing rapid economic growth and industrialisation (slower in the highly developed Japan) when women born around 1950 were reaching adulthood and forming their families.

The second stage of the fertility decline includes women born between 1955 and 1970, who saw in their youth the first post-war economic crises (especially the energy crises in the 1970s), unemployment and vanishing lifetime jobs (Blossfeld et al. 2005). They experienced the collapse of state socialism in the Eastern Bloc and the shrinking of the welfare state across Europe. They also benefited from expanding educational opportunities, including a gradual rise in university education. In the Western world people born in the late 1950s and in the 1960s continued the socio-cultural changes initiated by the earlier cohorts, resulting in a widening acceptance of less conventional family forms and living arrangements, including voluntary childlessness (Sobotka and Testa 2008, Merz and Liefbroer 2012, Kreyenfeld and Konietzka 2017). These changes also included increasing gender equality, especially in the domestic sphere (McDonald 2000). In East Asia, childbearing remained confined to marriage, and traditional expectations about women's role in the family made it difficult for women to continue working after marriage despite their increasing education and employment opportunities. This growing

conflict between career opportunities and family life expectations resulted in a rising rate of non-marriage (and childlessness), especially among highly educated women (Jones and Gubhaju 2009, Tsuya 2015, Yoo 2016).

2.3 Regional Context of the Two-Stage Fertility Decline: Which Parity Was Driving the Trend to Low Cohort Fertility?

In the first stage, fertility fell more rapidly in countries where the fertility transition started later and the share of families with three and more children had remained relatively high until the 1940s birth cohorts, especially in Southern Europe or East Asia. Also in the English-speaking non-European countries fertility decreased steeply during the first stage, but this might have been a reaction to the previous great increases in high-parity births during the baby boom (van Bavel et al. 2015). The magnitude of the fertility decline in the second stage has often been linked to the stability of the labour markets (Adserà 2004, 2005) and the degree of gender equality in the family and work spheres (Esping-Andersen and Billari 2015, Goldscheider et al. 2015). Except in some post-socialist countries (Czech Republic, Poland, Hungary, Russia, Bulgaria and Romania – Myrskylä et al. 2013, Brzozowska 2015) the first-stage fertility decline was stronger than the second-stage one.

The regional differences in cultural and institutional settings may correspond to a wide diversity in parity-specific fertility trends across the analysed regions. In Western and Northern Europe, the fertility decrease in the first stage was largely connected to couples limiting their family size to two children and thus reducing their third and higher-order birth rates (Frejka and Sardon 2007). The mild fertility decline in the second stage may not have been dominated by any specific parity. Relatively good living standards together with well-developed family policies, most comprehensive in Belgium, France and the Nordic countries, are expected to slow-down the fall in fertility across all parities, especially in second and third birth rates. This expectation is partly supported by Breton and Prioux's (2002) study which demonstrated a strong correlation between fertility around replacement and the proportion of women having three and more children: European countries with completed fertility around two in the 1960 birth cohort (France, Norway, Sweden, England and Wales, and Finland) had relatively high shares (above 25%) of women with three or more children.

In Austria, Germany and Switzerland, the strong work-family conflict and the associated fall in first birth rates certainly contributed to the fertility decline among the more recent cohorts analysed (Sobotka 2012, Kreyenfeld and Konietzka 2017). However, an analysis of fertility decline in Austria, Germany and Switzerland among women born in 1940–1965 revealed remarkable differences between them: in Western Germany, falling first birth rates were the key factor, whereas in Austria and Switzerland fertility decline was driven especially by falling third- and higher-order births, and, in Eastern Germany (former GDR), falling second birth rates had the main influence (see also Bujard and Sujak 2016).

In Southern Europe, the rapid social and economic changes in the 1960s and 1970s together with spreading effective contraception probably resulted in strong reductions in the transition rates to third and further births in the first-stage fertility decline. In the second stage, rising women's employment in combination with precarious labour market conditions, limited work flexibility for women, and traditional gender roles within the family should depress both first and second birth rates (Adserà 2011). They may also fuel further decline in third- and higher-order birth rates to very low levels, a trend identified in several studies on the region (Delgado et al. 2008, De Rose et al. 2008).

In Central Europe, the almost universal full-time employment of women during state socialism is expected to result in very low third birth rates. In addition, the negative attitudes towards childlessness (Sobotka and Testa 2008, Merz and Liefbroer 2012) imply that fertility decline was probably driven by falling second birth rates, especially among the women having children during state-socialist period. The same factors should also operate in Eastern Europe. In addition, the lower living standards (especially among the late-1960s cohorts having children in the turbulent period of the 1990s) and relatively poor housing conditions in the region should further depress second birth rates (Avdeev and Monnier 1995), making them the most important "determinant" of cohort fertility decline to very low levels (Frejka and Gietel-Basten 2016). For instance, in Russia four in ten women born in the late 1960s had only one child (Barkalov 1999, Andreev et al. 2002).

In the English-speaking countries outside Europe, the developments should largely resemble those in Northern and Western Europe, with reductions in third birth rates dominating the first-stage fertility decline, and milder declines in all parity progressions in the second stage.

Finally, in East Asia, we expect a shift to low progression ratios to first, second, as well as third births, with falls in first and second birth rates driving the second stage fertility decline among women born in 1955–1970. This region—especially Japan—saw a sharp rise in childlessness among women born in the 1950s and 1960s (Frejka et al. 2010), partly fuelled by the very traditional gender role division within marriage (the so-called "marriage package" – Bumpass et al. 2009, Kim and Cheung 2015). In addition, the second and third birth rates can be further suppressed by the "education fever", a strong orientation towards children's success in life, manifested by the resources and time parents provide for their children's education, including after-class tutoring (Anderson and Kohler 2012, Tan et al. 2016).

2.4 A Shift to Very Low Cohort Fertility Levels

Given the demographic literature's strong interest in explaining fertility declines to very low levels, we pay special attention to analysing which parity progressions drive cohort fertility decline to very low levels. For period total fertility (*TFR*), the thresholds of very low fertility are well established: "very low fertility" is usually defined as a *TFR* below 1.5 (e.g. McDonald 2006), whereas "lowest-low fertility" or "ultra-low fertility" is commonly defined as a TFR falling below 1.3 (Kohler et al. 2002, Jones et al. 2008). However,

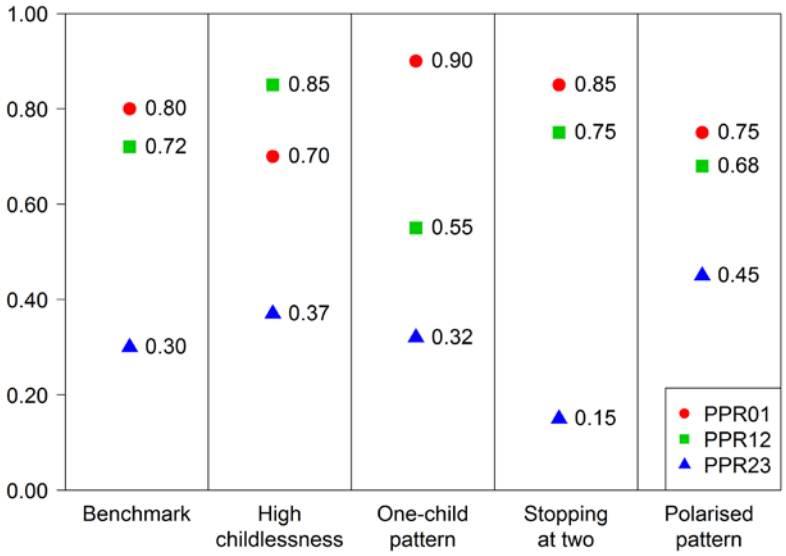
demographers have not yet adopted a common definition of very low cohort fertility. Because of the tempo distortions negatively affecting period fertility indicators, cohort fertility in low-fertility countries has typically stayed at a higher level than the conventional period fertility rates during the last four decades. Two recent contributions, by Myrskylä et al. (2013) and Rindfuss et al. (2016), adopted a cohort fertility level of 1.75 children per woman as a threshold below which cohort fertility becomes "very low". We use the same threshold and label completed fertility below 1.75 as "very low". This level corresponds to cohort fertility at about 85% of the population replacement level in low-mortality countries, implying that in a closed population without migration each subsequent generation would shrink by about 15%.[4]

Among women born in 1950, completed fertility below 1.75 was seen only in one country, Germany (Pötzsch 2016); for cohorts born 20 years later, 13 out of 32 countries analysed here had fertility below 1.75 (Figure 1 above; see also Frejka et al. 2010). Except for Slovenia, they belong to four out of eight analysed regions: Eastern Europe (Belarus, Bulgaria, Russia and Ukraine), Southern Europe (Greece, Italy and Spain), "German-speaking countries" (Austria, Germany and Switzerland), and in East Asia (Japan and Singapore). Two of these countries, Greece and Slovenia, reached a cohort fertility level below 1.75 only in the latest cohort observed in our data. Therefore, our analysis of cohort fertility decline to very low levels focuses on the remaining 11 countries.

We expect that the parity-specific components of the decline to very low fertility levels differed between broader regions. Previous research has shown that similar cohort fertility levels can result from very different parity distributions (Sobotka 2013: 24, Table 2). Figure 2 illustrates this with different hypothetical combinations of parity-specific fertility that sum up to the same low level of completed fertility (1.6 children per woman in our example). The benchmark pattern of generally low parity progression ratios across all parities can be contrasted with four other stylised patterns: one with high childlessness at 30% (and the corresponding low progression to first birth, with PPR_{01} at 0.70), another with a strong one-child pattern, marked by very low progression to second birth (PPR_{12} at 0.55), another with a "stopping at two" pattern of very low progression rates to third and fourth births (PPR_{23} and PPR_{34} at 0.15), and, finally, polarised pattern combining high childlessness (25%) and high likelihood of progressing to third or fourth birth (PPR_{23} and PPR_{34} at 0.45). While we do not expect that any country will fit perfectly to one of these stylised patterns, we aim to discuss whether the parity-specific fertility patterns in the analysed countries and regions with very low fertility correspond to any of these models.

[4] We do not aim to suggest that a "very low" completed fertility at 1.6 or 1.7 is unsustainable or is a reason for serious concern. Rather, we expect that the threshold when fertility is "too low" depends on many other factors, including migration, economic productivity, health and human capital of the population, as well as the ways how societies adjust to the ongoing increase in longevity and population ageing (Striessnig and Lutz 2013; Lee et al. 2014).

Figure 2 Possible combinations of parity progression ratios (PPR) corresponding to a completed fertility of 1.6 children per woman (an illustration)



Note: For simplicity, these illustrations assume identical parity progression ratios to third (PPR_{23}) and fourth (PPR_{34}) birth and we limit the family size to a maximum of four children.

3 Data and Methods

We have collected data for 32 countries with a prolonged experience of low fertility. To summarise key trends, we present some of the results for eight broader regions specified in Section 2.1 and Figure 1 (see also Table A1 and A2 in Appendix for further details). As we consider data for women with almost completed reproductive histories aged 43 and older, our analysis spans birth cohorts of 1940 to 1965–1971 (Table A1). For a few countries, we miss data for several oldest cohorts and start the analyses with younger cohorts born between 1941 and 1945. For Japan the first cohort in our analysis was born in 1952. Thus, the averages computed for the regions may include a different number of countries for a few cohorts, depending on the data availability. Japan was excluded from the analyses of fertility change in the first stage (cohorts born in 1940–1955). For details on data sources see Table A1 in Appendix.

Whenever possible we base our analysis on the most recent census data from the 2011 census round, which usually collected information on children ever born among all women living in the country. Such data are available for 17 countries and they come mostly from the Cohort Fertility and Education database (CFE, Zeman et al. 2014). Other data sources include large-scale surveys (for France and Italy), micro-census data (2012

round for Germany[5]), and other sources provided by the national statistical offices (for England and Wales). We also utilise population registers (Denmark, Finland, Norway, the Netherlands and Sweden) and the Human Fertility Database (HFD 2016)[6], which contains data from the censuses around 2001 supplemented by fertility rates for the subsequent period through 2013–2014 (Austria, Slovenia, Switzerland, Ukraine). For Japan and the United States, where no recent census is available, the cohort fertility is reconstructed from period age-specific fertility rates by birth order using the HFD methodology (Jasilioniene et al. 2015). Data for Italy are reconstructed from period age specific fertility rates from the Human Fertility Collection (HFC 2016).

By using census and large scale survey or register data we cover past fertility experience of the women living in a country at the time of the census or survey. These data also include migrant women who recently moved into the country and report children they gave birth to before migrating. Relying on these retrospective data provides more stable and often more reliable information on family size distribution than the cohort fertility data reconstructed from long-term series of period indicators, that have dominated most of the research on cohort fertility in the past (see the methods section in Council of Europe 2005 and Calot and Sardon 2004 for information on the methodology of cohort indicators provided by the European Demographic Observatory). Cohort measures converted from past period rates are very sensitive to the quality of birth order reporting in vital statistics, but also to the reliability of population estimates by age and sex in the past. Furthermore, period data only contain the records on births that took place in the country and the reproductive histories of immigrants are ignored up to the date when they arrived. The cohort fertility histories created in this way are somewhat artificial, and may not reflect the actual childlessness of the residents in countries with high immigration or emigration. Different methods used in estimating completed fertility can also explain some of the differences[7] between our indicators and those based on period series, published in Frejka and Calot (2001), Council of Europe (2005), Sardon (2006a, 2006b), Frejka and Sardon (2007), and Myrskylä et al. (2013).

We measure the cohort fertility level with the completed cohort fertility rate (*CFR*), and interpret its change between the 1940 and 1970 birth cohorts by changes in the parity progression ratios ($PPR_{i-1,i}$), which express the probability of reaching parity i among

[5] We show data for Western Germany, i.e. the former Federal Republic of Germany excluding Berlin. We do not present data for Eastern Germany (including Berlin) as the sample size was too small and the resulting data on cohort fertility and parity distribution are not robust.

[6] The HFD data were extracted from the respective files on Female population exposure by parity in the Input Data section *exposRRpa.txt where * stands for country code.

[7] The discrepancy between *CFR* levels published by Sardon (2006a, 2006b), Council of Europe (2005) and in our paper is relatively small: In most countries, the *CFR* for the cohorts born in 1940, 1955 and around 1970 was slightly higher (up to 0.1 children per woman) in our data. However, for four countries—Bulgaria, Belarus, France and New Zealand—our indicators show significantly lower *CFR* (by 0.1–0.3 births per woman).

women of parity *i-1*. For each birth cohort analysed, the *CFR* can be defined as the sum of parity-specific *CFRi*:

$$CFR = \sum_i CFR_i \quad (1)$$

where CFR_i is the average number of children of birth order i born to women – it relates the number of women who reached parity i or higher to the total number of women in that cohort.

The parity progression ratios to first birth and to higher birth orders are given as:

$$PPR_{0,1} = CFR_1 \quad (2)$$

$$PPR_{i-1,i} = \frac{CFR_i}{CFR_{i-1}} \text{ for } i > 1 \quad (3)$$

We combine data on fourth and further births together, computing an indicator of the progression rate from the third to the fourth and later births:

$$PPR_{3,4+} = \frac{CFR_{4+}}{CFR_3} \quad (4)$$

It also holds that:

$$CFR_i = \prod_{j=1}^{i} PPR_{j-1,j} \quad (5)$$

We decompose changes in *CFR* into the effect of changes in the transition to first birth ($dPPR_{01}$), second birth ($dPPR_{12}$) and third and higher birth ($dPPR_{23+}$). Note that PPR_{34+} is used for the calculations but not displayed separately in the results, due to its instability and its low importance for understanding the changes in *CFR*, as higher birth orders have become marginal in contemporary developed countries. To simplify the discussion of results, we use the indicator of $dPPR_{23+}$ defined below in equation (12), which includes the combined effects of changes in progression rates to third birth (PPR_{23}) and to fourth and later births (PPR_{34+}). The decomposition method we employ proceeds directly from Barkalov (1999) and takes into account the sequential nature of childbearing as a chain of transitions across parities, starting from the transition to first birth and then proceeding to subsequent parity transitions (see Appendix for the method details). Thus, the underlying idea is that the change in the progression rate to a given parity i affects not only the number of women in this parity, but also all the higher-parity distributions[8].

In order to estimate the effect of changes in PPR_{01}, PPR_{12}, and PPR_{23} and higher on the overall change in *CFR* between two cohorts compared, the changes in parity progression

[8] Consider, for instance, a hypothetical case of a population where women have three children at most and each parity progression rate (PPR_{01}, PPR_{12}, and PPR_{23}) is fixed at 0.8. The total share of women with three children is then computed as 0.80 * 0.80 * 0.80 = 0.512. If the first birth progression rate, PPR_{01}, falls to 0.6, this will not only affect the number of women having a first birth, but, assuming the other progression rates remain the same, it will also lower the share of women with three children, computed as 0.6 * 0.8 * 0.8 = 0.384

ratios are considered stepwise, from lower to higher parity. First, we analyse the effect of changes in the progression rate to first birth, PPR_{01}, between the two cohorts compared, *c1* and *c2*, fixing the values of the subsequent progressions to higher parities at the level of the initial cohort, *c1* (see equations 8 and 10). Then, we consider in addition the effect of the change in second-birth progression rate (equations 9 and 11) and then the effects of changes in progression rates to third and fourth and higher parities (equation 12).

The difference between CFR in cohort 1 (*c1*) and in cohort 2 (*c2*) is expressed as:

$$CFR^{c2} - CFR^{c1} = \sum_i \left[\left(\frac{CFR_i^{c2}}{CFR_i^{c1}} - \frac{CFR_{i+1}^{c2}}{CFR_{i+1}^{c1}} \right) \sum_{j=1} CFR_j^{c1} \right] \quad (6)$$

In practice, for each cohort *c*, the following indicators are computed. The relationship between cohort fertility rate and parity progression ratios is expressed as:

$$CFR = PPR_{0,1} + PPR_{0,1} * PPR_{1,2} + PPR_{0,1} * PPR_{1,2} * PPR_{2,3} + PPR_{0,1} * PPR_{1,2} * PPR_{2,3} * PPR_{3,4+} \quad (7)$$

Cohort fertility rate under condition of fixed $PPR_{1,2}$ and higher is computed as:

$$CFR_{fixPPR1+}^{c1,c2} = PPR_{0,1}^{c2} + PPR_{0,1}^{c2} * PPR_{1,2}^{c1} + PPR_{0,1}^{c2} * PPR_{1,2}^{c1} * PPR_{2,3}^{c1} + PPR_{0,1}^{c2} * PPR_{1,2}^{c1} * PPR_{2,3}^{c1} * PPR_{3,4+}^{c1} \quad (8)$$

Cohort fertility rate under condition of fixed $PPR_{2,3}$ and higher is computed as:

$$CFR_{fixPPR2+}^{c1,c2} = PPR_{0,1}^{c2} + PPR_{0,1}^{c2} * PPR_{1,2}^{c2} + PPR_{0,1}^{c2} * PPR_{1,2}^{c2} * PPR_{2,3}^{c1} + PPR_{0,1}^{c2} * PPR_{1,2}^{c2} * PPR_{2,3}^{c1} * PPR_{3,4+}^{c1} \quad (9)$$

Then we compute the effects of changes in each parity-progression ratio on the overall change in completed cohort fertility rate $dPPR_{i-1,i}^{c1,c2}$,

$$dPPR_{0,1}^{c1,c2} = CFR_{fixPPR1+}^{c1,c2} - CFR^{c1} \quad (10)$$

$$dPPR_{1,2}^{c1,c2} = CFR_{fixPPR2+}^{c1,c2} - CFR_{fixPPR1+}^{c1} \quad (11)$$

$$dPPR_{2,3+}^{c1,c2} = CFR^{c2} - CFR_{fixPPR2+}^{c1} \quad (12)$$

A similar method of decomposing the differences in total fertility rate into the effects of the parity-progression ratios was developed by Ní Bhrolcháin (1987) and Pullum et al. (1989), and further extended by Barkalov (1999). However, these studies analysed the synthetic period fertility measures while we focus solely on the cohort fertility. Later on, a

more general method has been proposed by Andreev et al. (2002), who developed algorithm of stepwise replacement as a universal tool for the decomposition of differences between values of aggregate measures by age and other demographic dimensions.

4 Results

4.1 Changes in the Parity Progression Ratios across Regions

Low transition rates to second and third births explain why cohort fertility in Eastern Europe and, to a smaller extent, in Central Europe was lower than in other regions in the early 1940s birth cohorts (Table 1). In Eastern Europe, the progression to third birth declined slowly but steadily, remaining the lowest of all the regions until the mid-1960s cohorts, when Southern Europe experienced plummeting third birth rates, eventually reaching equally low values (Figure 3). In Central Europe, PPR_{23} remained low, while the second birth rates kept increasing until the early 1950s cohorts, remained stable until the late 1950s cohorts and then started declining to medium-ranged values. In Eastern Europe they remained lower, declining since the late 1950s birth cohorts to extremely low levels, not seen in any other region.

Childlessness levels were rising from the early 1940s cohorts in all regions apart from the post-socialist countries, where they started rising gradually only from the late 1950s cohorts. At the other end of the scale, the German-speaking countries exhibited the highest levels of childlessness across all analysed cohorts, followed by Southern Europe in the 1960s cohorts. These two regions also had one of the lowest transition rates to second birth. While in the German-speaking countries second birth rates stabilised at a low level, in Southern Europe they raced continuously down, coinciding with a steep decline in the progression to third birth.

Western and Northern Europe, and the English-speaking non-European countries show comparable developments of their parity transitions. In all three regions the largest falls in the parity progression ratios took place between the 1940 and 1955 birth cohorts. The levels of childlessness varied greatly, with lower values in the United States, Scandinavia and France, and higher shares in Finland (which was in all indicators very similar to England and Wales), Ireland and the Netherlands (Table A1). The progression to third birth remained substantially higher in the English-speaking non-European countries than in Western and Northern Europe, while the transition rates to second birth eventually converged in these regions.

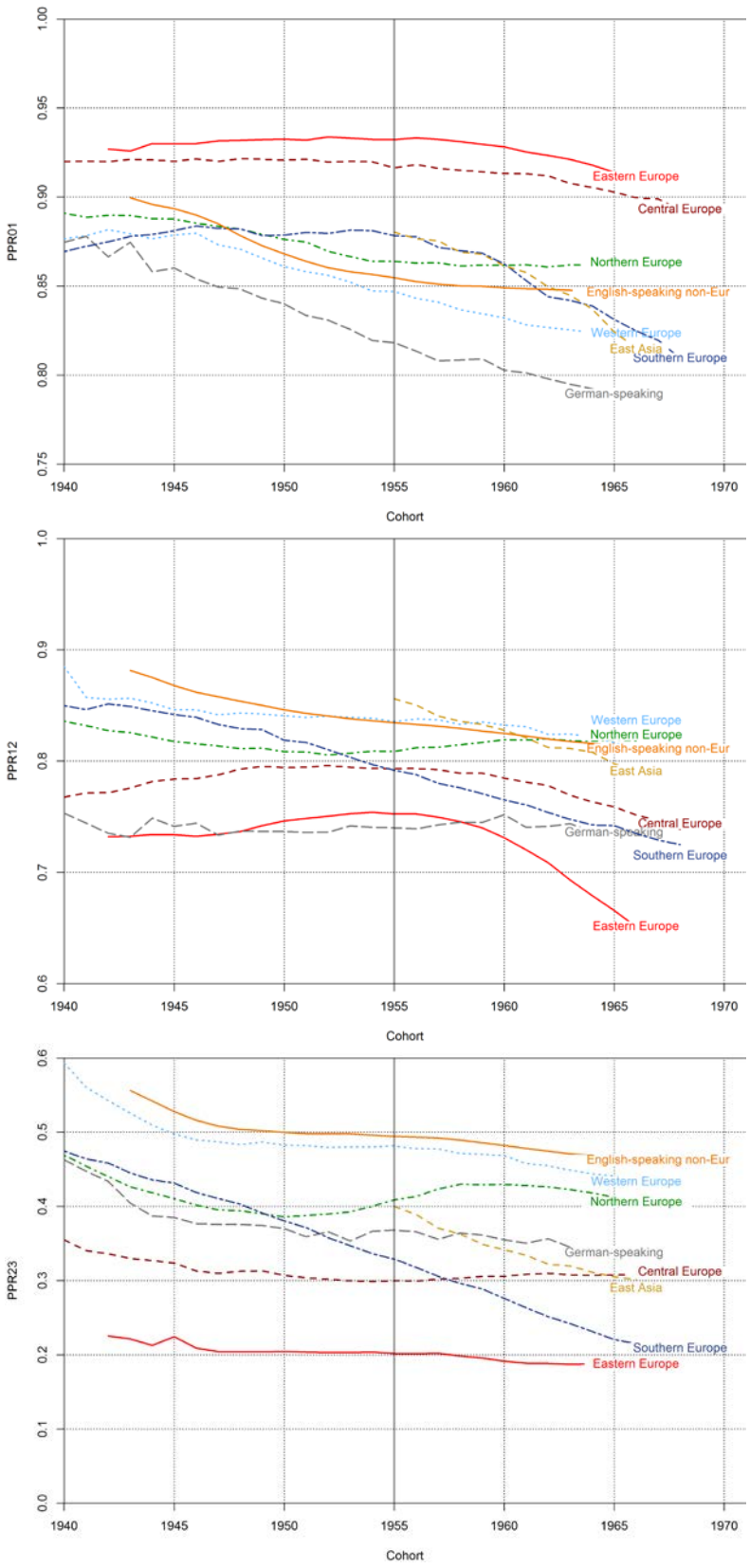
In East Asia rapid declines across all parity progression ratios took place among the analysed cohorts, going down from very high levels among women born in the early 1950s and reaching low values among those born in 1965. Although comprising only three countries, the region showed immense diversity, especially in the childlessness rates, which increased dramatically in Japan and Singapore, but only moderately in South Korea, remaining below 10%.

Table 1 Completed cohort fertility around 1940, 1955 and 1970 and parity progression ratios in the regions

Region	Cohort range	CFR	PPR01	PPR12	PPR23
Eastern Europe	1940–1945	1.86	0.93	0.73	0.24
	1955	1.84	0.93	0.75	0.20
	1966–1968	1.64	0.91	0.63	0.19
Central Europe	1940	2.05	0.92	0.77	0.36
	1955	1.97	0.92	0.79	0.30
	1968	1.86	0.89	0.74	0.31
Western Europe	1940–1941	2.56	0.88	0.86	0.57
	1955	2.15	0.85	0.84	0.48
	1966–1971	1.93	0.83	0.80	0.43
Northern Europe	1940	2.19	0.89	0.84	0.47
	1955	1.99	0.86	0.81	0.41
	1966–1971	2.00	0.86	0.82	0.41
German speaking	1940–1944	1.99	0.86	0.77	0.43
	1955	1.76	0.82	0.74	0.37
	1965–1969	1.64	0.78	0.74	0.33
Southern Europe	1940	2.23	0.87	0.85	0.47
	1955	1.90	0.88	0.79	0.33
	1968–1970	1.57	0.80	0.73	0.21
English-speaking non-European	1940–1943	2.58	0.91	0.89	0.59
	1955	2.15	0.85	0.83	0.49
	1967–1968	2.05	0.85	0.81	0.46
East Asia (without Japan)	1940–1941	2.94	0.93	0.91	0.65
East Asia	1955	2.03	0.88	0.86	0.40
East Asia	1966–1969	1.68	0.81	0.79	0.30

Note: The list of countries belonging to the regions and the exact cohort range available for each country are listed in Appendix tables A1 and A2. Regional values are calculated as non-weighted averages using the oldest (for the first cohort) and the youngest (for the last cohort) cohort data available for each country.

Figure 3 Parity progression ratios to first (PPR_{01}), second (PPR_{12}) and third birth (PPR_{23}) between birth cohorts around 1940 and 1970, regional means



4.2 The Contribution of Changing Parity Progression Rates to Fertility Decline: Regional Patterns and Country Exceptions

The decomposition of fertility trends into the effects of changes in parity progression ratio to first ($dPPR_{01}$), second ($dPPR_{12}$) and third and later births ($dPPR_{23+}$; Table 2 and Figure 4) confirmed our general expectations: the fertility decline between the 1940 and 1955 birth cohorts was mostly driven by the decreasing transition to higher order births, whereas the change among the later cohorts, born between 1955 and 1970, was mostly due to the falling transitions to first and second birth. The applied decomposition method enabled us to quantify these effects and to compare their roles across different regions and countries.

In the first stage, completed fertility rates declined dramatically in East Asia (taking into account only Singapore and South Korea, not Japan) and in Southern Europe (Figure 1). In both regions about two-third of this fall was due to the reduction in the progression ratio to third and later births (Figure 4). The English-speaking non-European countries also experienced a substantial fertility decline (by 0.43 children per women), but it resulted equally from the increasing childlessness and the declining third and higher-order progression rates, with a smaller contribution of decreasing second birth progression rate. Similar changes in parity progression ratios took place in the German-speaking countries, but they were moderate, leading to a fertility decline of 0.23 children per woman. In Western Europe, completed fertility fell by 0.41 children per woman, mostly because of the decline in high parity births (by 0.28, which constituted two thirds of the overall fall in CFR). Finally, Central and Eastern Europe experienced only a modest fertility decline of 0.08 and 0.03, respectively, which was entirely driven by the fall in third and higher-order progression rates. These were the only regions in which transition to second birth increased between the 1940 and 1955 birth cohort.

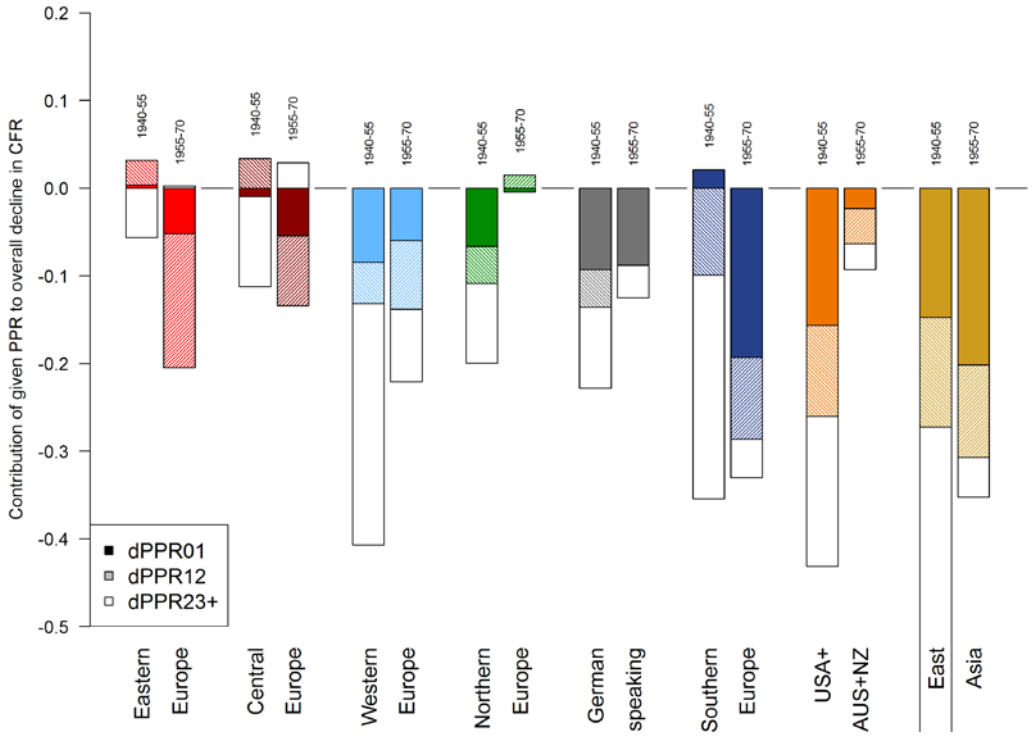
Despite the large degree of coherence within the regions, some countries deviated from their region's pattern. The most striking example is Ireland, where fertility dropped by 0.78 children per woman between 1940 and 1955, the highest value in Europe, and where the decline was almost exclusively driven by the falling progression rates among women with two or more children. In Central and Eastern Europe, Estonia, Hungary and Serbia experienced fertility increase, mostly because of the rising transitions to first and second births (see Table A2 in Appendix).

Table 2 Change in completed fertility between cohorts around 1940, 1955 and 1970, and decomposition into parity progression ratios

Region	ΔCFR	ΔCFR	$dPPR_{01}$	$dPPR_{12}$	$dPPR_{23+}$	ΔCFR	$dPPR_{01}$	$dPPR_{12}$	$dPPR_{23+}$
	1940–	*1940–55*				*1955–70*			
Eastern Europe	-0.23	-0.03	0.00	+0.03	-0.06	-0.20	-0.05	-0.15	0.00
Central Europe	-0.18	-0.08	-0.01	+0.03	-0.10	-0.11	-0.05	-0.08	+0.03
Western Europe	-0.63	-0.41	-0.08	-0.05	-0.28	-0.22	-0.06	-0.08	-0.08
Northern Europe	-0.19	-0.20	-0.07	-0.04	-0.09	+0.01	0.00	+0.01	0.00
German speaking	-0.35	-0.23	-0.09	-0.04	-0.09	-0.13	-0.09	0.00	-0.04
Southern Europe	-0.66	-0.33	0.02	-0.10	-0.26	-0.33	-0.19	-0.09	-0.04
English-speaking non-European	-0.52	-0.43	-0.16	-0.10	-0.17	-0.09	-0.02	-0.04	-0.03
East Asia (without Japan in 1940–55)	-1.26	-0.90	-0.15	-0.12	-0.63	-0.35	-0.20	-0.11	-0.05

Note: The first (around 1940) and the last cohort available (1965 to 1971) differs across countries; see more precise specification in Table 1 above and in Appendix Table A1.

Figure 4 Contribution of the change in parity progression ratio to first ($dPPR_{01}$), second ($dPPR_{12}$) and higher order births ($dPPR_{23+}$) to the decline in completed cohort fertility in cohorts (around) 1940 to 1955 (left-hand bars) and 1955 to (around) 1970 (right-hand bars), by region



Fertility decline was weaker among the women born between 1955 and around 1970 in all regions except in Eastern and Central Europe and resulted mostly from decreases in parity progression ratios to first and second births. However, the role of each of these

transitions differed widely across regions. The sharp fall in second birth progression rate in Eastern Europe accounted for three quarters of the *CFR* fall of 0.20 children per woman. In Central Europe, the fertility decline was more moderate (-0.11), but it was also mostly driven by the falling second birth rates, with childlessness playing a smaller role (Table 2). In contrast, in Western Europe and the English-speaking non-European countries, the decrease in *CFR* resulted equally from the declines in PPR_{01}, PPR_{12} and PPR_{23} or higher. A *CFR* drop of 0.13 in the German-speaking countries was caused mostly by the increase in childlessness. Southern Europe and East Asia saw the largest fertility reductions, by 0.33 or 0.35 children per woman, resulting primarily from the rises in childlessness (which constituted almost 60% of the overall fall in fertility) and decreases in second birth rates, and only marginally from reductions in higher order births.

Ireland continued being an outlier: its fertility declined much faster (and from higher level) than in most other European countries, mostly due to the falling transition rates to third birth. In the Nordic countries, fertility hardly changed (Finland, Norway and Sweden) or even increased (Denmark). In the United States, unlike in Australia and New Zealand, fertility increased, mostly as a result of increasing transitions to first and third birth.

4.3 Fertility Decline below 1.75 Children per Woman

The eleven countries in which fertility declined below 1.75 children per woman for at least two successive cohorts belong to four regions: Eastern Europe and Southern Europe, the German-speaking countries and East Asia – see details in Table 3, which contains the main information on the overall and average observed fall in *CFR*, starting with the first cohorts for which it fell below 1.75 children per woman, up to the latest cohort observed.

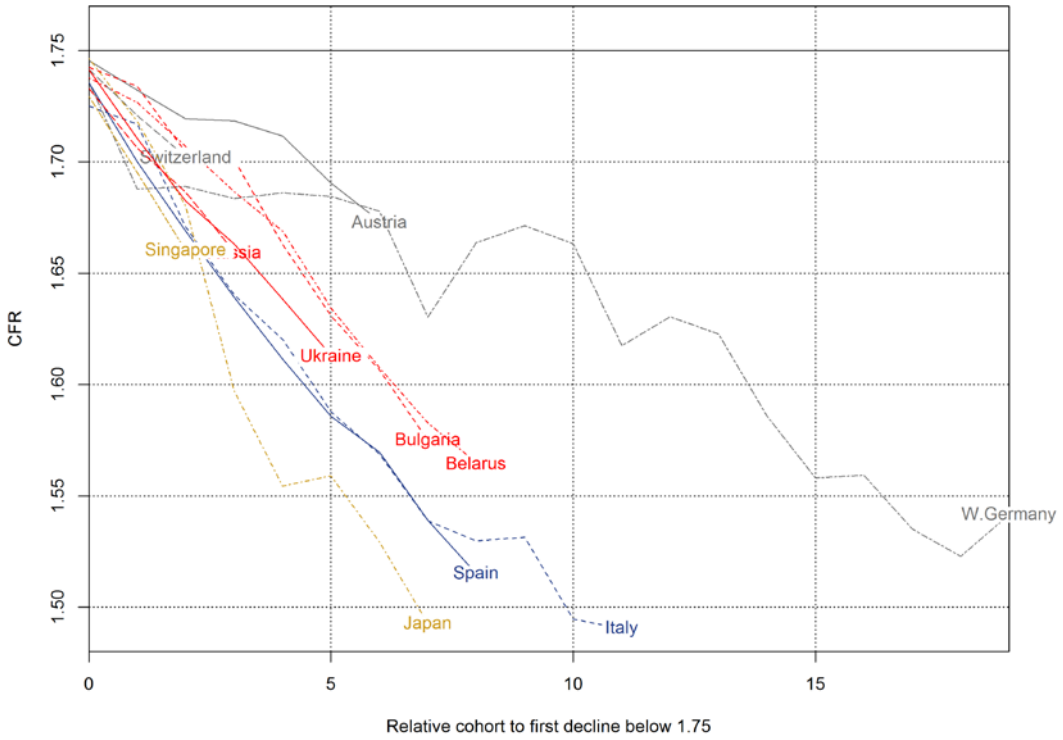
In most countries, fertility fell below 1.75 children per woman in the early 1960s cohorts. The fall started much earlier in Western Germany, where women born in 1950 already had fewer than 1.75 children on average. However, the pace of the following decline was the slowest there, and the low level of 1.53 children per woman in the late 1960s cohorts was reached gradually (Table 3 and Figure 5). By contrast, in Italy and Spain, fertility fell much more quickly: the *CFR* declined on average by 0.02–0.03 per cohort, heading towards a low of 1.5 in the late 1960s cohorts. However, nowhere did the fertility decline proceed as fast as in Japan[9]. Within seven birth cohorts, fertility in Japan dropped by 0.25 children per woman, falling to 1.49 in the 1969 cohort.

[9] In Singapore the decline reached a comparable speed, but so far it covered only 2 cohorts.

Table 3 Characteristics of the very-low-fertility countries: first cohort of CFR below 1.75 and last observed cohort; total decline below 1.75 and average decline in CFR per cohort

Country	CFR, 1955 cohort	First cohort below 1.75	Last cohort observed	CFR	dCFR	Number of cohorts	dCFR per cohort
Austria	1.81	1961	1967	1.67	-0.07	6	-0.012
Bulgaria	1.83	1961	1968	1.57	-0.17	7	-0.024
Belarus	1.77	1958	1966	1.56	-0.17	8	-0.022
Switzerland	1.79	1963	1965	1.70	-0.04	2	-0.020
W. Germany	1.71	1950	1969	1.53	-0.19	19	-0.010
Spain	1.91	1960	1968	1.52	-0.22	8	-0.028
Italy	1.83	1959	1970	1.49	-0.23	11	-0.021
Japan	1.98	1962	1969	1.49	-0.25	7	-0.036
Russia	1.88	1964	1967	1.66	-0.07	3	-0.024
Singapore	1.91	1964	1966	1.66	-0.07	2	-0.035
Ukraine	1.88	1963	1968	1.61	-0.13	5	-0.026

Figure 5 Decline in completed cohort fertility in the very-low-fertility countries, beginning from cohort in which the CFR dropped below 1.75 for the first time



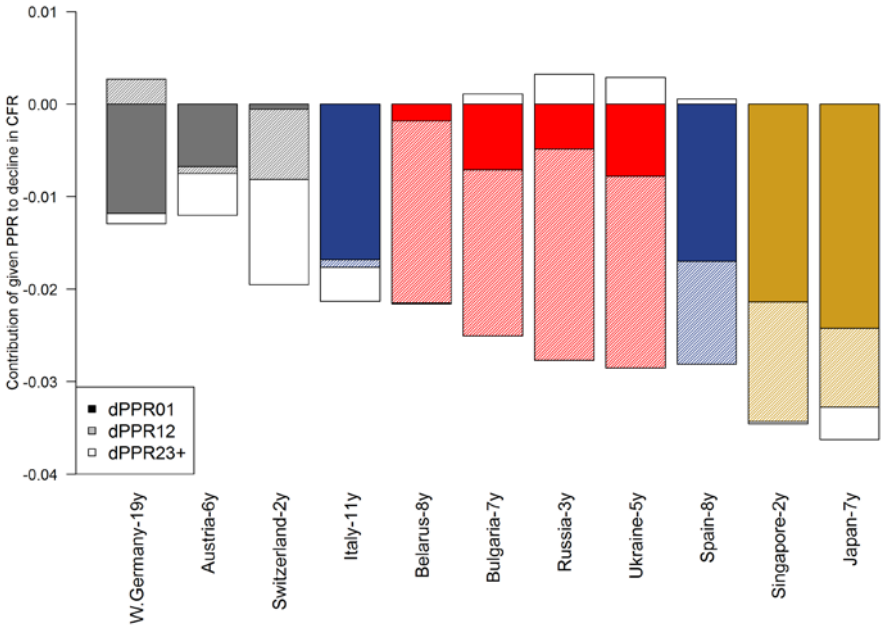
The decomposition of the overall CFR decline (Figure 6) reveals no common pattern of cohort fertility decline to very low levels shared across the groups of analysed countries. Instead, parity-specific fertility declines followed trajectories typical of the corresponding regions.

In Eastern European countries (Belarus, Bulgaria, Russia and Ukraine) the fertility decline was driven primarily by the falling transition from first to second birth. In contrast, in all other countries except Switzerland increasing childlessness levels played the main role (see Figure 6 and Figure 7). Decreasing progression rates to second birth were also pronounced in Spain, Switzerland, Japan and Singapore, but they contributed less to the overall fall in *CFR* than in Eastern Europe. In Austria and Switzerland, the decline in transition to third and later births also contributed to the observed fertility decrease.

Despite often similar fertility levels, the very-low-fertility regions clearly differ in their parity progression ratios. Figure 7 illustrates the changes in parity progression ratios among women born between 1955 and around 1970, when their CFR fell below 1.75 (except in Western Germany). The German-speaking countries, represented by Austria and Germany, show low and gradually declining first birth rates combined with relatively stable second birth rates and moderately high third birth rates. In terms of their parity composition they resemble the polarised pattern in Figure 2. Southern Europe, represented by Italy and Spain, combines two stylised patterns, Benchmark and "Stopping at two", showing a fall in progression rates across all parities, especially in third birth rates. Eastern Europe, represented by Belarus, Bulgaria, Russia and Ukraine, shows a steep decrease in second birth rates and very low and slightly declining third birth rates, but persistently high first birth rates. This pattern embodies the One child pattern and "Stopping at two" depicted in Figure 2. Finally, in East Asia, represented by Japan and Singapore, each progression rate fell to low levels, with first and second birth trajectory moving in tandem. Besides Switzerland, these are the only countries where progressions to first birth were as low as to second birth.

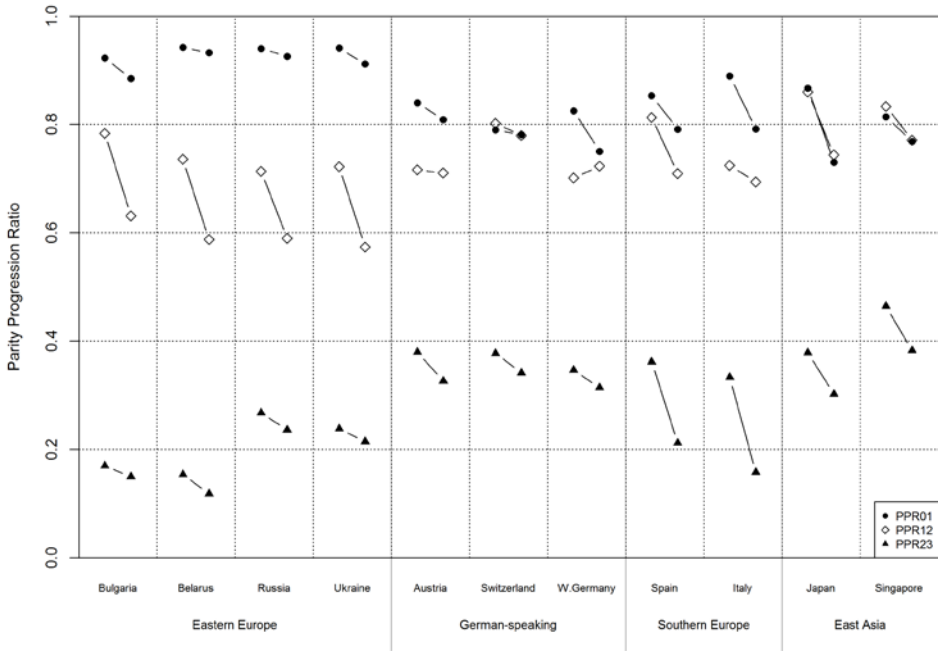
These different patterns of progression ratios result in distinct parity compositions (see Figure A1 in Appendix). While most low-fertility regions are characterised by high and increasing childlessness, in Eastern Europe it is rather the high proportion of one-child families, quickly increasing at the expense of families with two and more children.

Figure 6 Average contribution of the change in parity progression ratio to first ($dPPR_{01}$), second ($dPPR_{12}$) and further birth ($dPPR_{23+}$) to the decline in completed cohort fertility in countries with CFR below 1.75 (per birth cohort)



Note: The colours indicate the broader country regions.

Figure 7 Changes in parity progression ratios to first, second, and third birth (PPR_{01}, PPR_{12}, and PPR_{23}) in eleven countries that reached CFR below 1.75; women born between 1955 and (around) 1970



Note: The last cohort available (1965 to 1970) differs by country; see more precise specification in Table 3 above.

5 Discussion: Regional Context of Cohort Fertility Declines

Our study provides a systematic analysis of parity components of the cohort fertility decline in low-fertility countries among women born between 1940 and 1970. The fall in fertility was mostly driven by reductions in the progression ratios to third and higher-order births among the older cohorts analysed, born in 1940 to 1955. It was also stronger in countries, in which the fertility transition started later, e.g. in Ireland, Spain, and in countries of East Asia.

Among women born between 1955 and 1970, the fertility decline slowed down in most regions except in Southern and in Central Europe where it continued, and in Eastern Europe, where it accelerated in connection with the turbulent social and economic transformation after the collapse of state socialism. In this second stage of the cohort fertility decline we found distinct regional patterns of fertility change. This is also the case for the countries and regions that saw their CFR falling to very low levels below 1.75 children per woman: clearly, there are different pathways towards very low fertility, broadly confirming our hypotheses sketched in section 2. The main distinction can be drawn between the countries of Central and Eastern Europe, where the fertility decline was primarily driven by the falling second birth rates, and the German-speaking countries, Southern Europe, and East Asia, where the fall in first birth rates had a stronger effect. In contrast, in the Nordic countries, the United States, Australia and New Zealand, fertility broadly stabilised, while the moderate fertility decline in Western Europe was equally driven by relatively minor changes across all parity progression rates.

The fact that the regional trends in parity progression ratios differed from each other, even in regions with similarly low completed fertility, suggests that there is no uniform "explanation" of low fertility that fits the whole low fertility world (see also Rindfuss and Choe 2015). Here we summarise key differences between regions and discuss selected region-specific factors that were arguably important in the second stage of the observed cohort fertility decline, i.e., among women born after 1955.

The English-speaking non-European countries together with Western and Northern Europe had the highest fertility among the analysed regions, ranging from 1.8 children per woman in the Netherlands to 2.2 in the United States in the late 1960s birth cohorts. These countries are distinguished especially by higher progression rates after the second birth, with the third birth progression rate well above that in the other regions; they also share a pattern of relatively high second birth rate. In the United Kingdom and the United States relatively high fertility levels partly arose from the social status polarisation in fertility (Ekkert-Jaffé et al. 2002, Schoen 2006, Sardon 2006a, 2006b). Both countries display high childlessness among highly educated women on the one hand and a high share of large families among the lower educated on the other hand (Berrington et al. 2015, Schoen 2006). The high share of larger families is partly driven by unplanned pregnancies: in the United States lower-educated women have more children than they intended (Morgan and Rackin 2010).

Western and Northern Europe together with the English-speaking non-European countries are the most gender-equal regions globally, whose institutional arrangements make it "easier, not easy" (Rindfuss et al. 2016: 1) for women to combine work and family. In this respect the most developed work- and family- friendly policies with generous family transfers, high level of child care coverage and policies promoting work-family balance can be found in the Nordic countries (Rindfuss et al. 2016) and in some countries of Western Europe, especially France (Klüsener et al. 2013). In France, the pro-natalist set of policies have created and maintained positive attitudes towards two and more-children families in France (Toulemon et al. 2008). In the Netherlands the male bread-winner model is still strongly accepted in the society, but the labour market offers abundant and rewarding part-time job opportunities (Mills 2015).

The German-speaking countries—Austria, Germany and Switzerland—and Southern Europe have followed a different trajectory. Among younger cohorts born after 1955 rising childlessness accounted for most of the fertility decrease; in Spain, also second birth rates fell steeply. In the late 1960s cohorts, the CFR ranged from 1.5 in Italy and Spain to 1.7 births per woman in Greece and Switzerland. The German-speaking countries and Southern Europe share high levels of childlessness, but they increasingly differ in higher-order transitions, with German-speaking countries showing more polarised pattern marked by more frequent transition to third and later birth, and Southern Europe displaying a continuing fall to very low third and higher order birth rates. In the German-speaking countries, traditional social expectations towards mothers remained strong in the analysed cohorts: working outside home when children are small is widely perceived as harmful for the children's development (Klüsener et al. 2013) and, in line with that, public childcare for children below age three was very limited until recently (with the exception of Eastern Germany; e.g. Leitner 2010). Perhaps this is why the low family-size ideals, "child-free lifestyles" and "culture of childlessness" gained greater popularity than in any other country (Sobotka and Testa 2008, Klüsener et al. 2013, Burkimsher and Zeman 2017). In Italy childcare still strongly relies on the traditional family organisation (e.g. grand-parents taking care of the children) which has been weakening (De Rose et al. 2008). Childcare facilities for pre-school children are not compatible with full-time employment of both parents, and women who want to pursue professional career often have to forgo motherhood. In addition, the chronically high unemployment and unstable labour market in Southern Europe, especially among young people have been accompanied by late leaving parental home and fertility postponement, contributing to high childlessness, and generally low levels of fertility (Adserà 2005, De Rose at al. 2008).

In Central and Eastern Europe, fertility decline accelerated among women born after 1955, especially in the 1960s, bringing the CFR down to 1.5–1.8 in Eastern Europe and to 1.7–2.1 in Central Europe. Fertility fell mostly due to the declining transition to second child, while third birth rates remained low, which contrasted with the highest first birth rates among all the regions and the continuing negative attitudes to childlessness (Sobotka and Testa 2008, Merz and Liefbroer 2012).

Especially highly educated women often chose to have only one child to satisfy the social norm of having children while at the same time limiting the inevitable double

burden of working full-time and taking care of the household tasks (Frejka 2008, Brzozowska 2015). The transition to market economy, new economic uncertainties and relatively low wages together with traditional gender roles within the family have contributed to the continuously rising share of one-child families, with the second birth progression ratio falling to or below 0.6 in Eastern Europe. This development has been strengthened by the "failure" of many couples to realise their childbearing intentions (Spéder and Kapitány 2014). The rise in one-child families has been particularly dramatic in Eastern Europe, which is economically weaker and suffered the most turbulent social and economic transition in the 1990s (e.g. Philipov et al. 2006, Sobotka 2011).

East Asia has seen the most rapid shifts from high to very low fertility among the analysed regions, with CFR falling below 1.5 in Japan. In the younger cohorts, this decline was fuelled by a fall across all parity progression ratios, with South Korea "lagging behind" in the first birth decline. The whole region has undergone a rapid transformation towards high education and rising career aspirations among younger men and women combined with long working hours and competitive labour market (see contributions in Rindfuss and Choe 2015). At the same time, gender roles within the family have remained far more traditional than in Europe (Jones et al. 2008) and, until recently, family policies have mostly focused on financial incentives that did not promote the reconciliation of work and family. For women, having children usually means quitting the labour market (Ma 2014, Rindfuss et al. 2016). In addition, in the middle class the social pressure on investing in children's education is stronger than anywhere else in the world, further nurturing the trend towards higher childlessness and more one-child families.

In countries, where fertility fell below 1.75 children per woman, the trends in parity-specific fertility conform to those seen in the regions to which they belong. Except for the German-speaking countries they share low and declining second birth rates, which is broadly in line with the argument pursued by Billari and Kohler (2004). In addition, most of these countries remain strongly gender-unequal, fostering the traditional male-breadwinner model and not actively supporting the reconciliation of work and family (Esping-Andersen 2009). Thus, our findings lend support to the idea of gender systems being a "critical component" in explaining fertility levels and differentials (McDonald 2000, 2006, Esping-Andersen 2009, Esping-Andersen and Billari 2015, Baizán et al. 2016).

How will the fertility trends develop among women born in the 1970s and early 1980s? In Central and Eastern Europe childlessness is likely to start rising faster than in the previous cohorts because of the educational expansion, delayed union formation and late home leaving documented for the region since the 1990s (e.g., Frejka and Gietel-Basten 2016). One-child families are set to become yet more prevalent in Central Europe. Similarly, in Southern Europe and East Asia, we expect further increase in childlessness and a more pronounced shift to one-child families. In the other regions the available data and projections suggest a broad stabilisation of cohort fertility among women born in the 1970s (Myrskylä et al. 2013), which indicates that also the parity-specific fertility is likely to remain similar to that in the late 1960s cohorts.

However, the future fertility trends will be conditioned by the social reaction to the continuous decrease in fertility in the 1940–1970 birth cohorts. In East Asia future fertility will be affected by the change (or its lack) in the rigid labour markets and the strongly unbalanced gender relations. In Eastern Europe cohort fertility trends partly depend on the effectiveness of pro-natalist measures implemented especially by the Belarusian, Russian and Ukrainian governments in the 2000s, which aimed to target especially second and third births and which have had a mixed effect so far (for Russia, see Frejka and Zakharov 2013, Biryukova et al. 2016). In the German-speaking countries, especially in Austria and Germany, the more flexible parental leave schemes and the expansion of early childcare provision may help achieve a modest upturn in completed fertility, possibly even heralding a decline in childlessness in the region. Finally, in Southern Europe, the share of larger families is already so low that it cannot decline much further. However, a further shift towards more childless women and more one-child families is likely, considering that the whole region has been badly hit by the recent economic recession. Future cohort fertility trends will be affected by the pace of the economic recovery as well as the progress of labour market reforms in creating more career opportunities and more stable employment for the young.

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APPENDIX

Our methodology proceeds directly from Barkalov (1999), who used period parity-progression ratios derived from the age-parity model (originally introduced by Whelpton 1946). According to Barkalov, "It would be wrong to interpret the share attributed to a parity-progression ratio as a sole impact of fertility at that parity", stressing the "influence of lower parities on the upper by affecting the ... numbers of births" (p. 29, fn. 12). Barkalov thus used a formula with stepwise replacement of *PPR* from lower to higher parities: he measured the impact of each parity-progression ratio on the overall change in period total fertility rate (formulae [3–6] in Barkalov 1999, p. 52–53). Note that in our paper we do not need to rely on age-parity models because in a cohort perspective the simple parity-progression ratios are equal to the life-table ones.

Barkalov first defines survivorship function

$$\lambda_i = PPR_{0,1} * \ldots * PPR_{i-1,i} \tag{13}$$

which is similar to CFR_i and computes "expected parity"

$$e_i = \frac{1}{\lambda_i}\sum_{j=i+1}\lambda_j \text{ , where } e_0 = CFR \tag{14}$$

Following Barkalov (1999), the difference between two respective values of CFR is then approximated as

$$e_0^{c2} - e_0^{c1} = \sum_i (PPR_i^{c2} - PPR_i^{c1}) \frac{\partial e_o}{\partial PPR_i}\Big|_{c1} = \sum_i \left(\frac{\lambda_i^{c2}}{\lambda_i^{c1}} - \frac{\lambda_{i+1}^{c2}}{\lambda_{i+1}^{c1}}\right) e_i^{c1}\lambda_i^{c1} \tag{15}$$

Equation (15) corresponds to equation (6) in the main text.

Table A1 Data description for all covered countries and completed cohort fertility around 1940, 1955 and 1970

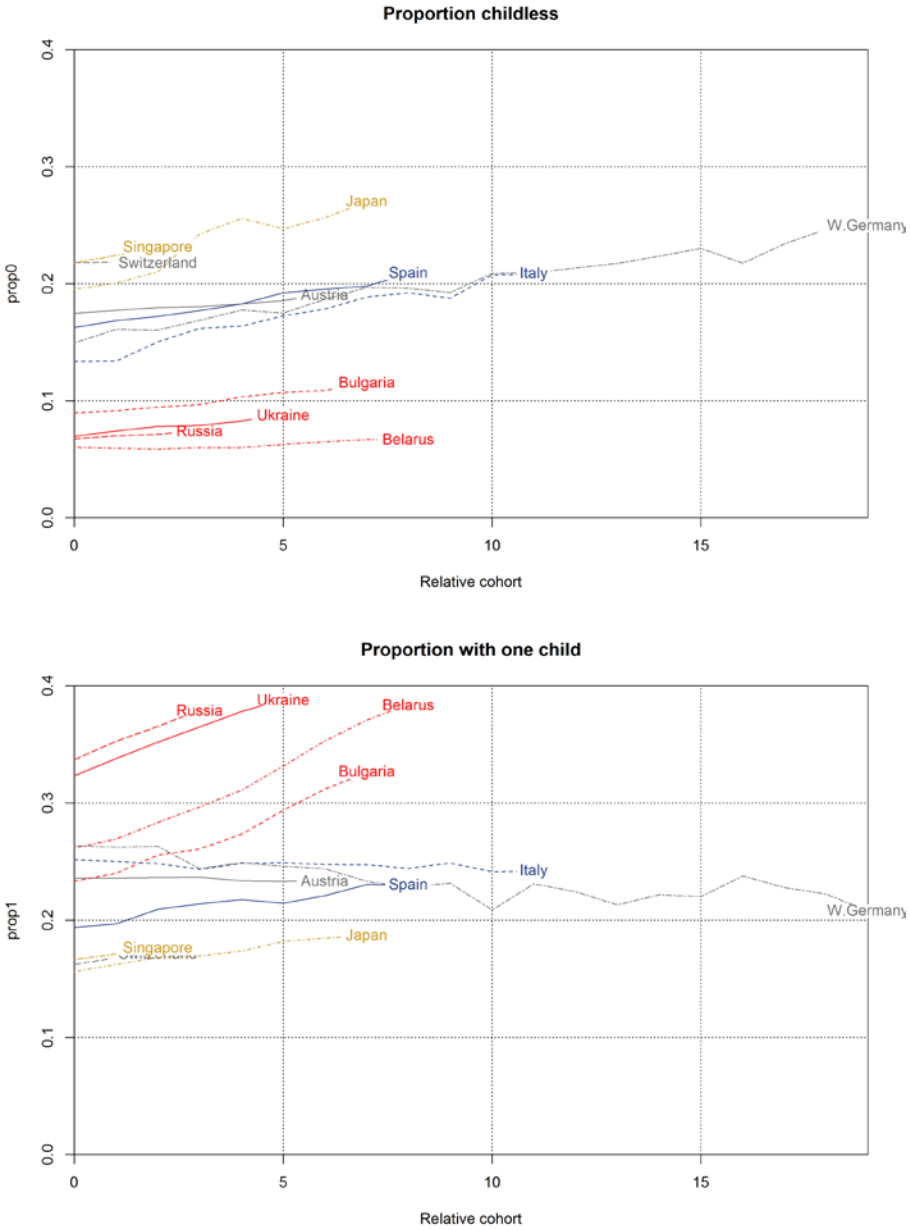
Region	Code	Country	Survey	First cohort		C1955	Last cohort	
				Cohort	CFR	CFR	Cohort	CFR
Eastern Europe	BGR	Bulgaria	Census 2011	1940	1.84	1.83	1968	1.57
	BLR	Belarus	Census 2009	1944	1.83	1.77	1966	1.56
	RUS	Russia	Census 2010	1940	1.94	1.88	1967	1.66
	SRB	Serbia	Census 2011	1940	1.75	1.83	1968	1.76
	UKR	Ukraine	HFD (Census 2001+ASFR till 2013)	1945	1.95	1.88	1968	1.61
Central Europe	CZE	Czech Republic	Census 2011	1940	2.03	2.01	1968	1.84
	EST	Estonia	Census 2011	1940	1.81	1.91	1968	1.85
	HRV	Croatia	Census 2011	1940	2.05	1.92	1968	1.91
	HUN	Hungary	Census 2011	1940	1.82	1.91	1968	1.85
	LTU	Lithuania	Census 2011	1940	2.03	1.90	1968	1.80
	SVK	Slovakia	Census 2011	1940	2.57	2.28	1968	2.05
	SVN	Slovenia	HFD (Census 1991+ASFR till 2014)	1940	2.01	1.84	1969	1.74
Western Europe	ENW	England & Wales	ONS-2014	1940	2.41	2.07	1971	1.93
	FRA	France	Surveys 1982, 1990, 1999 & 2011	1941	2.23	2.05	1966	1.93
	IRL	Ireland	Census 2011	1940	3.38	2.59	1968	2.08
	NLD	Netherlands	HFD (register data)	1940	2.23	1.90	1967	1.80
Northern Europe	DNK	Denmark	HFD (register data)	1940	2.17	1.88	1969	2.01
	FIN	Finland	HFD (register data)	1940	2.01	1.89	1971	1.86
	NOR	Norway	HFD (register data)	1940	2.52	2.11	1969	2.11
	SWE	Sweden	HFD (register data)	1940	2.08	2.09	1966	2.03
German speaking	AUT	Austria	HFD (Census 2001+ASFR till 2014)	1940	2.16	1.81	1967	1.67
	CHE	Switzerland	HFD (Census 2000+ASFR till 2014)	1944	1.86	1.79	1965	1.70
	DEU	Western Germany	Microcensus 2012	1940	1.96	1.68	1969	1.54
Southern Europe	ESP	Spain	Census 2011	1940	2.52	1.91	1968	1.52
	GRC	Greece	Census 2011	1940	2.02	1.95	1968	1.70
	ITA	Italy	HFC (estimated from period ASFR)	1940	2.16	1.83	1970	1.49
English-speaking non-European	AUS	Australia	Census 2011	1942	2.47	2.16	1967	1.98
	NZL	New Zealand	Census 2013	1943	2.56	2.25	1968	2.02
	USA	USA	HFD (estimated from period ASFR)	1940	2.70	2.02	1967	2.16
East Asia	JPN	Japan	HFD (estimated from period ASFR)	1952	2.02	1.98	1969	1.49
	KOR	South Korea	Census 2010	1940	3.86	2.21	1967	1.89
	SGP	Singapore	Census 2010	1941	2.94	1.91	1966	1.66

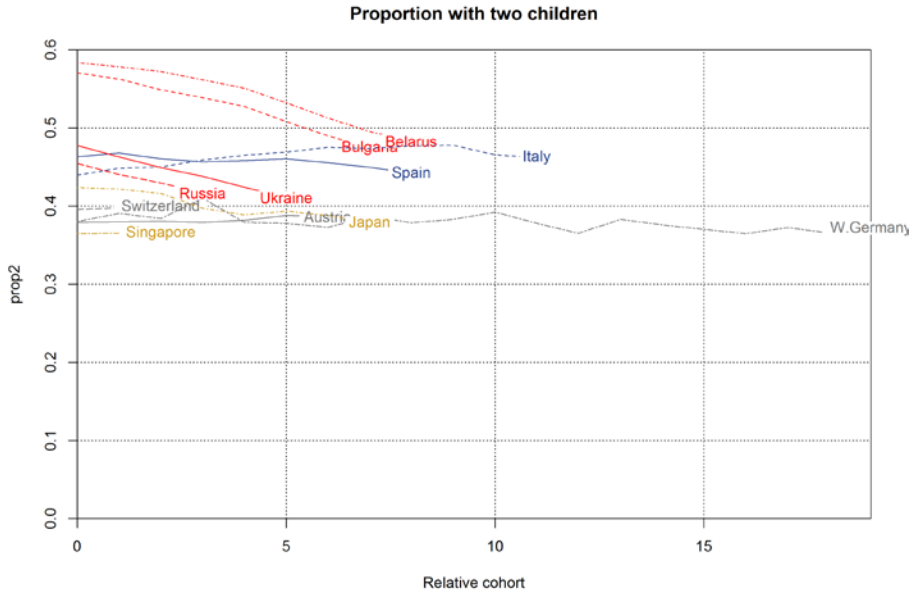
Table A2 Change in completed cohort fertility around 1940, 1955 and 1970 and its decomposition into effect of parity progression ratios

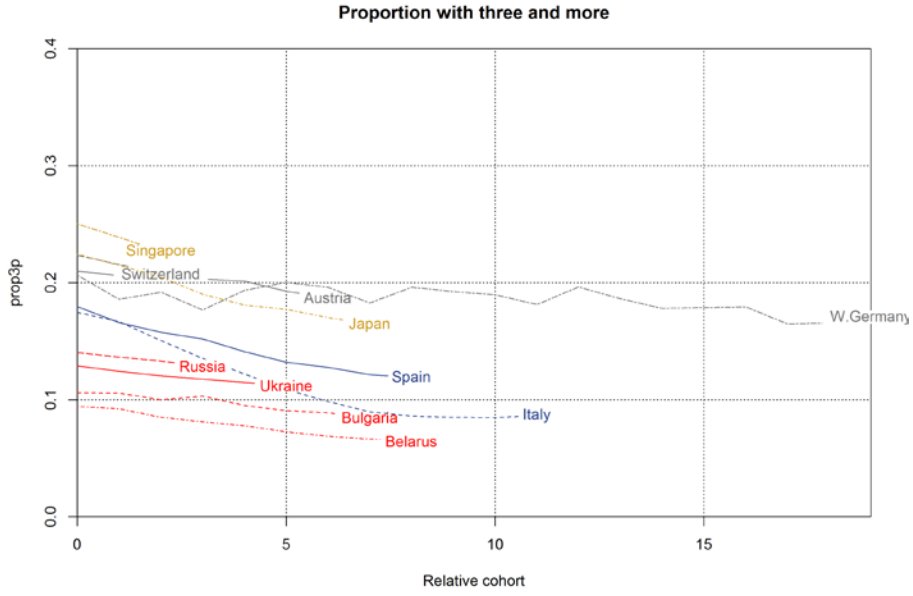
Country	dCFR 1940-1970	dCFR 1940-1955	dPPR01	dPPR12	dPPR23+	dCFR 1955-1970	dPPR01	dPPR12	dPPR23+
Bulgaria	-0.27	-0.02	-0.03	+0.03	-0.01	-0.25	-0.07	-0.17	-0.01
Belarus	-0.26	-0.06	+0.01	-0.02	-0.05	-0.20	-0.02	-0.17	-0.01
Russia	-0.28	-0.06	+0.01	+0.02	-0.09	-0.22	-0.03	-0.18	-0.01
Serbia	+0.01	+0.08	+0.02	+0.12	-0.07	-0.07	-0.08	-0.04	+0.05
Ukraine	-0.34	-0.07	+0.01	-0.01	-0.07	-0.27	-0.06	-0.20	-0.01
Czech Republic	-0.18	-0.02	-0.02	+0.06	-0.06	-0.17	-0.05	-0.10	-0.02
Estonia	+0.03	+0.10	+0.01	+0.07	+0.02	-0.06	-0.04	-0.06	+0.04
Croatia	-0.14	-0.13	-0.02	+0.06	-0.17	-0.01	-0.09	-0.02	+0.10
Hungary	+0.03	+0.09	+0.02	+0.10	-0.04	-0.06	-0.07	-0.07	+0.09
Lithuania	-0.23	-0.13	-0.02	0.00	-0.10	-0.10	-0.01	-0.09	-0.01
Slovakia	-0.52	-0.29	-0.06	-0.02	-0.21	-0.23	-0.06	-0.14	-0.03
Slovenia	-0.27	-0.17	+0.02	-0.03	-0.16	-0.10	-0.06	-0.07	+0.04
England & Wales	-0.48	-0.34	-0.14	-0.01	-0.19	-0.14	-0.05	-0.11	+0.02
France	-0.30	-0.18	-0.03	-0.02	-0.13	-0.12	-0.05	+0.01	-0.08
Ireland	-1.30	-0.78	0.00	-0.09	-0.69	-0.51	-0.11	-0.17	-0.24
Netherlands	-0.43	-0.32	-0.17	-0.07	-0.08	-0.11	-0.03	-0.04	-0.04
Denmark	-0.15	-0.28	-0.10	-0.10	-0.09	0.13	+0.05	+0.03	+0.04
Finland	-0.15	-0.12	-0.07	-0.01	-0.05	-0.03	-0.09	+0.01	+0.05
Norway	-0.41	-0.41	-0.08	-0.08	-0.26	0.00	+0.01	0.00	-0.01
Sweden	-0.04	0.02	-0.03	+0.01	+0.03	-0.06	0.00	0.02	-0.08
Austria	-0.48	-0.34	-0.08	-0.06	-0.20	-0.14	-0.08	-0.01	-0.06
Switzerland	-0.15	-0.06	-0.08	0.00	+0.02	-0.09	-0.02	-0.03	-0.05
W. Germany	-0.42	-0.28	-0.11	-0.07	-0.09	-0.14	-0.17	0.03	-0.01
Spain	-1.01	-0.61	-0.01	-0.15	-0.45	-0.40	-0.18	-0.17	-0.05
Greece	-0.32	-0.06	0.03	-0.02	-0.08	-0.25	-0.16	-0.08	-0.02
Italy	-0.66	-0.32	0.05	-0.13	-0.24	-0.34	-0.24	-0.03	-0.07
Australia	-0.49	-0.31	-0.11	-0.07	-0.14	-0.18	-0.08	-0.05	-0.05
New Zealand	-0.54	-0.31	-0.12	-0.09	-0.09	-0.23	-0.08	-0.08	-0.08
USA	-0.54	-0.68	-0.24	-0.15	-0.29	0.14	+0.09	+0.01	+0.03

Country	dCFR 1940-1970	dCFR 1940-1955	dPPR01	dPPR12	dPPR23+	dCFR 1955-1970	dPPR01	dPPR12	dPPR23+
Japan	-0.53	-0.04	-0.04	-0.01	+0.01	-0.49	-0.31	-0.12	-0.05
South Korea	-1.96	-1.64	-0.09	-0.21	-1.34	-0.32	-0.15	-0.08	-0.09
Singapore	-1.28	-1.03	-0.31	-0.16	-0.57	-0.25	-0.15	-0.11	0.00

Figure A1 Parity distribution among women in countries with completed fertility below 1.75 children per woman; the horizontal axis depicts cohorts relative to the first cohort experiencing a drop of CFR below 1.75 (marked with 0).




Proportion with two children
prop2
Relative cohort
Belarus
Bulgaria
Italy
Spain
Russia
Ukraine
Switzerland
Austria
Japan
Singapore
W.Germany


Proportion with three and more
prop3p
Relative cohort
Singapore
Switzerland
Austria
Japan
W.Germany
Spain
Russia
Ukraine
Italy
Bulgaria
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