Educational Differences in Cohort Fertility across Sub-National Regions in Europe

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Short abstract

Educational differences in female cohort fertility vary widely across developed countries, but little attention has been paid to potential subnational variation therein. Our aim is to provide a comprehensive overview of the association between female cohort fertility and educational attainment at the regional level in contemporary Europe. We harmonise data – from population registers, censuses and large-sample surveys – for 15 European countries and measure education and region of residence at the end of women's reproductive lives. We link these data to regional estimates of GDP in order to examine the role of regional development in explaining our results. We find evidence of subnational variation in educational gradients in completed fertility. In nine out of 15 studied countries the highly educated were most similar to the medium-educated in their fertility in the most developed region. The findings imply further evidence on systematic variation of the educational gradient in women's fertility.

Introduction

The relationship between education and fertility continues to be at the focus of the study of variation in fertility patters in contemporary societies (Sobotka, Beaujouan, & Van Bavel, 2017). Associations between educational attainment and the number of children among women are considered to be related to an effect of educational enrolment and attainment on fertility behavior (Kravdal, 2007; Lappegård & Rønsen, 2005; Skirbekk, Kohler, & Prskawetz, 2006). However, effects of fertility on educational careers (Cohen, Kravdal, & Keilman, 2011; Rindfuss, St. John, & Bumpass, 1984) and of confounding factors (Nisén, Myrskylä, Silventoinen, & Martikainen, 2014; Tropf & Mandemakers, 2017) are also likely to be present. While a woman's region of living may influence both her educational attainment as well as her fertility, regional contextual factors may also modify the effect of education on fertility, or even the effect of fertility on education. Further, women of different educational levels and varying numbers of children may also have different incentives to migrate within a country. Within this broad framework, this study aims at *describing* the relationship between the educational attainment and the fertility of women according to the subnational region of living at the end of the reproductive career in contemporary Europe. Our main interest is to investigate, whether the educational gradient in the number of children among women varies across subnational regions. We take a cohort perspective by describing the eventual fertility of women born in the late 1960s by the highest achieved educational attainment across subnational regions.

Typically, women educated to higher levels have eventually a lower mean number of children (Skirbekk, 2008). However, changes from this well-known pattern have been witnessed in Northern and North-Western European countries in the female cohorts born in the 1940s to 1970s (Andersson et al., 2009; Jalovaara et al., 2018; Kravdal & Rindfuss, 2008; Neels & De Wachter, 2010). Some indications of changes have been documented also elsewhere. For instance, stronger recuperation of fertility at older ages and decreases in the differences between socioeconomic groups in the risk of remaining childlessness have been documented in Germany (Bujard & Passet, 2013; Bundesamt, 2018). Previous literature has also shown that there is variation across countries in the magnitude of differences in ultimate fertility between educational groups (Neyer & Hoem, 2008; Wood, Neels, & Kil, 2014). Overall, these patterns suggest that educational gradients in women's fertility are subject to change across time and place. Yet, despite the tradition of studying sub-national regional variation in fertility (Kulu, Vikat, & Andersson, 2007; Fiori, Graham, & Feng, 2014; Bujard & Scheller, 2017), little attention has been paid on potential variation in the educational gradient across sub-national regions. Importantly, a recent study

showed that women of different educational levels are likely to respond in their childbearing differently to regionally varying contextual factors such as the provision of childcare (Wood, Klüsener, Neels, & Myrskylä, 2017). This is in line with prior research showing that across countries women of higher education are more sensitive to contextual factors in their childbearing behavior (Bavel & Rózanska-Putek, 2010). Further, there is recent evidence of a changing subnational patterning of fertility, in the favor of relatively high fertility in more developed regions (Fox et al., 2018). It remains unclear how these recent findings at the subnational level may relate to educational patterning in women's fertility.

It is plausible that an interplay of compositional factors, selective sub-national migration and contextual factors (Hank 2002; Basten, Huinink, & Klüsener, 2012; Kulu, 2013) may contribute to variation in educational patterning of fertility across sub-national regions. Individual characteristics, such as marital or employment status, which distribution varies differently across educational groups in different regions, can bring about regional variation in the educational patterning of fertility. This may be related to the regional educational level: varying shares of women educated to higher levels may contribute to more and less selected groups of women at different educational levels, contributing potentially to differences in the childbearing between educational groups (Adserà, 2017). Patterns of selective sub-national migration may also contribute to regional variation in the educational patterning of fertility: migration is likely to be selective of socioeconomic characteristics and prospects (Abramitzky, Boustan, & Eriksson, 2012), some decisions to move are likely to be related to the presence of or preferences for children (Kulu, 2005; Kulu & Washbrook, 2014), and it is possible that these two may be correlated. For instance, young people tend to move to more developed regions to attain higher degrees, whereas lower living costs in less developed regions may attract (prospective) parents with fewer economic resources.

Contextual factors – such as local living costs and housing conditions, family policies, labor markets and gender equality – that vary across regions may affect fertility behavior of women of different educational levels to a different degree. For instance, higher living costs typical of more developed regions might contribute to challenges for the less educated women with typically lower earnings to afford adequate housing for a larger family (Kulu & Washbrook, 2014). Second, the more highly educated women may have benefited more from some recent developments in the family policies than the less educated groups, such as income-tested parental leave allowance and childcare availability (Wood et al., 2017). While policies itself may vary across regions, their effect could also potentially have larger consequences on childbearing in highly developed regions with high living costs. Third, labor

market conditions are likely to be better in more developed regions, and being employed is likely to be a precondition for childbearing in contemporary Europe (Adserà, 2017; Ramiro-Fariñas, Viciana-Fernández, & Cobo, 2017) among the highly educated at least (Kreyenfeld & Andersson, 2014). In addition, more flexible working arrangements and more gender equal attitudes and practices in more developed regions could ease the childbearing of highly educated women in particular (Fox et al., 2018).

The previous evidence on the general sensitivity of educational gradients, recent indications of changes in the relationship between regional development and fertility levels in Europe, and considerations regarding the effect of contextual and other factors at the regional level motivate our investigation into the educational gradient of women's cohort fertility rate (CFR) at the subnational level in contemporary Europe. We have two hypotheses: 1) Due to a number of factors affecting the childbearing of women of educational groups potentially differently we hypothesize variation in the educational gradient in CFR at the sub-national level generally; 2) Due to recent developments described above we tentatively hypothesize less negative educational gradients in CFR in more highly developed sub-national regions within countries. We study these patterns with rich data sources, mainly register or census data, from 15 European countries by measuring women's CFR, educational attainment and region of living at the end of their reproductive lives. Because regional estimates are subject to uncertainty due to small group sizes, we apply empirical Bayesian estimation to calculate prediction intervals of our estimates. In addition, we provide an interactive map showing in detail educational gradients across sub-national regions in Europe.

Data and methods

The data sets utilized in this study are described in Appendix 1. The sample covers women born between years 1964 and 1970 in the following countries: Austria, Belarus, Belgium, Finland, France, Germany, Greece, Hungary, Ireland, Lithuania, Netherlands, Norway, Romania, Spain, and Sweden. The study is based on register, census, and survey data sources. We measure fertility, highest educational attainment and region of living of women at the end of their reproductive career. In most countries the data reflects the achieved fertility as of 2011 (see Appendix 1 for details). All women were at the ages of 40 years or older at the time of the measurement. The study covers only native-born women. The data for Belarus, Greece, Ireland and Romania is derived from IPUMS International (IPUMS, 2018).

We measure the subnational region of living of women at the end of their reproductive career. In register data this information is derived from registers on the place of dwelling, in survey data it is self-

reported, and in census data either self-reported or derived from registers and corrected where necessary based on self-reports. The regional classification is based on the Nomenclature of Territorial Units for Statistics (NUTS) classification by Eurostat (Eurostat, 2011), a sub-regional categorization of territorial units in the European Union. For most countries we use the NUTS level 2 of classification, distinguishing between large regions within countries (e.g. provinces). Please see Appendix 2 for details of the classification. GDP (Gross domestic product) per capita in PPS (purchasing power standard) of different NUTS regions in 2011 were extracted from the Eurostat database (Eurostat, 2018). See Appendix 3 for GDP per capita across regions.

The measurement of education is based on registers in the register data and self-reports in other data. We distinguish between low, medium, and high educational attainment following the International Standard Classification of Education (ISCED) (OECD, 2015)**.** Low refers to education at the lower secondary level at most (ISCED levels 1-2),[1] and medium education comprises higher secondary level or post-secondary non-tertiary level of education (ISCED levels 3-4). High education covers education at the tertiary level (ISCED levels 5-6), covering also short-cycle tertiary level education. In Belarus, Greece, Ireland, and Romania, the classification is based on the protocol of the IPUMS international (IPUMS, 2018)**.** In order to bear close resemblance to ISCED, we categorize besides university degrees also technical education college degrees (Greece), third-level non-degree qualifications (Ireland), and short-term post-secondary (associate) degrees (Romania) at the high level. See Appendix 3 for distribution of education across regions.

Fertility is measured as the total number of children per woman, corresponding to cohort fertility rate (CFR). This information consists of all children women have ever given birth to, which is derived through self-reports in census or survey data and through information on registered births in register data. In Norway, Sweden and the Netherlands children given for adoption are linked to their adoptive parents instead of their biological parents. We assume to capture practically completed fertility of the studied female cohorts, but small underestimation of fertility of the youngest birth cohorts is likely.

We use empirical Bayesian (EB) estimation to assess the uncertainty of the regional estimates with prediction intervals (PIs) (Assunção, Schmertmann, Potter, & Cavenaghi, 2005; Longford, 1999). This estimation assumes that CFR of women in a region follows a Poisson distribution. We borrow strength for the estimate of CFR of an educational group within a region within a country from CFRs of the

[1] In the Nordic countries, a very small share of women with missing information on educational attainment are classified as low educated (<3% in Norway, <1% in Sweden and Finland).

corresponding educational groups in other regions within the country, with larger weight given for regions more similar in terms of their GDP. See Appendix 4 for more details of the EB estimation.

Results

Country, regional, and educational variation in CFR

We first situate the sub-national analysis within the broader cross-country context in Europe. Overall CFR showed expected variation across countries, ranging between 1.48 (Germany) and 2.09 (Ireland) (Table 1). Women educated to higher levels typically ended up having lower CFR across countries, but there is variation in the magnitude of these differences. The medium educated women tended to have fewer children than low educated women, with the difference ranging from close to zero in Finland (<0.01) and Norway (0.02) to over half a child in Romania (0.70) and Hungary (0.65). The highly educated women had fewer children than medium educated women in all countries except Belgium, with the difference ranging from a surplus in Belgium (0.09) and close to zero in Sweden (0.01) to 0.44 and 0.30 children in Romania and Lithuania, respectively. Overall, the high and medium educated women were more similar in terms of CFR than low and medium educated women. In all countries the highly educated had lower CFR than the low educated, with the difference ranging from 0.04 (Belgium) and 0.05 (Norway) up to 0.76 (Romania) and 1.15 (Hungary) children.

[Table 1 about here]

Within countries, the CFR was lower among women residing in the most developed region at the end of their reproductive career overall and within educational groups (Table 2). Exceptions to this pattern were Germany and the Netherlands and, regarding low educated women only, Belgium and Spain[2]. Beyond the distinction between the most developed and other regions, there was no systematic relationship between the regional level of development and CFR overall or within educational groups.[3] A cross-country average of CFR in the most developed regions was 1.55, ranging from 1.17 to 2.05. For women of low, medium and high education the respective averages (ranges) were 1.73 (1.06-2.34), 1.56 (1.18-2.04) and 1.46 (1.01-1.85). Outside the most developed regions, the cross-country average of overall CFR was higher at 1.83, ranging from 1.48 to 2.12 (not shown). This also applied within

[2] Notably, the Netherlands and Germany are also the only studied countries where the capital region is not the most economically developed region in terms of GDP per capita.

[3] Notably, the differences in the absolute GDP per capita across regions other than the most developed one are often small.

educational groups, with averages (ranges) for low, medium and high educated at 2.03 (1.66-2.48), 1.80 (1.50-2.12) and 1.66 (1.16-2.11), respectively. Also within these two broad regions, women educated to high and medium levels were on average more similar in their CFR than medium (or high) and low educated women.

[Table 2 about here]

Educational gradient in CFR: variation across sub-national regions

The difference in CFR between the medium and low educated women tended to vary across regions within countries, but prediction intervals (PI) of the differences often overlapped (Table 2). In nine out of 15 studied countries there is at least one region where the PI for the difference between these two educational groups in CFR included zero and one region where it did not (and thus indicates a significant difference from zero in the region). To test the hypothesis that smaller educational differences may be witnessed in the more developed regions, we place attention to the regions within countries where the medium educated where least likely to have fewer children than the low educated. According to the point estimates, in six countries (Belarus, Netherlands, Lithuania, Finland, Norway, Spain), medium educated seemed to have (0.01-0.44) more children in such a region, but only in the Netherlands did the PI of the estimate not include zero. In other countries the corresponding estimate varied between <0.01 (Belgium) and 0.48 (Romania) fewer children among the medium educated women, with the PI not including zero in Austria, France, Hungary, Ireland, and Romania. However, there is no systematic variation in this difference between the educational groups between regions according to their level of economic development.

Next we compare the CFR of the women educated to high and medium levels (Table 2). Again, the difference between these groups showed variation across regions within countries, but no clear systematic variation according to the level of economic development was immediately evident. We continue with the focus on the regions where the high educated were least likely to have fewer children than the medium educated according to the point estimates. In five countries (Belgium, France, Norway, Sweden, Spain) the highly educated women had (0.01-0.21) more children than the medium educated in such a region, and in Belgium, France and Norway the PI of these estimates did not include zero. In other countries the corresponding number varied between 0.02 (Greece) and 0.43 (Netherlands) fewer children among the highly educated women, with the PI not including zero in Belarus, Germany, Hungary, Ireland, Lithuania and Romania. In nine out of 15 countries such a region is the most

economically developed one. Among the rest, in France and Belgium the (negative) difference of the high as compared to the medium educated women is the smallest in a region well above the average in terms of economic development, whereas in Netherland, Germany, Greece and Spain this is not the case. If the comparison group is changed from medium to low educated women (Table 2), the region where highly educated women least likely to have fewer children is the most developed region in six countries only (Belarus, Germany, Ireland, Lithuania, Romania, Sweden).[4]

Educational gradient in CFR: the most developed region versus other regions

According to the results above the most economically developed regions often show a pattern favoring relatively small difference in CFR between high and medium educated women, whereas more generally systematic variation in educational gradient according to the regional level of economic development was not found. In order to explore these results further, we contrast the region of the highest level of development to the rest of the country, i.e. combine other regions in each country. Based on this categorization, Figures 1, 2 and 3 illustrate the differences in CFR between the three educational groups. The right-hand side panels in these figures additionally report the difference in difference between these two regions within a country, with positive signs indicating a smaller difference between the two educational groups in the most developed region than in the rest of the country. Figures 1 and 2 confirm that low and medium educated women were generally more different in terms of CFR than high and medium educated women, but the differences between low and high educated women were the largest.

In the regions outside the most developed ones, women educated to the medium level had on average fewer children than low educated women in all countries except Norway and Finland (Figure 1). In the most developed regions, on the other hand, women educated to the medium level had significantly lower CFR only in seven countries, whereas no differences were found in eight countries. The point estimate of the difference between medium and low educated women in CFR fell more positive in nine out of 15 countries and the difference in difference was significant in four of these (Germany, Hungary, Lithuania, Romania). In Belgium, the difference is significantly different in the opposite direction.

[4] In addition to the absolute differences reported here, we compared relative differences across regions (not shown). The main findings were not changed, indicating that generally lower CFR in the well-developed regions was not driving the educational patterns witnessed.

Highly educated women had fewer children than those educated to the medium level in regions outside the most developed ones in 11 countries, in three countries the difference was not significant and in Belgium it was in the opposite direction (Figure 2). In the most developed regions, the highly educated had fewer children on average than those at the medium level in nine countries, in four countries the difference was not significant, and in Sweden and Norway women educated to the high level had more children than the medium educated. The point estimate of the difference in the most developed region fell more positive than that of other regions in 12 countries, out of which for six (Belarus, Finland, Hungary, Lithuania, Romania, Sweden) the PI for the difference of difference did not include zero. In addition, the differences were significantly different in the opposite direction in Belgium and Netherlands.

The difference between the high and low educated in CFR was significant in the less-developed regions in 13 countries and in the well-developed regions in 11 countries. In nine countries the point estimate for the difference in CFR between high and low educated women residing in the most developed regions was more positive than the corresponding estimate for women living in other regions (Figure 3). Formal test of the difference in difference was significant in six of these (Belarus, Hungary, Lithuania, Norway, Romania, Sweden), suggesting more similar childbearing between high and low educated women in the most developed region. Again, Belgium stood out with a statistically significant opposite pattern. Finally, we note that regional differences in the educational gradients are generally moderate irrespective of which groups are being compared. In terms of cross-country averages (not shown) the differences in the most developed versus other regions were -0.17 vs. -0.24 (medium-low), -0.10 vs. -0.14 (high-medium) and -27 vs. -0.37 (high vs. low).

[Figure 1 about here]

[Figure 2 about here]

[Figure 3 about here]

Conclusion

This study shows that educational differences in women's cohort fertility vary, not only between countries and over time as indicated previously, but also across sub-national regions in Europe. Relatively to the magnitude of the educational differences in cohort fertility overall, variation across regions appears not insignificant. The results further indicate that women residing in the most

developed region of a country, typically the capital region, in the end of their reproductive life are often more similar in their fertility than are respective groups of women residing in less-developed regions. However, evidence for this pattern largely stemmed from Northern and Central and Eastern European countries and several exceptions remained. We also note that the results are not entirely insensitive to the regional classification. For instance, when level one instead of level two NUTS classification or region was used for Spain, Madrid showed smallest educational differences among the Spanish regions (results not shown). Moreover, it is important to note that the cohort fertility rate can obscure substantial variation in parity-specific childbearing behavior (Zeman, Beaujouan, Brzozowska, & Sobotka, 2017), and thus a closer look into educational differences by parity at the sub-national level is warranted.

A possible explanation for the often encountered larger similarity in fertility between educational groups in the most developed regions is the larger share of women educated to higher levels in such regions. In such settings there is likely to be more variation among the highly educated women in terms of their abilities and skills, preferences for work and family, and actual labor market attachment – all with potential consequences for childbearing. On the contrary, when remaining educated to compulsory level only becomes uncommon, women of this group are likely to be more selected. The composition of women can vary regionally also irrespective of the general educational level in ways that may affect childbearing. Further, it is possible that the well-developed regions are contexts favoring more the childbearing of the highly educated, for instance due to high living costs. In addition, sub-national migration may be affected by regional contexts and contribute to varying regional population compositions, for instance childbearing may encourage moves to less developed regions among the low educated. Further research on individual-level data is needed to validate the relevance of these mechanisms for educational patterns in fertility.

The environment that women born in the late 1960s experienced during their prime childbearing years differs across countries. An elaborated analysis of such differences is beyond our focus, but we need to point out that women in former communist countries – Belarus, East-Germany (classified here as one region of Germany), Lithuania, Hungary and Romania – experienced a very particular childbearing context (Billingsley, 2010; Sobotka, 2011). The late 1960s' female cohorts were in their early 20s at the onset of the crisis of the Soviet Union in 1989. By then those who did not continue studying often had already become mothers, while those studying longer often finished studying after the onset of the crisis and were thus more likely to postpone childbearing, contributing to strong variation in fertility in

the cohorts studied (Kreyenfeld, 2006). It is plausible that the crisis may have contributed to some of the regional patterns we observe in the Central and Eastern European countries.

Also the data sources of this study vary by country and we generally assume that measurement is more accurate in register than census or survey data. Moreover, regionally selective non-response in census was found in Belarus, with high (10%) non-response in the capital region. Also in the German micro census the share of imputed values was relatively high (3-5%) in two large cities, Berlin (East Germany) and Hamburg (North Germany). In our view, it is however unlikely that measurement error would have brought about the main results of this study as systematic patterns were found also in countries with the most reliable data.

Women educated to different levels have become more similar in terms of their eventual number of children In the Nordic countries often labeled as forerunners of family demographic behavior (Andersson et al., 2009; Jalovaara et al., 2018). It is of considerable interest for demographers to see whether similar patters may emerge elsewhere, and more generally, how the childbearing of the increasing group of highly educated women continues to develop (Sobotka et al., 2017). This study provides evidence suggesting that in the most developed regions the childbearing of highly educated women is often more similar to that of women educated to lower levels at the end of the reproductive live and leaves open the question whether less developed regions may follow this pattern.

Link to the interactive map showing CFR by educational attainment at the sub-national level in 15 European countries: https://penglistat.shinyapps.io/penglistat/

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Table 1 CFR of women by educational attainment in 15 European countries.

	Low	Medium	High	Total	Δ Medium - Low	Δ High - Medium	Δ High - Low
Austria	1.96	1.68	1.48	1.67	-0.28	-0.20	-0.48
Belarus	1.94	1.75	1.45	1.68	-0.19	-0.31	-0.49
Belgium	1.78	1.65	1.74	1.72	-0.13	0.09	-0.04
Finland	1.98	1.98	1.82	1.90	0.00	-0.16	-0.16
France	2.09	1.90	1.77	1.89	-0.20	-0.13	-0.33
Germany	1.66	1.50	1.37	1.48	-0.17	-0.13	-0.30
Greece	2.09	1.69	1.55	1.76	-0.39	-0.15	-0.54
Hungary	2.42	1.77	1.66	1.86	-0.65	-0.11	-0.76
Ireland	2.38	2.10	1.88	2.09	-0.28	-0.22	-0.50
Lithuania	2.04	1.89	1.59	1.80	-0.15	-0.30	-0.44
Norway	2.05	2.03	2.00	2.02	-0.02	-0.03	-0.05
Romania	2.27	1.57	1.13	1.65	-0.70	-0.44	-1.15
Spain	1.68	1.51	1.36	1.49	-0.17	-0.15	-0.32
Sweden	2.04	1.94	1.93	1.95	-0.10	-0.01	-0.11
Netherlands	1.89	1.82	1.71	1.81	-0.07	-0.11	-0.18
Average	2.02	1.79	1.63	1.78	-0.23	-0.16	-0.39

Table 2 CFR of women by educational attainment and sub-national region in 15 European countries.

Country	Region	Low	Medium	High	Total	Δ Medium - Low (95% PI		Δ High - Medium (95% P		Δ High - Low (95% PI)	
Austria	Vienna	1.64	1.22	1.13	1.22	-0.43	(-0.93,-0.02)	-0.08	(-0.25,0.09)	-0.53	(-1.22,-0.02)
	Rest of Austria	2.00	1.77	1.61	1.78	-0.23	(-0.45,0.00)	-0.16	(-0.33,0.01)	-0.38	(-0.64,-0.13)
Belarus	Minsk city	1.06	1.50	1.33	1.43	0.44	(-0.25,0.85)	-0.17	(-0.26,-0.08)	0.20	(-0.41,0.66)
	Minsk	2.03	1.82	1.58	1.77	-0.22	(-0.71,0.16)	-0.24	(-0.38,-0.10)	-0.47	(-0.93,-0.07)
	Gomel	2.10	1.80	1.47	1.74	-0.30	(-0.80,0.09)	-0.33	(-0.45,-0.20)	-0.66	(-1.13,-0.23)
	Brest	1.88	1.93	1.59	1.86	0.05	(-0.49,0.49)	-0.34	(-0.48,-0.20)	-0.45	(-1.16,0.12)
	Vitebsk	1.80	1.64	1.36	1.57	-0.16	(-0.75,0.26)	-0.28	(-0.40,-0.16)	-0.49	(-1.04,-0.01)
	Grodno	1.94	1.82	1.53	1.75	-0.12	(-0.87,0.39)	-0.29	(-0.43,-0.16)	-0.30	(-0.82,0.16)
	Mogilev	1.97	1.75	1.40	1.68	-0.22	(-0.78,0.25)	-0.35	(-0.47,-0.20)	-0.55	(-1.10,-0.08)
Belgium	Brussels	1.59	1.33	1.31	1.38	-0.26	(-0.34,-0.17)	-0.02	(-0.09,0.04)	-0.28	(-0.35,-0.21)
	Antwerp	1.67	1.62	1.74	1.68	-0.06	(-0.11,-0.02)	0.13	(0.09,0.17)	0.07	(0.02,0.12)
	Brabant Walonne	1.79	1.72	1.93	1.84	-0.06	(-0.18,0.06)	0.21	(0.11,0.31)	0.15	(0.03,0.26)
	Vlaams Brabant	1.56	1.57	1.74	1.65	0.00	(-0.06,0.06)	0.18	(0.13,0.23)	0.18	(0.12,0.24)
	West Flanders	1.79	1.73	1.88	1.79	-0.06	(-0.12,-0.01)	0.15	(0.10,0.20)	0.09	(0.03,0.15)
	East Flanders	1.65	1.59	1.72	1.65	-0.07	(-0.11,-0.02)	0.13	(0.09,0.18)	0.07	(0.02,0.12)
	Limburg	1.65	1.61	1.72	1.66	-0.04	(-0.10,0.02)	0.11	(0.05,0.17)	0.07	(0.00,0.13)
	Liège	1.91	1.72	1.73	1.79	-0.19	(-0.25,-0.13)	0.01	(-0.05,0.07)	-0.18	(-0.24,-0.12)
	Namur	2.00	1.81	1.90	1.90	-0.19	(-0.29,-0.10)	0.08	(-0.01,0.17)	-0.11	(-0.20,-0.01)
	Luxembourg	2.15	2.06	2.01	2.07	-0.09	(-0.23,0.04)	-0.05	(-0.19,0.08)	-0.13	(-0.27,0.00)
	Hainaut	1.98	1.71	1.68	1.80	-0.27	(-0.33,-0.22)	-0.02	(-0.08,0.03)	-0.30	(-0.35,-0.24)
Finland	Helsinki-Uusimaa	1.84	1.69	1.66	1.69	-0.15	(-0.34,0.02)	-0.03	(-0.13,0.07)	-0.19	(-0.36,-0.02)
	West Finland	2.00	2.06	1.95	2.00	0.06	(-0.20,0.28)	-0.11	(-0.25,0.02)	-0.06	(-0.30,0.16)
	South Finland	2.04	1.95	1.78	1.88	-0.08	(-0.32,0.15)	-0.18	(-0.31,-0.04)	-0.26	(-0.50,-0.03)
	North and East Finland	2.18	2.26	2.00	2.12	0.07	(-0.22,0.34)	-0.26	(-0.41,-0.11)	-0.19	(-0.49,0.09)
France	Parisian region	1.90	1.68	1.56	1.66	-0.22	(-0.24,-0.20)	-0.11	(-0.12,-0.10)	-0.32	(-0.55,-0.10)
	Central East France	2.11	1.87	1.93	1.93	-0.24	(-0.26,-0.22)	0.06	(0.05,0.08)	-0.18	(-0.43,0.06)
	Mediterranean France	1.98	1.77	1.65	1.76	-0.21	(-0.23,-0.19)	-0.12	(-0.14,-0.11)	-0.31	(-0.53,-0.10)
	South West France	1.90	1.73	1.74	1.76	-0.17	(-0.19,-0.15)	0.01	(-0.01,0.02)	-0.14	(-0.36,0.07)
	West France	2.24	2.06	1.98	2.06	-0.18	(-0.20,-0.16)	-0.08	(-0.10,-0.07)	-0.22	(-0.45,-0.02)
	Paris Basin	2.15	1.91	1.82	1.94	-0.24	(-0.26,-0.22)	-0.09	(-0.10,-0.08)	-0.31	(-0.47,-0.16)
	East France	2.09	1.89	1.72	1.88	-0.20	(-0.23,-0.18)	-0.17	(-0.19,-0.15)	-0.40	(-0.62,-0.19)
	North France	2.47	2.12	1.80	2.11	-0.35	(-0.38,-0.31)	-0.33	(-0.35,-0.31)	-0.65	(-1.00,-0.32)
Germany	South	1.64	1.58	1.41	1.54	-0.06	(-0.18,0.05)	-0.17	(-0.24,-0.11)	-0.23	(-0.35,-0.12)
	West	1.65	1.40	1.25	1.39	-0.24	(-0.46,-0.03)	-0.16	(-0.27,-0.03)	-0.40	(-0.65,-0.17)
	North	1.66	1.44	1.31	1.43	-0.22	(-0.36,-0.08)	-0.13	(-0.22,-0.04)	-0.34	(-0.50,-0.19)
	NRW	1.63	1.42	1.28	1.41	-0.21	(-0.33,-0.09)	-0.15	(-0.23,-0.07)	-0.36	(-0.49,-0.22)
	East	1.88	1.54	1.44	1.52	-0.34	(-0.58,-0.12)	-0.10	(-0.18,-0.02)	-0.45	(-0.69,-0.24)
Greece	Attiki	1.81	1.50	1.38	1.52	-0.31	(-0.39,-0.24)	-0.12	(-0.17,-0.07)	-0.44	(-0.51,-0.35)
	Notio Aigaio	2.26	1.89	1.59	2.00	-0.37	(-0.64,-0.11)	-0.31	(-0.56,0.00)	-0.66	(-0.96,-0.35)
	Dytiki Makedonia	2.19	2.11	1.74	2.05	-0.08	(-0.38,0.19)	-0.37	(-0.59,-0.09)	-0.43	(-0.73,-0.17)
	Ionia Nisia	2.05	1.67	1.52	1.77	-0.38	(-0.66,-0.06)	-0.15	(-0.42,0.14)	-0.53	(-0.85,-0.18)
	Sterea Ellada	2.13	1.80	1.60	1.88	-0.34	(-0.54,-0.15)	-0.19	(-0.38,0.00)	-0.54	(-0.74,-0.31)
	Kriti	2.39	1.91	1.72	2.02	-0.48	(-0.68,-0.28)	-0.19	(-0.37,0.01)	-0.66	(-0.88,-0.44)
	Peloponnisos	2.10	1.68	1.66	1.82	-0.43	(-0.61,-0.25)	-0.02	(-0.21,0.17)	-0.45	(-0.66,-0.23)
	Voreio Aigaio	1.98	1.89	1.70	1.87	-0.09	(-0.42,0.28)	-0.19	(-0.57,0.15)	-0.29	(-0.62,0.08)
	Kentriki Makedonia	2.01	1.79	1.64	1.81	-0.22	(-0.33,-0.11)	-0.15	(-0.24,-0.05)	-0.37	(-0.48,-0.26)
	Dytiki Ellada	2.37	1.86	1.70	2.02	-0.50	(-0.69,-0.33)	-0.17	(-0.35,0.02)	-0.66	(-0.87,-0.47)
	Anatoliki Makedonia, Thral	2.20	1.80	1.71	1.95	-0.40	(-0.59,-0.18)	-0.09	(-0.31,0.11)	-0.49	(-0.69,-0.29)
	Ipeiros	2.09	1.90	1.72	1.91	-0.19	(-0.48,0.08)	-0.17	(-0.45,0.08)	-0.36	(-0.66,-0.10)
	Thessalia	2.20	1.87	1.74	1.95	-0.33	(-0.51,-0.15)	-0.12	(-0.29,0.06)	-0.45	(-0.64,-0.27)
Hungary	Central Hungary	2.14	1.63	1.59	1.67	-0.51	(-0.56,-0.47)	-0.04	(-0.06,-0.02)	-0.55	(-0.60,-0.51)
	Western Transdanubia	2.14	1.78	1.74	1.83	-0.36	(-0.42,-0.30)	-0.04	(-0.09,0.01)	-0.40	(-0.47,-0.33)
	Central Transdanubia	2.34	1.86	1.76	1.93	-0.48	(-0.54,-0.42)	-0.10	(-0.15,-0.05)	-0.58	(-0.65,-0.51)
	Southern Great Plain	2.35	1.85	1.71	1.88	-0.50	(-0.68,-0.56)	-0.14	(-0.14,-0.04)	-0.70	(-0.77,-0.63)
	Southern Transdanubia	2.38	1.76	1.68	1.91	-0.62	(-0.56,-0.45)	-0.08	(-0.18,-0.10)	-0.64	(-0.70,-0.58)
	Northern Great Plain	2.65	1.90	1.72	2.05	-0.75	(-0.80,-0.70)	-0.18	(-0.22,-0.14)	-0.93	(-0.98,-0.87)
	Northern Hungary	2.78	1.82	1.67	2.00	-0.96	(-1.02,-0.89)	-0.15	(-0.20,-0.11)	-1.11	(-1.18,-1.04)

Table 2 continues

Country	Region	Low	Medium	High	Total	Δ Medium - Low (95% PI)		Δ High - Medium (95% PI)		Δ High - Low (95% PI)	
Ireland	Southern and Eastern	2.34	2.04	1.85	2.05	-0.29	(-0.40,-0.18)	-0.19	(-0.28,-0.11)	-0.49	(-0.59,-0.38)
	Border, Midland and West	2.50	2.24	1.96	2.21	-0.25	(-0.45,-0.07)	-0.28	(-0.44,-0.13)	-0.54	(-0.72,-0.35)
Lithuania	Vilnius	1.43	1.49	1.44	1.47	0.06	(-0.09,0.20)	-0.05	(-0.10,-0.01)	0.01	(-0.14,0.15)
	Rest of Lithuania	2.09	1.94	1.65	1.87	-0.15	(-0.22,-0.09)	-0.29	(-0.32,-0.27)	-0.45	(-0.51,-0.38)
Netherlands	Groningen	1.82	1.80	1.61	1.75	-0.02	(-0.09,0.04)	-0.19	(-0.24,-0.13)	-0.21	(-0.28,-0.14)
	Noord-Holland	1.69	1.67	1.56	1.63	-0.03	(-0.06,0.00)	-0.11	(-0.13,-0.08)	-0.13	(-0.17,-0.10)
	Utrecht	1.79	1.79	1.71	1.76	0.00	(-0.05,0.05)	-0.08	(-0.11,-0.04)	-0.07	(-0.12,-0.02)
	Noord-Brabant	1.69	1.81	1.79	1.78	0.12	(0.09,0.15)	-0.02	(-0.04,0.01)	0.10	(0.07,0.14)
	Zuid-Holland	2.47	1.89	1.46	2.06	-0.58	(-0.63,-0.52)	-0.43	(-0.48,-0.37)	-1.00	(-1.06,-0.95)
	Gelderland	1.88	1.90	1.79	1.86	0.01	(-0.02,0.05)	-0.11	(-0.14,-0.08)	-0.10	(-0.13,-0.06)
	Overijssel	2.03	1.99	1.89	1.97	-0.04	(-0.10,0.02)	-0.10	(-0.15,-0.06)	-0.14	(-0.20,-0.09)
	Limburg	1.56	1.65	1.67	1.63	0.10	(0.06,0.14)	0.02	(-0.03,0.06)	0.11	(0.06,0.16)
	Zeeland	2.18	1.87	1.77	1.93	-0.30	(-0.41,-0.21)	-0.10	(-0.18,-0.02)	-0.41	(-0.52,-0.31)
	Flevoland	2.20	1.89	1.86	1.96	-0.31	(-0.40,-0.21)	-0.03	(-0.12,0.04)	-0.34	(-0.45,-0.24)
	Friesland	1.91	2.02	1.91	1.97	0.11	(0.04,0.17)	-0.11	(-0.17,-0.04)	0.00	(-0.08,0.07)
	Drenthe	1.83	1.87	1.85	1.86	0.04	(-0.03,0.11)	-0.02	(-0.09,0.05)	0.03	(-0.06,0.11)
Norway	Oslo and Akershus	1.67	1.67	1.73	1.70	0.00	(-0.07,0.07)	0.06	(0.00,0.11)	0.06	(-0.01,0.13)
	Agder and Rogaland	2.29	2.24	2.22	2.24	-0.05	(-0.18,0.08)	-0.02	(-0.12,0.08)	-0.07	(-0.20,0.06)
	Western Norway	2.35	2.29	2.20	2.26	-0.06	(-0.19,0.07)	-0.09	(-0.18,0.00)	-0.15	(-0.28,-0.03)
	Trøndelag	2.13	2.18	2.16	2.16	0.05	(-0.12,0.20)	-0.02	(-0.14,0.09)	0.03	(-0.12,0.19)
	Northern Norway	2.29	2.19	2.12	2.18	-0.10	(-0.26,0.04)	-0.07	(-0.18,0.04)	-0.18	(-0.33,-0.03)
	South Eastern Norway	1.98	1.95	2.00	1.97	-0.03	(-0.11,0.05)	0.05	(-0.02,0.12)	0.02	(-0.07,0.11)
	Hedmark and Oppland	1.98	2.00	2.05	2.01	0.02	(-0.11,0.15)	0.05	(-0.07,0.17)	0.07	(-0.08,0.21)
Romania	Bucharest - Ilfov	1.75	1.28	1.01	1.24	-0.48	(-0.57,-0.38)	-0.26	(-0.31,-0.22)	-0.74	(-0.84,-0.65)
	West	2.10	1.46	1.07	1.54	-0.64	(-0.74,-0.55)	-0.38	(-0.45,-0.32)	-1.03	(-1.13,-0.93)
	Center	2.42	1.60	1.24	1.71	-0.82	(-0.93,-0.72)	-0.36	(-0.42,-0.29)	-1.18	(-1.30,-1.06)
	Northwest	2.38	1.63	1.21	1.75	-0.74	(-0.84,-0.65)	-0.43	(-0.49,-0.36)	-1.17	(-1.27,-1.07)
	South - Muntenia	2.14	1.55	1.16	1.65	-0.59	(-0.66,-0.51)	-0.39	(-0.45,-0.33)	-0.98	(-1.06,-0.90)
	South East	2.24	1.49	1.12	1.62	-0.75	(-0.84,-0.66)	-0.37	(-0.43,-0.31)	-1.13	(-1.22,-1.03)
	South-West Oltenia	2.19	1.60	1.14	1.66	-0.59	(-0.69,-0.49)	-0.47	(-0.54,-0.40)	-1.05	(-1.16,-0.94)
	Northeast	2.61	1.83	1.17	1.94	-0.78	(-0.88,-0.68)	-0.66	(-0.72,-0.59)	-1.44	(-1.54,-1.34)
Spain	Madrid	1.41	1.18	1.08	1.17	-0.23	(-0.50,-0.04)	-0.10	(-0.19,-0.01)	-0.33	(-0.60,-0.13)
	Basque Community	1.48	1.46	1.41	1.45	-0.02	(-0.12,0.06)	-0.05	(-0.09,0.00)	-0.07	(-0.17,0.01)
	Navarre	1.63	1.52	1.37	1.50	-0.11	(-0.21,-0.02)	-0.16	(-0.21,-0.10)	-0.26	(-0.36,-0.17)
	Catalonia	1.54	1.48	1.33	1.44	-0.06	(-0.37,0.23)	-0.15	(-0.31,0.03)	-0.22	(-0.53,0.11)
	Aragon	1.89	1.73	1.45	1.69	-0.16	(-0.33,0.01)	-0.27	(-0.40,-0.15)	-0.43	(-0.62,-0.25)
	La Rioja	1.86	1.67	1.45	1.66	-0.19	(-0.25,-0.13)	-0.22	(-0.27,-0.17)	-0.41	(-0.48,-0.34)
	Castile-Leon	1.41	1.35	1.28	1.34	-0.05	(-0.32,0.17)	-0.08	(-0.20,0.06)	-0.13	(-0.42,0.11)
	Cantabria	1.82	1.71	1.49	1.69	-0.11	(-0.25,0.02)	-0.22	(-0.32,-0.10)	-0.33	(-0.48,-0.17)
	Principality of Asturias	1.71	1.65	1.34	1.61	-0.06	(-0.15,0.04)	-0.31	(-0.39,-0.23)	-0.37	(-0.48,-0.26)
	Galicia	1.52	1.40	1.22	1.36	-0.13	(-0.24,-0.01)	-0.18	(-0.25,-0.11)	-0.31	(-0.43,-0.18)
	Valencian Community	1.46	1.48	1.32	1.43	0.02	(-0.15,0.18)	-0.16	(-0.25,-0.08)	-0.14	(-0.31,0.02)
	Murcia	1.45	1.44	1.23	1.39	-0.02	(-0.11,0.07)	-0.21	(-0.26,-0.16)	-0.23	(-0.32,-0.13)
	Castille-La Mancha	1.33	1.31	1.33	1.32	-0.02	(-0.17,0.10)	0.01	(-0.05,0.08)	-0.01	(-0.16,0.12)
	Andalucia	1.50	1.42	1.37	1.40	-0.07	(-0.18,0.03)	-0.06	(-0.10,-0.01)	-0.13	(-0.24,-0.03)
	Extremadura	1.64	1.46	1.44	1.46	-0.18	(-0.42,0.06)	-0.02	(-0.13,0.08)	-0.20	(-0.46,0.03)
Sweden	Stockholm	1.85	1.78	1.81	1.80	-0.07	(-0.13,-0.01)	0.03	(0.00,0.06)	-0.04	(-0.10,0.02)
	Upper Norrland	2.06	2.04	2.00	2.03	-0.02	(-0.15,0.10)	-0.05	(-0.11,0.03)	-0.07	(-0.20,0.05)
	West Sweden	2.04	1.94	1.93	1.95	-0.10	(-0.16,-0.04)	-0.01	(-0.05,0.03)	-0.11	(-0.17,-0.05)
	Middle Norrland	2.14	2.03	2.01	2.03	-0.11	(-0.26,0.03)	-0.02	(-0.10,0.06)	-0.12	(-0.27,0.01)
	East Middle Sweden	2.12	1.99	1.99	2.00	-0.13	(-0.20,-0.06)	0.00	(-0.04,0.03)	-0.13	(-0.20,-0.06)
	Småland and the islands	2.13	2.09	2.06	2.08	-0.05	(-0.14,0.05)	-0.03	(-0.08,0.03)	-0.08	(-0.18,0.03)
	South Sweden	2.05	1.89	1.90	1.91	-0.16	(-0.23,-0.09)	0.02	(-0.02,0.06)	-0.14	(-0.22,-0.07)
	North Sweden	2.10	2.01	2.02	2.02	-0.09	(-0.18,-0.01)	0.01	(-0.05,0.06)	-0.08	(-0.17,0.01)

Note: results for Austria, France and Spain are based on a weighted sample. Subnational regions within a country are ranked according to the GDP per capita of the region, from highest to lowest. 95% PI = 95 percent prediction interval based on Empirical Bayesian estimation.

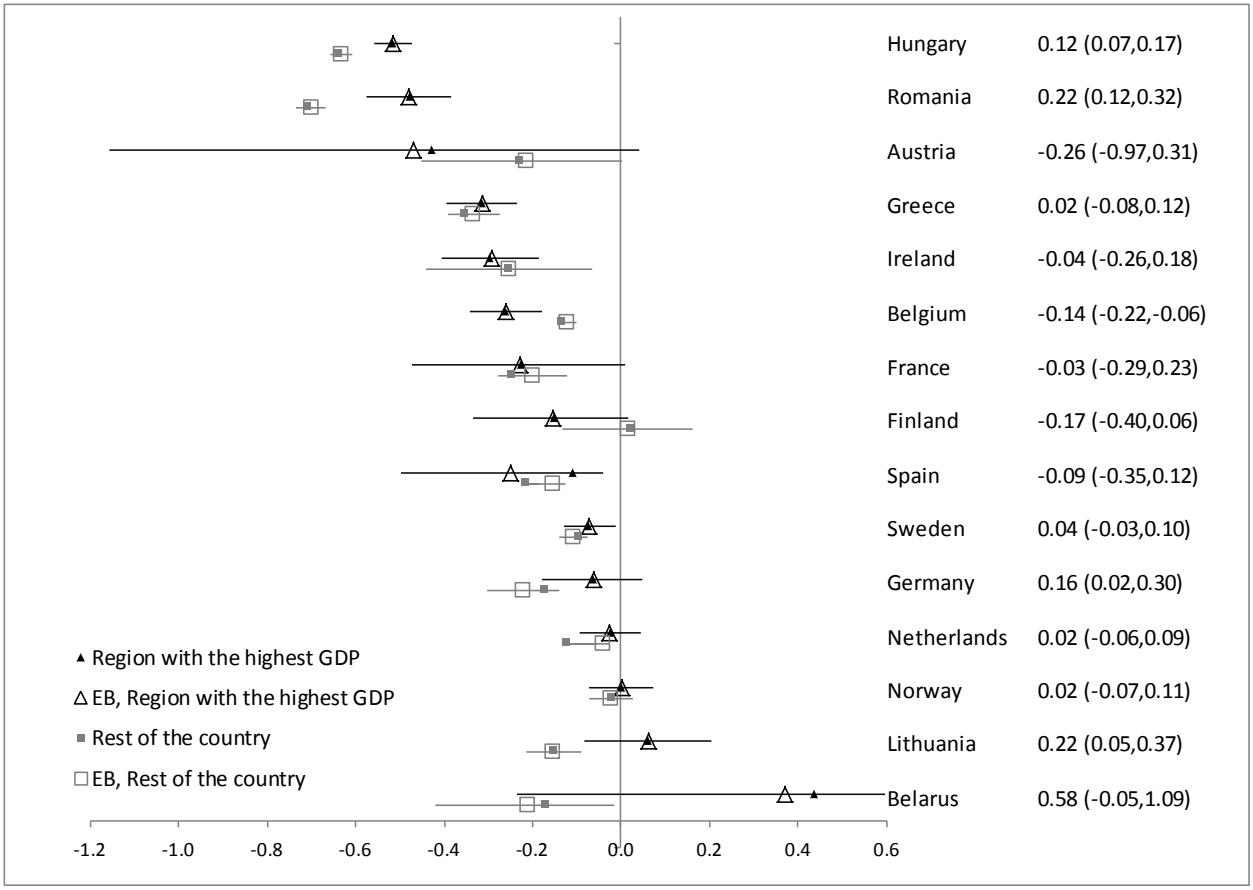

Figure 1. The difference of medium versus low educated women in CFR by country: region of the highest GDP value compared to the rest of the country (other regions combined). Countries sorted according to the observed difference between medium versus high educated women in the region of the highest GDP value. The panel on the right-hand side reports the difference in difference between the two regions within a country and the 95 percent prediction interval. EB=Empirical Bayesian.

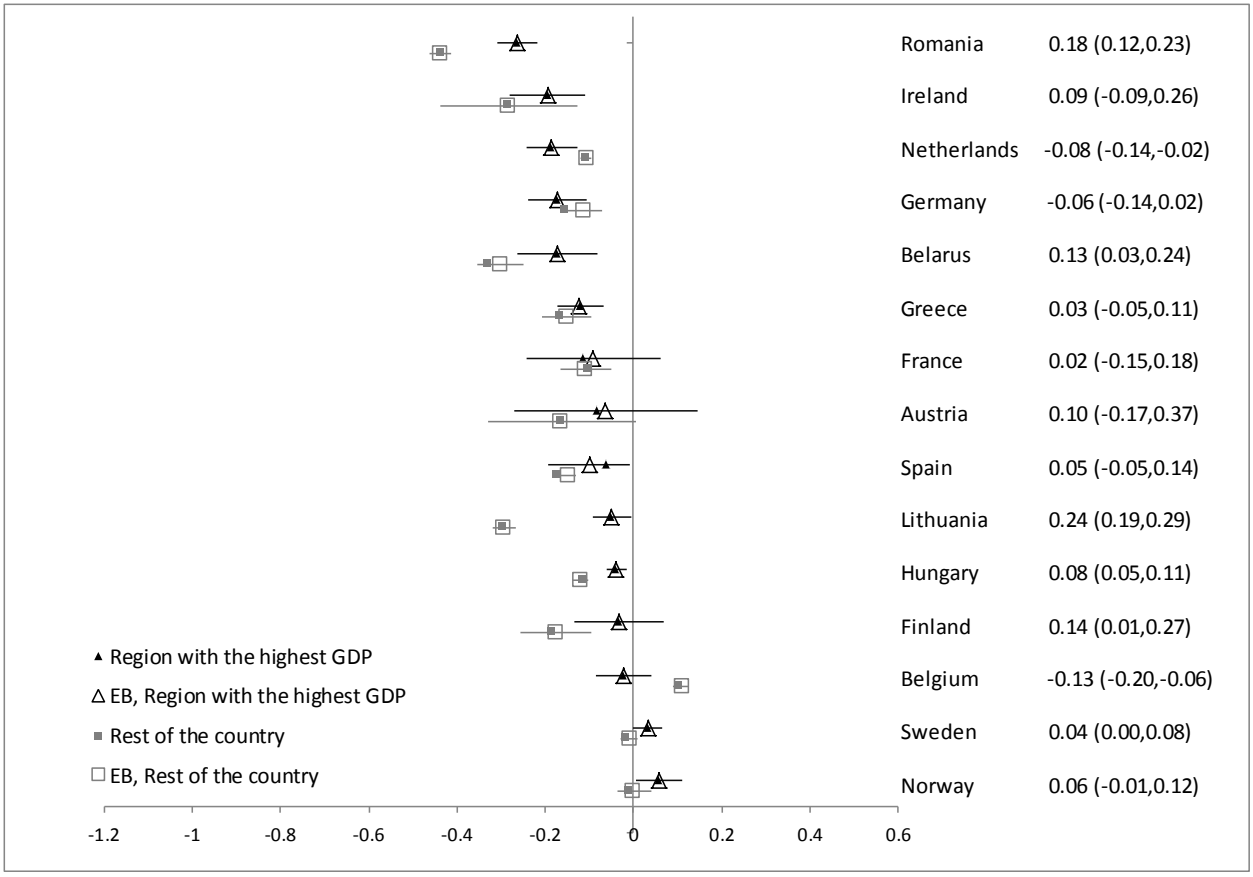

Figure 2. The difference of high versus medium educated women in CFR by country: region of the highest GDP value compared to the rest of the country (other regions combined). Countries sorted according to the observed difference between high versus medium educated women in the region of the highest GDP value. The panel on the right-hand side reports the difference in difference between the two regions within a country and the 95 percent prediction interval. EB=Empirical Bayesian.

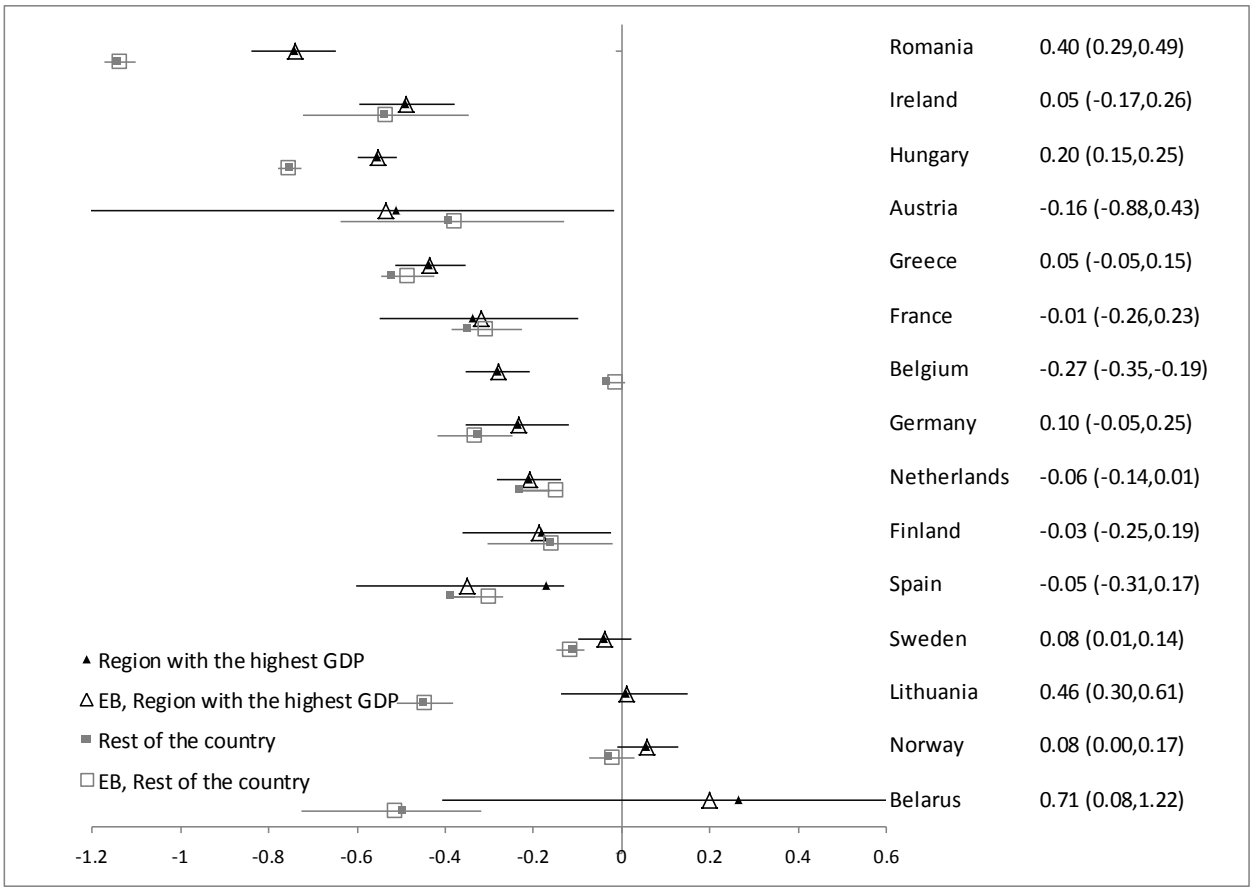

Figure 3. The difference of high versus low educated women in CFR by country: region of the highest GDP value compared to the rest of the country (other regions combined). Countries sorted according to the observed difference between high versus low educated women in the region of the highest GDP value. The panel on the right-hand side reports the difference in difference between the two regions within a country and the 95 percent prediction interval. EB=Empirical Bayesian.

Appendix 1 Data sources of the study

Country	Cohorts	Sample	Data type	Measurement date	Age at measurement
Austria	1965-1970	>1%	Microcensus+survey	2012-2013/2016[1]	42-46
Belarus	1965-1968	10%	Census	14.-24.10.2009	41-45
Belgium	1964-1966	Total	Register	31.12.2006[2]	40-42
Finland	1966-1970	10%	Register	31.12.2012[3]	42-46
France	1965-1970	1%	Survey	26.2.2011	40-45
Germany	1964-1970	0.75%	Microcensus	2008/2012[4]	41-48
Greece	1965-1970	10%	Census	10.-20.5.2011	40-46
Hungary	1966-1970	Total	Census	1.10.2011	41-51
Ireland	1965-1970	10%	Census	10.4.2011	41-45
Lithuania	1966-1970	Total	Census	1.3.2011	41-45
Netherlands	1966-1970	Total	Register	31.12.2011	41-43
Norway	1966-1970	Total	Register	31.12.2011	41-45
Romania	1965-1970	10%	Census	20.-31.10.2011	40-45
Spain	1966-1970	9%	Census	11.1.2011	41-45
Sweden	1966-1970	Total	Register	31.12.2012	40-44

[1] Data sources in Austria are microcensus in 2012 (4th quarter) and 2016 (4th quarter), Austrian Gender and Generations Survey gathered from September 2012 to March 2013 and Basic Social Science Research for Vienna Survey gathered from October 2012 to July 2013. [2] In Belgium education is measured in census 1.10.2001 when women were aged 34 to 37. [3] In Finland, education and region were measured 31.12.2007 when women were aged 37 to 41 years. [4] Data sources for Germany are microcensus in 2008 and 2012 gathered throughout the year.

Appendix 2: Description of the regional categorization

The NUTS categorization is strongly linked to existing administrative divisions in a country, and considers also the general character and population size of the region. This categorization is a three-level categorization, and we generally aimed to use NUTS 2 level at which regions have generally 800,000-3 Mio inhabitants. At the NUTS 1 level, on the other hand, many smaller countries would just consist of one region. NUTS 2 level data was analyzed for Belarus, Belgium, Finland, Greece, Hungary, Ireland, the Netherlands, Norway, Romania, Spain, and Sweden. These regions generally cover populations between 800,000 and three million inhabitants. In Austria, France, and Germany, limited sample sizes forced us to conduct the analysis at a higher level of geographic detail. In Austria, the capital city Vienna (NUTS 2) is contrasted with the rest of the country. For France we exclude oversea territories and cover the NUTS 1 level. For Germany, we aggregated NUTS 1 level regions to derive five regions. In Finland we exclude the Åland islands, and in Spain the Canary Islands and the Balearic Islands, Ceuta and Melilia due to their small population size and distinct culture. For Lithuania, which just consists out of one NUTS 2 region, we separated out the NUTS 3 region with the capital city of Vilnius. Belarus is not an EU country, but a corresponding classification has been developed for it, please see http://riate.cnrs.fr/wp-content/uploads/2015/03/M4D_20121220_TR_russia.pdf.

Appendix 3 Descriptive characteristics of the study population

Country	Region	Low, %	Medium, %	High, %	N	GDP per capita
Austria	Vienna	7	62	32	813	42,900
	Rest of Austria	16	65	19	1,893	31,147
Belarus	Minsk city	0	60	40	3,922	16,209
	Minsk	3	78	20	3,533	11,879
	Gomel	3	76	21	3,474	8,604
	Brest	2	76	23	3,411	7,329
	Vitebsk	2	75	24	2,996	7,886
	Grodno	1	75	24	2,904	8,003
	Mogilev	2	77	21	2,664	7,300
Belgium	Brussels	26	25	49	9,753	56,800
	Antwerp	23	41	36	33,484	36,600
	Brabant Walonne	22	28	50	6,910	33,700
	Vlaams Brabant	18	36	46	22,053	32,800
	West Flanders	29	39	32	24,065	29,700
	East Flanders	27	38	36	29,704	28,300
	Limburg	27	40	33	16,818	25,700
	Liège	34	34	33	18,787	23,100
	Namur	31	35	35	8,980	22,100
	Luxembourg	30	35	35	4,884	20,700
	Hainaut	37	34	29	23,647	20,500
Finland	Helsinki-Uusimaa	10	32	58	5,118	40,500
	West Finland	9	42	50	3,848	28,000
	South Finland	10	42	48	3,317	27,000
	North and East Finland	8	42	50	3,419	25,000
France	Parisian region	15	36	49	352,428	46,400
	Central East France	16	49	35	270,447	27,500
	Mediterranean France	18	48	35	291,688	24,900
	South West France	15	48	37	246,325	24,600
	West France	16	50	34	321,986	24,100
	Paris Basin	22	50	28	400,242	23,600
	East France	19	51	30	194,127	23,400
	North France	24	45	31	148,062	23,000
Germany	South	9	68	23	10,681	37,021
	West	9	68	24	2,675	33,770
	North	11	68	21	5,501	32,268
	NRW	11	67	21	6,829	32,095
	East	10	68	23	25,686	24,367
Greece	Attiki	18	49	34	14726	26,800
	Notio Aigaio	43	40	17	1075	20,900
	Dytiki Makedonia	39	37	25	1111	17,900
	Ionia Nisia	36	42	22	766	17,600
	Sterea Ellada	37	42	22	2048	17,500
	Kriti	33	41	25	2248	16,400
	Peloponnisos	36	42	22	1964	15,800
	Voreio Aigaio	36	38	26	673	15,500
	Kentriki Makedonia	29	41	30	6990	15,400
	Dytiki Ellada	39	39	22	2600	14,700
	Anatoliki Makedonia, Th	44	34	22	2112	14,100
	Ipeiros	35	34	31	1140	14,100
	Thessalia	36	36	28	2731	14,100
Hungary	Central Hungary	11	58	31	97,031	27,900
	Western Transdanubia	17	64	20	33,439	17,500
	Central Transdanubia	20	62	19	36,369	15,300
	Southern Great Plain	22	59	19	31,485	11,600
	Southern Transdanubia	19	61	20	43,003	11,500
	Northern Great Plain	25	57	19	50,040	11,200
	Northern Hungary	22	59	19	40,142	10,400

Appendix 3 continues

Country	Region	Low	Medium	High	N	GDP per capita
Ireland	Southern and Eastern	24	41	35	10,475	38,300
	Border, Midland and We	25	42	33	3,772	22,600
Lithuania	Vilnius	2	45	52	17,445	24,500
	Rest of Lithuania	5	67	28	89,592	14,592
Netherlands	Groningen	21	51	28	18,462	46,000
	Noord-Holland	18	45	37	81,843	42,300
	Utrecht	17	41	42	40,787	41,200
	Noord-Brabant	23	50	27	82,607	35,400
	Zuid-Holland	45	34	21	30,974	34,800
	Gelderland	23	49	29	68,838	29,500
	Overijssel	21	53	25	37,527	28,800
	Limburg	25	51	24	36,124	28,600
	Zeeland	24	56	20	12,173	27,100
	Flevoland	24	50	26	12,087	26,800
	Friesland	20	54	26	22,576	25,200
	Drenthe	21	53	26	17,589	24,400
Norway	Oslo and Akershus	14	34	52	19,290	47,800
	Agder and Rogaland	19	43	39	9,689	37,300
	Western Norway	16	42	43	11,474	36,300
	Trøndelag	15	41	44	6,389	31,300
	Northern Norway	16	39	45	7,024	30,000
	South Eastern Norway	20	43	36	15,211	27,500
	Hedmark and Oppland	21	45	34	6,107	26,000
Romania	Bucharest - Ilfov	13	50	37	11,206	33,600
	West	25	55	20	8,658	15,100
	Center	22	60	19	10,154	12,800
	Northwest	26	56	19	11,214	11,700
	South - Muntenia	27	58	16	14,805	11,700
	South East	26	55	19	11,485	11,400
	South-West Oltenia	22	62	16	9,657	9,900
	Northeast	28	56	16	13,626	7,900
Spain	Madrid	6	66	29	2,744	32,800
	Basque Community	6	65	29	21,332	31,500
	Navarre	10	67	23	13,219	30,100
	Catalonia	8	66	25	1,345	28,200
	Aragon	14	64	22	3,749	26,600
	La Rioja	18	62	20	24,744	26,000
	Castile-Leon	7	70	24	2,027	22,900
	Cantabria	16	67	17	5,326	22,500
	Principality of Asturias	16	68	17	8,905	22,100
	Galicia	9	65	25	7,613	21,300
	Valencian Community	6	67	27	5,595	21,300
	Murcia	9	67	25	13,179	19,700
	Castille-La Mancha	5	60	35	7,460	19,500
	Andalucia	5	55	40	17,579	18,300
	Extremadura	6	64	31	3,013	16,800
Sweden	Stockholm	8	49	43	54,235	46,200
	Upper Norrland	9	51	41	14,216	32,200
	West Sweden	9	53	37	52,153	31,600
	Middle Norrland	10	55	35	10,780	29,400
	East Middle Sweden	10	54	36	42,457	28,700
	Småland and the islands	9	57	34	22,080	28,100
	South Sweden	9	52	39	36,575	27,800
	North Sweden	11	56	33	23,241	26,800

Note: results for Austria, France and Spain are shown as weighted. Subnational regions within a country are ranked by the GDP per capita of the region, from highest to lowest. Population-weighted average GDP was used for regions containing more than one NUTS region.

Appendix 4

We use empirical Bayesian estimation to calculate prediction intervals (Assunção et al., 2005; Longford, 1999). The estimation method can be described as following. Suppose the total number of women from selected cohorts observed from country c ($c = 1,\ldots,C$), region r ($r = 1,\ldots,Rc$) with education level e ($e = 1,2,3$) is denoted as $NWomen_{c,r,e}$and the number of children is denoted by $NChild_{c,r,e}$. The crude fertility is denoted by $\hat{\lambda}_{c,r,e} = NChild_{c,r,e}/NWomen_{c,r,e}$ and $\hat{\lambda}_{c,r} = NChild_{c,r}/NWomen_{c,r}$, where

$NWomen_{c,r} = \left(NWomen_{c,r,1}, NWomen_{c,r,2}, NWomen_{c,r,3}\right)$, and

$NChild_{c,r} = \left(NChild_{c,r,1}, NChild_{c,r,2}, NChild_{c,r,3}\right)$.

Suppose the *real* fertility $\lambda_{c,r,e}$follows:

$$NChild_{c,r,e}|\lambda_{c,r,e} \sim Poisson(NWomen_{c,r,e} \times \lambda_{c,r,e})$$

The distance between region $r_1$of country $c_1$and region r_2 of country $c_2$is defined as

$d_{c_1,c_2;r_1,r_2} = \left|GDP_{c_1,r_1} - GDP_{c_2,r_2}\right|/range_{1\le c\le C,1\le r\le Rc}(GDP_{c,r})$if $c_1 = c_2$, and$d_{c_1,c_2;r_1,r_2} = 0$if $c_1 \neq c_2$.

The local average fertility is defined as:

$\lambda^*_{c,r_1,e} = \hat{\lambda}_{c,r_1,e} + \tau_{c,e}\left(\underline{\lambda}_{c,r_1,e} - \hat{\lambda}_{c,r_1,e}\right) + \varepsilon_c$ for $e = 1,2,3$ (1)

Where $\underline{\lambda}_{c,r_1,e} = \sum_{r_2=1}^{Rc}\left[\left(1 - d_{c,c;r_1,r_2}\right) \times \hat{\lambda}_{c,r_2,e}\right]$ is the average fertility of region $r_1$by borrowing information from other regions in country $c$according to their distances of GDP. The shrinking factor denoted as $\tau_{c,e}$.;$\varepsilon_c \sim N(0,\sigma)$ is a country-specific random error to model residual spatial variation and $\sigma \sim Gamma(1, 0.001)$. All CIs (credible intervals) were estimated based on 20,000 iteration with the first 10,000 disregarded (burn-in). The analysis was performed using R version 3.4.1 and R package '*jags*'.