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Abstract

Early evidence demonstrates that the fertility response to the COVID-19 pandemic has varied across European countries. Yet, prior research indicates that fertility responses to disasters are often localized sub-nationally. Moreover, SARS-CoV-2 incidence, economic pandemic impacts, and the affectedness by virus containment measures varied sub-nationally across Europe during the first year of the COVID-19 pandemic. Sub-national variation in the fertility response seems therefore possible. We conducted a rigorous data collection effort in 28 European countries (equaling 241 European sub-national regions) and used cutting-edge forecasting methods to assess sub-national variation in the fertility response to the first six months of the COVID-19 pandemic. While we find sub-national variation, our results reveal that the fertility response to the pandemic was dominated by the country level, with Southern European countries witnessing more negative fertility response to the early pandemic than Northern Europe. Variance decomposition even indicates a ‘nationalization’ of birth rates during the winter months of 2020, as the within-country variance in fertility declined and between-country variance increased. Nonetheless, highly urbanized areas in Europe experienced significantly steeper fertility declines as a response to the beginning of the pandemic, which is partly explained by their higher SARS-CoV-2 incidence rates. SARS-CoV-2 incidence rates emerged as another important predictor of the fertility response more broadly. Higher incidences were associated with steeper fertility declines across the regions. Overall, country-level estimates represent fertility responses to the COVID-19 pandemic generally well, but the regional dimension provides additional important insight into how the COVID-19 pandemic has impacted fertility.

Introduction

During the first months of the COVID-19 pandemic, scientists and the media alike speculated about how human fertility would develop during and in the aftermath of this worldwide health crisis. Across the media, everything between a baby bust and a baby boom was predicted (“Will the Coronavirus Lockdown Lead to a Baby Boom?,” 2020; Yuhas, 2020). Demographers, with more nuance, argued that post-pandemic fertility trajectories would likely depend on contextualized pandemic impacts such as on economic livelihoods and uncertainty, work-life balances and living conditions, partnering dynamics, affectedness of physical and mental health, health care aspects, or access to contraception and assisted reproductive technologies (Aassve et al., 2020; Berrington et al., 2022; Ullah et al., 2020). A survey of couples across Western Europe revealed that many had abandoned or postponed fertility plans in March and April 2020 (Luppi et al., 2020), corroborating the notion of an imminent baby bust, in response to the first pandemic wave across European high-income countries.

Two years later, we have learned that post-pandemic fertility has unfolded in complex patterns across time and space (Aassve et al., 2021; Sobotka et al., 2021). First studies indicate that fertility, measured as monthly crude numbers of births, plummeted in many countries between November 2020 and January 2021, compared with birth rates in previous years. This was followed by small baby booms in March and April 2021. Yet, in other countries, in particular across Northern and North-Central Europe, fertility remained stable or boomed throughout 2021 without falling first (Aassve et al., 2021; Sobotka et al., 2021). Birth rate fluctuations seem to continue into 2022, as most European countries experienced sharp declines in its first quarter (Sobotka et al. 2022). Such detailed and almost real-time assessments of how monthly birth rates behave in an array of European, American, and Asian societies during a worldwide crisis is unprecedented. It was made possible by the Short-Term-Fertility Fluctuations (STFF) database, an administrative data collection effort of monthly numbers of births by the Max Planck Institute for Demographic Research in Germany and the Vienna Institute of Demography of the Austrian Academy of Sciences (HFD 2022).

Despite this detailed early documentation, pressing open questions on fertility trends after the onset of the COVID-19 pandemic remain. One central question pertains to sub-national variation in the pandemic fertility response. Available multi-country reports on birth rate changes in response to the pandemic have been based on country-level data and neglected potential sub-national variation (Aassve et al., 2021; Sobotka et al., 2021). One noteworthy exception is Arpino, Luppi and Rosina's study, which assessed state-level changes in monthly crude birth rates between November 2020 and May 2021 in comparison to the same period in the year before in France, Germany, Italy and Spain (Arpino et al., 2021). They document regional heterogeneity in the birth rate change in all four countries, but underscore that their study cannot assess causal pandemic response effects due to missing longer time series data prior to the pandemic.

Yet, assessing sub-national differences in a disaster's fertility response is of great relevance. Such an assessment of sub-national differences not only highlights the cohesion or fragmentation of a society's disaster impact on reproductive behaviors, and draws attention to affected areas and populations, but can also aid in identifying important contextual factors connected to the fertility response. This is especially important in the absence of comprehensive individual-level data on reproductive behaviors and its antecedents. Prior research indeed demonstrated that the fertility response to disasters has often been regionally diverse (Strid et al., 2022). Natural disasters, in particular, seem, in their aftermath, to affect birth rates in directly affected municipalities, but not in other regions (Davis, 2017; Nobles et al., 2015; Rodgers et al., 2005). Even more spatially generalized crises, like recessions, have triggered spatially heterogeneous changes in birth rates in the past (Goldstein et al., 2013; Matysiak et al., 2021).

Sub-national variation in the fertility response to the COVID-19 pandemic may thus be expected. Pandemic impacts varied sub-nationally, in particular during the first pandemic wave in the spring of 2020. At that time, the spread of the SARS-CoV-2 virus showed pronounced within-country spatial variation across and beyond Europe (Amdaoud et al., 2021; Naqvi, 2021). Local virus incidence rates may have affected individuals' perceptions of imminent health- and mortality threats, triggered disruptions in gynecological and obstetric health care and in assisted reproduction service provisions, or impacted the degree of worries regarding their safety of usage locally (Brislane et al., 2021), in turn affecting reproductive planning and behaviors. Conversely, some couples may have perceived the time of 'stay-at-home' orders as a good moment to reproduce (Qu, 2021), perhaps also contingent on SARS-CoV-2 affectedness of their residential region. Also, the health crisis rapidly translated into an economic recession, which has affected regions across Europe differently (EUROSTAT 2021a). This, in turn, may have caused sub-national variation in the fertility response, related to regionally unevenly distributed economic losses and uncertainty (Vignoli et al., 2020). Moreover, if sub-national changes in unemployment or GDP have been more pertinent in regions that were economically weaker coming into the pandemic (Antipova, 2021), pre-existing sub-national fertility differences may have leveled off as a consequence, as regional higher GDP has been an important predictor of lower birth rates across Europe, even though this relationship has weakened in recent years (Fox et al, 2019; Campisi et al. 2021).

At the same time, the COVID-19 pandemic represents a unique event that differs from previous disasters and crises. Not only did the first year of the COVID-19 pandemic unify a health crisis, a mortality inducing event, and a recession, but it also led to unprecedented disruptions to public and social life through virus containment and social distancing measures (Hale 2020). During the first pandemic wave across Europe, the SARS-CoV-2 spread was rather regionalized, but social distancing and lockdown measures such as mask wearing, school- and retail closures, and stay-at-home orders were imposed nationwide in many European countries (Hale et al., 2021). Thus, if containment measures or other nationalized factors such as media exposure affected birth rates primarily, a more nationally homogeneous and less regionally diverse fertility response to the first pandemic wave may be present (Comolli & Vignoli, 2021).

Further, regional disparities in the fertility response to the pandemic may emerge along the urban-rural axis. The first COVID-19 pandemic wave triggered stringent lockdowns, including 'stay-at-home' orders in many countries (Hale et al 2020). Yet, these strict pandemic containment measures have caused greater disruptions to daily lives, mental health, and physical activity among those living in urban centers, those without access to a green space, and individuals living in crowded housing (Greteman et al., 2022; Keller et al., 2022). Home confinement may have led to the postponement of childbearing particularly among couples living in densely populated urban centers. Hence, sub-national differences in the pandemic-fertility response may be especially pronounced between highly densely populated urban centers and other regions, if the intensity of lockdown affectedness and related losses in autonomy and well-being impacted reproductive behaviors.

Relatedly, while sub-national variation in fertility within European nations has been documented on the regional and municipal level (Campisi et al., 2020; Kulu, 2013; Kulu et al., 2009; Nisén et al., 2021), only little is known on the extent to which fertility rates vary within versus between European countries, and whether this changes in times of multi-national crises. Investigating within- and between-country variance in fertility rates is, however, important. It furthers our understanding of the extent to which nationalized versus regional factors may be relevant for fertility behavior in general and in times of crises specifically. Historically speaking, fertility rates differed markedly between local communities and regions across Europe. However, national homogeneity in fertility increased in the 20th century and again after 1990, when legal, administrative, language, and cultural structures became more nationally integrated (Basten et al., 2011; Watkins, 2014). In line with this growing importance of nation states for Europe's demographic map, the share of variation in non-marital fertility across European regions attributable to differences between countries grew from two thirds in 1960 to 78 percent in 2007 (Klüsener et al., 2013). No study has yet quantified the within- and between country components for general fertility measures like the total fertility rate. Yet, Matysiak et al. (2021) demonstrated that the TFR changes in the post Great Recession period starting in 2008 were larger between than within European countries, despite marked sub-national variation in some countries. This study points towards the possibility of a fertility response to the COVID-19 pandemic that is clustered at the country level, despite sub-national heterogeneity in the COVID-19 crisis itself.

Another pressing issue in the research on the impact of disaster on fertility in general and the fertility response to the COVID-19 pandemic especially is methodological. Fertility rates fluctuate and are subject to continuous changes (Bohk-Ewald et al., 2018; Bongaarts, 2008; Hellstrand et al., 2021; Mason, 1997). It is extremely challenging to ascertain whether observed birth rate differences from one point in time to another are attributable to a specific event or would have occurred also in its absence. To assess post-COVID-19 pandemic fertility rates in light of the pandemic, previous studies have compared observed monthly birth rates to those in the year (Arpino et al., 2021) or years prior to the pandemic (Sobotka et al., 2021), estimated a 'pandemic effect' on fertility based on a linear model (Aassve et al., 2021) or auto-regressive moving average (ARIMA) models (Nobles & Torche, 2022), or have developed fertility projections based on different scenarios (Berrington et al., 2022). Whatever the methodological approach, the expected value based on prior birth rate trends remains an approximation. Moreover, no consensus exists in the literature on how to best estimate an 'expected' birth rate, although recent advances suggest model averaging as the most accurate approach (Shang & Booth, 2020).

Our study seeks to fill the research gaps identified above. To this end, we embarked on a rigorous data collection of monthly numbers of births and female populations of childbearing age across 28 European countries, equaling 241 NUTS2 (nomenclature of territorial units for statistics) regions. We used cutting-edge forecasting and model averaging methodology to estimate expected numbers of births in each sub-national region. We refer to the difference between the predicted expected birth rate and the observed birth rate in each region as the 'fertility-response'. We cautiously interpret this measure as the response to the COVID-19 pandemic, approximating a causal effect, while acknowledging limitations of our approach.

Our study makes three contributions. First, we describe the regional fertility response to the pandemic for the birth months of November 2020 until June of 2021. This period covers births that were conceived between February 2020 and September 2020, spanning the time of the onset of the COVID-19 pandemic in Europe to the start of its second pandemic wave. We categorize the monthly births into three phases: Phase 1 includes November 2020 until January 2021 births, corresponding to conceptions that occurred during the first pandemic and lockdown wave (February to April 2020). Phase 2 includes February 2021 to April 2021 births, spanning conceptions in the reopening phase (May to July 2020). Phase 3 includes May 2021 to June 2021 births, corresponding to conceptions in August and September 2020, the late summer months before the second major pandemic wave occurred in Europe (Hale et al., 2021; Ritchie et al., 2020). We illustrate the fluctuations in births by presenting the deviations between observed and expected numbers of births, which we interpret as the *fertility response*. In other words, we depict whether more than expected (surplus) or fewer than expected (deficit) births occurred, for each NUTS2 region and phase. We also estimate the cumulative fertility response for the complete time window of February 2020 to June 2021. We theorize that each phase may have provided partially different circumstances for fertility decision-making. The first phase, when much was unknown about the virus and stay-at-home orders and social distancing measures were first rolled out, represents a time of acute uncertainty and rapid change in daily life. The second phase represents the re-opening phase of societies when first wave case numbers had peaked and were tapering off. The third phase represents the summer months after the first wave had subsided across most of Europe and societies had reopened (Hale et al., 2021; Ritchie et al., 2020).

Second, in order to assess the between- and within-country variation in fertility pre and post the COVID-19-pandemic onset more formally, we conducted a variance analysis of the general birth rate (number of births per female population of childbearing age). This allowed us to investigate the magnitude of the monthly total variance, between- and within-country variance, and changes therein in the general fertility rate across the 241 European NUTS-2 regions in the years prior to and after the COVID-19 pandemic onset.

Third, we investigated systematic differences in the fertility response between highly urbanized and other regions, and by SARS-CoV-2 incidence rates, by presenting results from descriptive analyses and linear regression models.

DATA AND METHOD

Data and Measures

The data on births and the female population of childbearing age were obtained either directly from the national statistical offices, were downloaded from their online databases, or were delivered by other holders of official population data (see Appendix A Table AA1 for an overview). The data collection was initiated in early 2021, with the aim to document the sub-national fertility response of the COVID-19 pandemic across Europe. We reached out to collaborators from the EAPS working group on Register-Based Fertility Research (EAPS 2021), other collaborators with access to administrative data, or obtained data directly from statistical offices via download in all member countries of the European Union, Norway, the UK, and Switzerland in June 2021. We collected monthly data on the number of births and either monthly, quarterly or yearly data on the female population aged 15-49 in each NUTS2 region for 28 European countries, containing 241 NUTS2 regions.

The current study uses the data covering the period from January 2015 to June 2021 in all available countries. Births are recorded at the month of occurrence and according to the place of mother's residence in all countries, with a few exceptions, which include Slovakia (all birth data) and Italy (births before 2019), where births are available by month of registration. Birth data for 2021 was subject to statistical adjustments in Croatia, to capture the correct place of residence of the mother and to exclude births to foreign women, and in Switzerland, to account for late registrations of births (see footnotes in Table AA1 for details). The data collection was finalized in June 2022. Please note, however, that data on births which occurred in 2021 is still preliminary for most countries, and subject to further updates. Also, while data for Romania were obtained, they had to be excluded from the latest set of analyses, due to underestimations in the number of births in 2021. Further versions of the manuscript will be updated as final data becomes available. An overview of included countries and details of data for each country can be found in Table AA1.

Data on population density come from EUROSTAT (EUROSTAT 2021b). Population density is measured in persons per square kilometer in the Eurostat data, and available at the NUTS3 municipality level. We aggregated the NUTS3 information to produce population density measures at the NUTS 2 level. We next classified the top 10% percent of most densely populated areas in our NUTS2 dataset (which includes all regions in our sample) as highly urbanized. In addition, we defined the capital city region of each country as highly urbanized, even if it was not included in the top 10% regions with the highest population density. This results in 31 out of the 241 regions classified as highly urbanized. The dichotomization of population density in highly urbanized versus all other regions is guided by our aim to assess whether highly urbanized centers experienced a differential fertility response to the stay at home orders of the first pandemic months.

Data on the documented SARS-CoV-2 cases in each NUTS2 region come from a variety of data sources, and were compiled into one dataset by our team. Data for England, Wales and

Northern Ireland come from the UK Health Security Agency (COVID-19 in the UK Dashboard 2021). Data for Estonia, Iceland, Latvia and Lithuania come from Our World in Data (Our World in Data 2021), data for Spain come from the COVID-19 Regional Labour Tracker (COVID-19 Regional Labor Tracker 2021), and data from all remaining countries were drawn from the COVID19-European-Regional-Tracker (COVID19-European-Regional-Tracker 2021). We accumulated total daily or weekly case numbers available in the original data sources by calendar month to estimate the monthly incidence of SARS-CoV-2 per 100,000 inhabitants. Population data for these estimations comes from EUROSTAT. We accumulated SARS-CoV-2 cases in each NUTS2 region from the onset of the pandemic to the month of May 2020, June 2020, and October 2020, to predict surplus and deficit births for the three phases respectively, as these time windows overlap with the respective conception windows (and prior months, leading up to the conception).

Method

We conduct three different sets of statistical analyses.

First, we produced fertility response estimates, in other words surplus and deficit birth estimates, for each phase (phase 1: 11/2020-1/2021; phase 2: 2-4/2021; phase 3: 5-6/2021) and NUTS2 region. We achieved this via a three-step procedure. First, we predicted monthly regional expected births in the absence of the COVID-19 pandemic by extrapolating regional pre-pandemic trends to the time period of November 2020 to June 2021. Our expected births model is an ensemble of 12 separate over-dispersed Poisson regressions stratified over NUTS2 region. All regressions include a log-linear time trend and month-fixed effects to adjust for seasonality. Models may also contain a log-quadratic effect of time and have been fit on 3 years, 5 years and 7 years of previous data. Models were fit with and without a person-month exposure offset. We used monthly population counts, where available, as the basis for the exposure estimates. Yearly and quarterly population counts were smoothed to reflect continuous population change over the year. We smoothed the population data by using a monotone Hermite spline. A set of 500 expected monthly birth counts were sampled jointly across all 12 models for each NUTS2 region, with higher weight given to those models which performed better in out-of-sample validation. Based on these samples, we calculated the fertility response by subtracting observed from expected birth counts. The corresponding surplus and deficit birth estimates were aggregated over space and time as needed, by summing observed and, respectively, expected births. Uncertainty is quantified via quantiles over the simulated estimates via a bootstrapping procedure with 500 replicates. The uncertainty intervals reflect modeling specification uncertainty as well as stochasticity in outcome and estimated model coefficients.

We present NUTS2 level fertility response estimates for each phase, including levels of statistical significance derived from 90% uncertainty intervals, and for the whole cumulative time period of November 2020–June 2021 births in maps in Figure 1. An additional map, showing the same estimates using a 50% uncertainty interval for assessing statistical significance of the surplus and deficit birth estimates, is shown in Appendix B (Figure AB1). A table with sample descriptives and fertility response estimates for the three phases is located in Appendix A (Table AA2). Fertility response estimates for the single months will be made available as supplementary materials in an online suppository upon publication of the manuscript.

Second, we tested differences in the distribution of the fertility response, in other words of the surplus and deficit births, by regions' degree of urbanization and SARS-Cov-2 incidence rates. Violin plots, shown in Figure 2, indicate the mean, interquartile range, and density of the distributions. To further evaluate systematic differences in the fertility response between the most urbanized and the other regions, and to assess its association with COVID-19 incidence rates, we estimated linear models predicting the surplus and deficit births. These models included the urbanization indicator, and cumulative SARS-CoV-2 incidences for each NUTS2 region. SARS-CoV-2 incidences were clustered in countries during the first half of 2020 across Europe. We estimated the models a) without fixed effects, to reproduce the descriptive findings, and b) with country-cluster fixed effects, and c) with country fixed effects, to adjust for country-(cluster) characteristics, including national-level differences in SARS-CoV-2 affectedness. Models with country clusters are more parsimonious than those with country fixed effects yet account for broad cross-national societal similarities and serve as robustness checks, Models were fitted separately for each phase, and for the cumulative time period encompassing all phases. The SARS-CoV-2 incidence for phase 1 models was accumulated for the time period of February to May 2020, for phase 2 models for the time period of February to June 2020, and for the phase 3 models for time period of February to October 2020. The cumulative model uses the cumulative incidence from February to October 2020. Table 1 summarizes the essential parameters of the models with country fixed effects. Full model results and all alternative model specifications are shown in Appendix B (Tables AB1-3).

Third, we estimated the total monthly variance, and between- and within country variance of the general birth rate (number of births/number of women aged 15-49) for all NUTS2 regions, for the time period of January 2015 to June 2021, using one-way ANOVA with an exposure offset. We further estimated the percentage of between-country variance out of the total variance. All four variance estimates are shown in Figure 3, panels a-c. Further, in order to test whether, and if so, which, single countries might drive the variance finding, we re-estimated all four variances measures 28 times, excluding one country at a time. The corresponding Figure is located in Appendix B (Figure AB2, panels a-c).

Code and Data Availability

All analyses were carried out in the R software suite. A repository hosting the code, but not the data, is available at https://github.com/jschoeley/xfertility. The data cannot be shared publicly because access in the case of many countries is restricted. We plan to release the dataset containing the monthly fertility response estimates (surplus and deficit births) upon publication of this study. However, it may be possible to obtain the original data upon request. Inquiries should be directed to Aiva Jasilioniene (Jasilioniene@demogr.mpg.de).

RESULTS

Is there sub-national variation in the fertility response in the aftermath of the first COVID-19 wave across Europe?

Figure 1 displays the fertility response measured in percent deviation between the expected value and observed numbers of births, for each NUTS2 region and phase. Bold colors indicate statistical significance of the fertility response on the 90% level.

Sub-national variation in the fertility response is present. All countries comprising more than one NUTS2 region, except Finland, Poland, and Portugal, experience positive and negative fertility responses in different regions simultaneously in at least one of the phases. However, the deviations from expected birth counts are largely statistically non-significant in most regions and phases according to standard significance levels. No country experienced significant positive and negative fertility responses across sub-national regions in the same phase. Rather, countries with multiple sub-national regions displaying statistically significant fertility responses at the same time show unidirectional effects across regions.

Positive fertility responses throughout all phases are present in Finland, the Netherlands and Norway in at least some sub-national regions. Ireland, with the exception of the West and the Border regions, experienced more births than expected in phase 2. Cantabria in Spain, and the Namur region in Belgium saw more than expected births in phase 3.

Significantly fewer births than expected occurred throughout several Spanish and Portuguese regions, Paris, Brussels, Budapest, the lake Geneva region in Switzerland, and Kuyavia-Pomerania in Poland in phase 1. Further, a negative fertility response was present in Lisboa, and the lake Geneva region in phase 2, and the Porto area, the lake Geneva region, the German city of Bremen, the East of Slovenia, and the Northern Aegean Islands in Greece in phase 3.

Thus, the maps do not indicate masking of large sub-national heterogeneity in country level averages in the fertility response to the first COVID-19 wave across Europe. Rather, both a North-South and a temporal divide appear. Large and significant birth declines are concentrated in phase 1 and most pronounced across Southern Europe (Portugal, Spain, Paris, the lake Geneva region), while birth increases are concentrated in the North of Europe and the Netherlands and present throughout all phases. In many regions, positive and negative fertility responses average each other out over the three phases. Significant cumulative positive fertility responses in response to the first 6 pandemic months are estimated for Finland and the north of Norway only, negative fertility responses in Porto, Lisboa, Madrid, and the lake Geneva region (Figure 1, panel 4).

Finally, major city areas stand out across several countries. Among the steepest declines in births occurred in the Porto, Lisboa and Madrid regions, leading to a significant negative cumulative fertility response to the first six months of the COVID-19 pandemic. Further Bratislava, Brussels, Budapest, Edinburgh, Paris and Sofia experienced larger birth declines than the surrounding and most other regions in their respective countries in phase 1 (please see Figure AB1 for greater detail). Interestingly, this pattern is absent or reverses across the North: Oslo, Stockholm, and Helsinki experience among the highest birth increases across sub-national regions in these countries.

Does the fertility response differ between highly urbanized and other regions in the aftermath of the first COVID-19 wave across Europe? And is there a relation between regional SARS-CoV-2 incidences and the fertility response?

Formal analyses indeed confirm the observed differences in the fertility response between highly urbanized and other regions across Europe in phase 1. While negative fertility responses occurred in both types of regions in phase 1 (Figure 1, panel a), the observed declines in highly urbanized regions were on average 1.4 percentage points larger than in the other regions (birth declines of -3.3 percent and -1.9 percent respectively). This difference is highly significant and rises to 1.8 percentage points in regression models which include country fixed effects and control for SARS-CoV-2 incidence rates (Table 1, full results available in Appendix B).

Both types of regions display positive fertility responses in phase 2, and almost no deviations from the expected numbers of births in phase 3 (Figure 3, panels b and c). While observed birth increases in phase 2 are slightly larger in highly urbanized areas (Figure 1), this difference is not statistically significant and even reverses when country or country-cluster fixed effects are added to the model (Table 1, for more details see Tables AB2a-c). Figure 1 further indicates a left-skewed distribution of the observed fertility response among the highly urbanized areas in phases 1 and 2, while the fertility response is approximately normally distributed in the other regions. This underscores a wider range of negative fertility responses, including the occurrence of large outliers, in highly urbanized regions.

Over the cumulative time spanning all three phases (Figure 1, panel d), negative and positive fertility responses averaged each other out in either type of region, so that the descriptive cumulative fertility response to the first 6 months of the pandemic approaches zero. Nonetheless, after controlling for country fixed effects, the fertility response in highly urbanized regions was slightly lower (0.7 percent, $p<=.05$) compared with the other regions.

Regression results further indicate a significant negative relationship between a region's SARS-CoV-2 incidence and its fertility response in all phases but phase 2 (Table 1). In phase 1, each standard deviation increase in the SARS-CoV-2 incidence rate between February and May 2020 per 100,000 habitants was associated with a .7 percentage point birth decline when urbanization was controlled for ($p<.01$). In phase 3, each standard deviation increase in the SARS-CoV-2 incidence rate (February – October 2020) predicted a birth decline of 1.4 percentage points ($p<.001$)., net of degree of urbanization. For the cumulative first six months of the pandemic, a one standard deviation increase in the SARS-CoV-2 incidence rate (February – October 2020) was associated with a 1.1 percentage birth decline ($p<.001$).

Finally, it is noteworthy that most of the statistical variation in the surplus and deficit births that occurred across Europe between November 2020 and June 2021 is absorbed by country (or country-cluster) fixed effects. While statistically significant, SARS-CoV-2 incidence rates and the highly urbanized status of a region explain only a relatively small portion of the variance. For instance, according to R^2 values in stepwise models (shown separately for each phase and for the cumulative fertility response in Tables AB1a-AB4c), 1% of variation in the cumulative fertility response across European regions is explained by the highly urbanized versus other regions indicator (AB4a), 5% by the SARS-CoV-2 incidence rates (AB4a), and 73.6% by country fixed effects alone (AB4c) (or 30% by country-cluster fixed effects, AB4b). The R^2 of the final model is 74.6, hence, some of the variance explained by the urbanization indicator and SARS-CoV-2 incidences is also absorbed by the country-level fixed effects.

Did between- and within country variance in the general fertility rate change in the aftermath of the first COVID-19 wave across Europe?

In further exploring the role of between- and within-country variance in fertility changes from prior to during the pandemic, we move to a different outcome measure, the general fertility rate. Figure 3 (panels a-d) shows the total variance, between-country variance, within-country variance, and the proportion of the variance explained by the between-country variance in the monthly general fertility rate, for the sample of all the regions in our data, for the years 2015-2021.

The total variance in birth rates increased substantially across our sample of European NUTS-2 regions post-pandemic, compared with the variance of prior years. The increase started in November 2020, peaked in December 2020, and remained elevated until May 2021 (panel a). This increase was exclusively driven by an increase in the between-country variance (panel b). In contrast, the within-country variance decreased between November 2020 and January 2021, returning to prior levels thereafter (panel c). The omega squared component confirms that the proportion of between-country variance increased substantially in November 2020 (panel d). The percent of variance in the general fertility rate in our sample that is explained by the between-country component increased by 5-10 percentage points between November 2020 and March 2021. It rose to unprecedented levels (86%) in December 2020, which makes this the month of highest between- and lowest within-country variance measured in the general fertility rate at any time point since 2015.

Furthermore, it is noteworthy that all variance measures of the general fertility rate across European regions are subject to a regular seasonality pattern, which mimics known seasonality patterns in birth rates themselves (Bobak & Gjonca, 2001; Cummings, 2009). The variance measures are usually lowest between September and January, thereafter increasing and then peaking between May and August. It is remarkable that the between-country variance increased to an all-time high in December 2020 and January 2021, which are months of the year when this measure is usually at its lowest. Hence, country level factors may have been of particular relevance for the phase 1 fertility response and for conception decisions during the earliest pandemic phase across Europe, leading to an unusual degree of sub-national homogeneity and cross-national heterogeneity in births rates in these months, compared with the same months in prior years.

Robustness checks (Figure AB2, panels a-d) indicate that France, Spain and Italy, all large and populous countries with many NUTS2 regions, are important contributors to the total sub-national variance in birth rates across Europe. Nonetheless, excluding each of them does not alter the general variance findings in the fertility response to the first half year of the COVID-19 pandemic. Total and between-country variances still rise to unprecedented levels, compared to the same months in prior years in the same sample, when each of these countries is excluded.

DISCUSSION

Interest in how fertility would develop in the aftermath of the COVID-19 pandemic spread rapidly after the pandemic started to hold the world in its grip. The unprecedented mix of health emergency, recession, and never-before-seen societal lockdowns spurred much speculation about how young adults, couples, and families with young children would cope, and how their fertility behaviors would be affected. Scientifically, this moment in time, in which the majority of the world's countries were simultaneously affected by this massive generalized crisis, offered a unique 'opportunity' to observe fertility rates unfold in its aftermath across societies. However, already in the decade prior to the pandemic, fertility rates had developed in puzzling ways, making it more challenging to estimate a true 'pandemic fertility response'. Since the Great Recession, total fertility rates had steeply fallen in many, but not all high income countries, most noteworthy in the US and Scandinavia, countries which had exhibited among the highest fertility rates across high-income countries prior to the Great Recession (Comolli et al., 2021; Schneider, 2015).

Against this backdrop, new questions emerged. Do first country level studies, which documented heterogeneous fertility responses across Europe, American and Asian countries mask sub-national heterogeneity (Aassve et al., 2021; Sobotka et al., 2021)? Did highly urbanized areas experience steeper fertility declines than other regions, perhaps in association with harsher living conditions amidst stay-at-home orders? Is the fertility response associated with local SARS-CoV-2 incidences? Did between- and within-country variance in the general fertility rate change in the aftermath of the first COVID-19 wave across Europe, i.e. did the relative weight of country level versus sub-national factors explaining fertility variation change during the crisis? Our study set out to address these questions and offers six main findings.

First, while sub-national variation in fertility in the aftermath of the first COVID-19 wave across Europe is present, the fertility response (i.e. deviations of observed from expected birth counts) was dominated by the country level. This conclusion is supported by spatial distributions and regression models of the fertility response, and by our variance analysis. In the regression models, country fixed effects explained the largest part of the variation in sub-national fertility responses (between 77 percent in phase 1 and 56 percent in phase 3). The variance analysis indicated that total and between-country variances in the general fertility rates increased to unprecedented levels since November 2020. The between-country contribution to the total variance reached up to almost 90 percent in December 2020. Our robustness checks confirm that this pattern was not driven by single outlier countries, corroborating the finding that a 'nationalization' of conception behaviors occurred during the first months of the COVID-19 pandemic across Europe, in conjunction with nation-specific policy responses to the COVID-19 pandemic onset, involving strict and unprecedented border closures across Europe (Medeiros et al., 2021). Future research is needed to analyze which socio-economic, health-related, and cultural factors, or pandemic containment measure policies may underlie this finding.

Second, significant but relatively small differences in the fertility response in highly urbanized regions versus all other regions across Europe emerged. Declines in November 2020-January 2021 births and in the cumulative fertility response to the first half year of the pandemic were significantly steeper in the most urbanized regions as compared to other regions, by 1.7 and 0.7 percentage points respectively. The generally more negative fertility response in highly urbanized regions was in part mediated by SARS-Cov-2 incidence rates. The question of which set of conditions produced this pattern remains to be addressed by future research. Changes in living conditions and quality of life during lockdowns – for instance due to crowded housing, social isolation, or economic uncertainty – were magnified in urban centers (Greteman et al., 2022.; Keller et al., 2022). Selective out-migration of couples planning or expecting a child may also have played a role. Studies document overall out-migration of cities during the pandemic (Åberg & Tondelli, 2021; Willberg et al., 2021), and future research may reveal whether that affected the fertility declines in large cities.

Third, we found that the higher a region's SARS-CoV-2 incidence rate was, the steeper was the decline in births for all phases but phase 2 (reopening phase conception). We used regional documented SARS-CoV-2 incidence rates instead of COVID-19 mortality to measure pandemic intensity because in the first months of the pandemic, sub-national infection rates were more widely reported than mortality rates, COVID-19 mortality was relatively low in many regions, infections preceded death by several weeks and were thus a more immediate measure, and infection risks may have been perceived as a threat to reproductive health or health care access. Future research is needed to investigate the precise channels of influence regional SARS-CoV-2 infection rates had on the fertility response.

Fourth, a north south gradient in the distribution of the fertility response in the aftermath of the first COVID-19 wave across Europe was present. It coincided in part with SARS-CoV-2 affectedness in the early phases of the pandemic. Our finding suggests that the pandemic may have served as a catalyst which ignited a trend reversal to the Nordic fertility declines of the last years. A case study on Finland corroborates the possibility of the early pandemic reinforcing a general trend reversal (Nisén et al. 2022). However, it remains to be seen how fertility will develop in the aftermath of subsequent waves across Europe, in particular given that birth rates fell steeply in the first months of 2022 across most European nations, including Northern Europe (Sobotka et al. 2022). Also, despite our rigorous modeling of the fertility response to the Covid-19 pandemic based on cutting-edge methodology, how fertility would have developed in the absence of the pandemic remains uncertain.

Fifth, the fine-grained temporal analyses based on monthly data have revealed short-term fertility responses of remarkable magnitude. Phase 1 was characterized by in part steep declines across Southern- and Central-Eastern Europe, phase 2 was a ‘catch-up’ phase across many of these regions. Nonetheless, apart from significantly higher fertility than expected across many Northern European regions, few statistically significant deviations from expected numbers of births based on prior trends were found over the cumulative aftermath period of the first pandemic wave across Europe. Hence, monthly data has much to reveal when it comes to studying disaster-aftermath fertility fluctuations, and depicts temporally heterogeneous trends that would remain hidden in analyses of yearly data. The findings also remind us of that the decision to postpone or avoid a pregnancy can more immediately be realized than a decision for a pregnancy, as achieving a conception may take several months for many couples (Buck Louis et al., 2014).

Finally, our study also makes methodological and data-related advances. Analyses of monthly data on births at the sub-national level over a large geographic area and multiple-year-time span are unprecedented in fertility research. They have, for example, also revealed that the *variance* in the general fertility rate is subject to pronounced seasonality. Furthermore, we offer a rigorous methodological approach for the estimation of the fertility response following a disaster, making the approximation of a causal effect plausible. Some caveats remain, too. The data for 2021 is still preliminary for most countries. Results for Switzerland and Croatia are based on adjusted estimates and should be interpreted with caution (please see table AA1 for further details). Further, we rigorously modeled trends of the fertility response across sub-national regions in Europe, but provide answers to the underlying mechanisms only to a limited extent.

CONCLUSIONS

In sum, our study shows that the fertility response to the first pandemic wave varied across sub-national regions, but was largely clustered on the country level. Country-level variation on fertility rates increased sharply starting in November 2020 while within-country variation became less pronounced. Hence, country-level estimates likely represent fertility in the aftermath of the COVID-19 pandemic fairly well. Nonetheless, we show that highly urbanized areas and areas with higher SARS-CoV-2 incidence rates experienced steeper fertility declines and deserve more attention in future studies on post-pandemic fertility.

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COVID-19 in the UK Dashboard 2021: https://coronavirus.data.gov.uk/details/download

Our Word in Data 2021: https://ourworldindata.org/coronavirus

COVID-19 Regional Labor Tracker 2021: https://crl-uoa-youthshare.hub.arcgis.com/datasets/15b2e476250b41a7abe597d5c46413a2_1/explore?location=50.782896%2C13.890515%2C6.00&showTable=true

COVID19-European-Regional-Tracker 2021: https://github.com/asjadnaqvi/COVID19-European-Regional-Tracker

TABLES AND FIGURES

Figure 1

The Fertility Response by Phases and Cumulative over 11/20-6/21. 90% Confidence Intervals

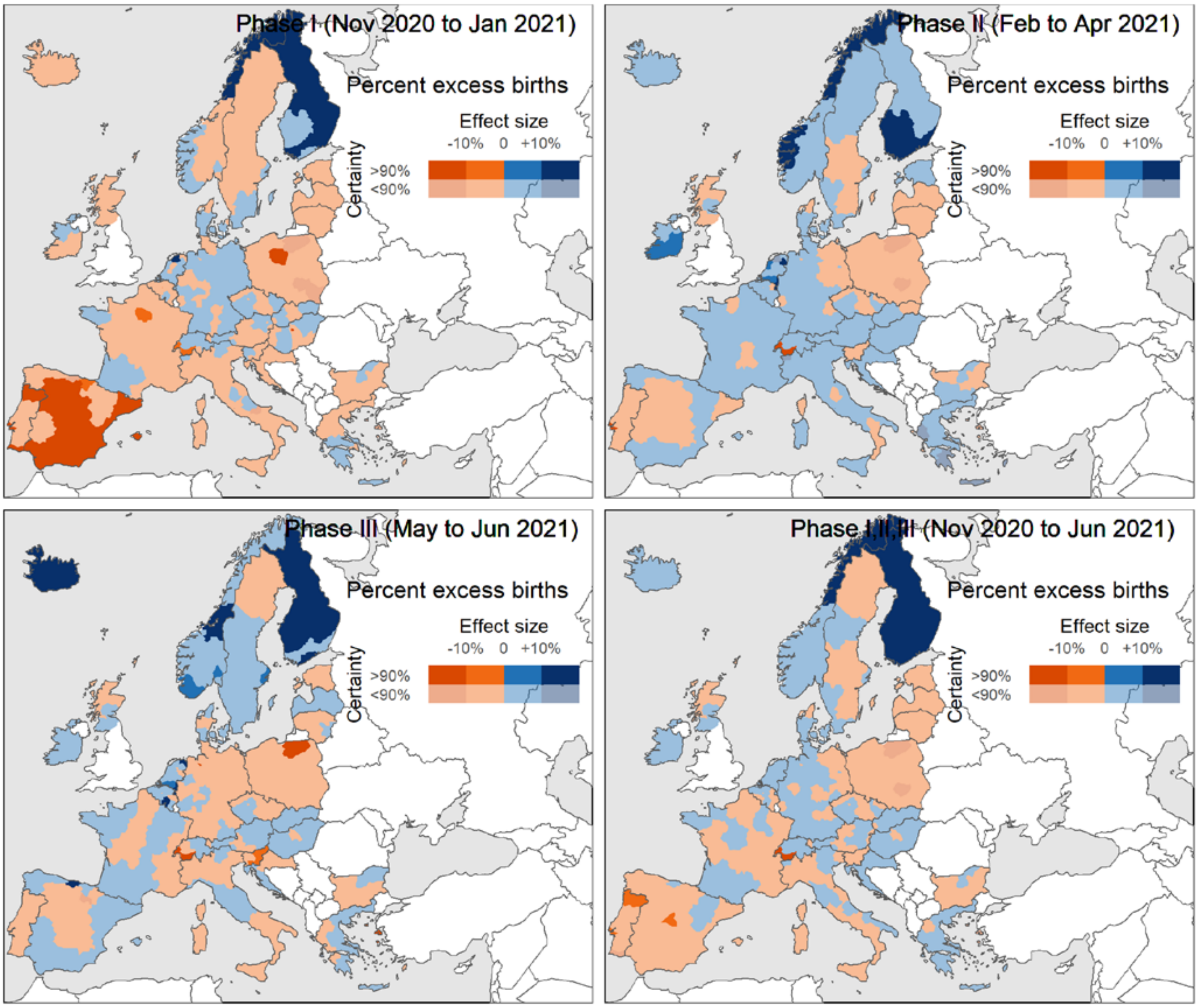


Figure 2

Violin Plots of the Fertility Response in Highly Urbanized versus All Other Regions. By Phases and Cumulative over 11/20-6/21.

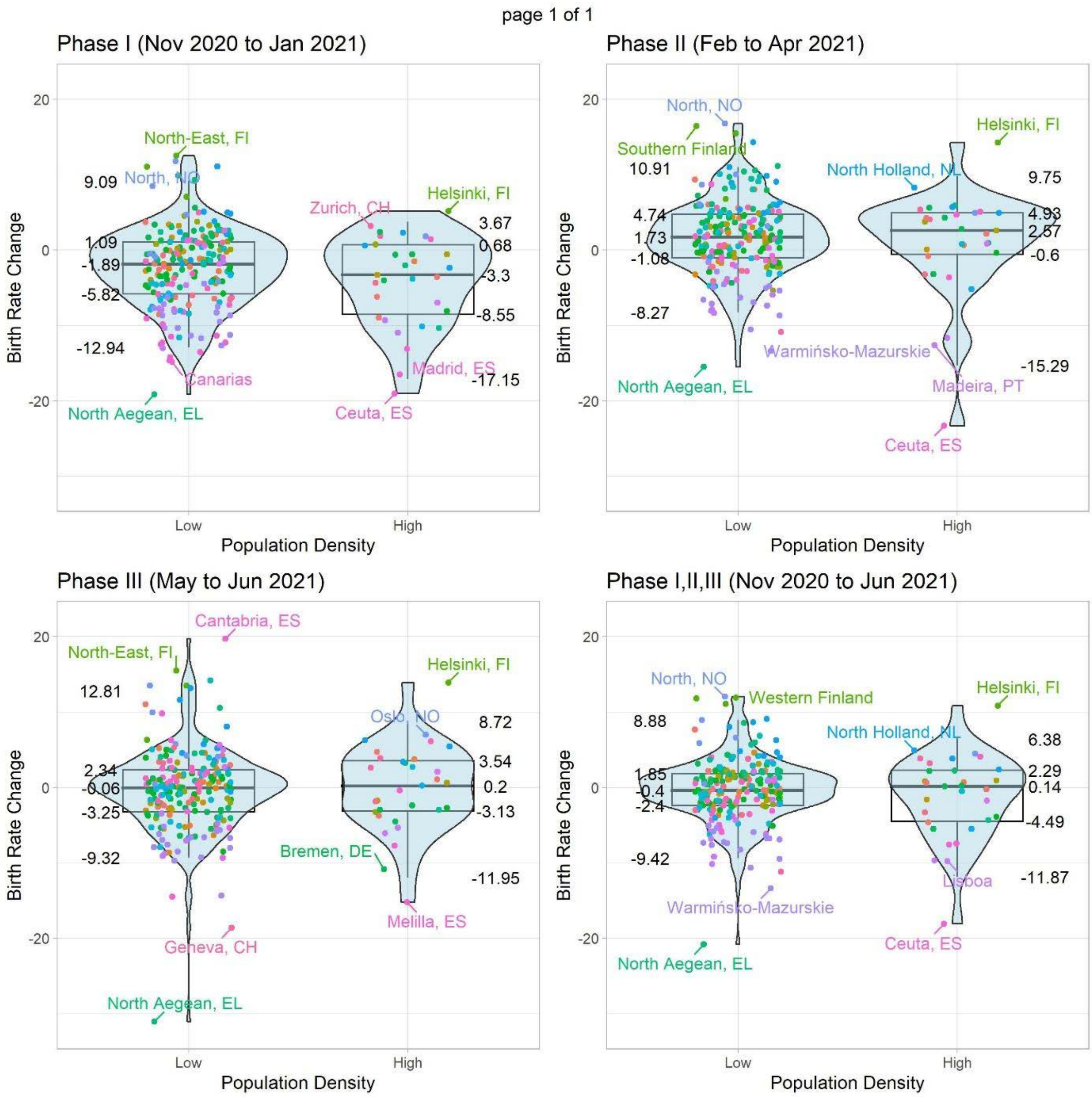
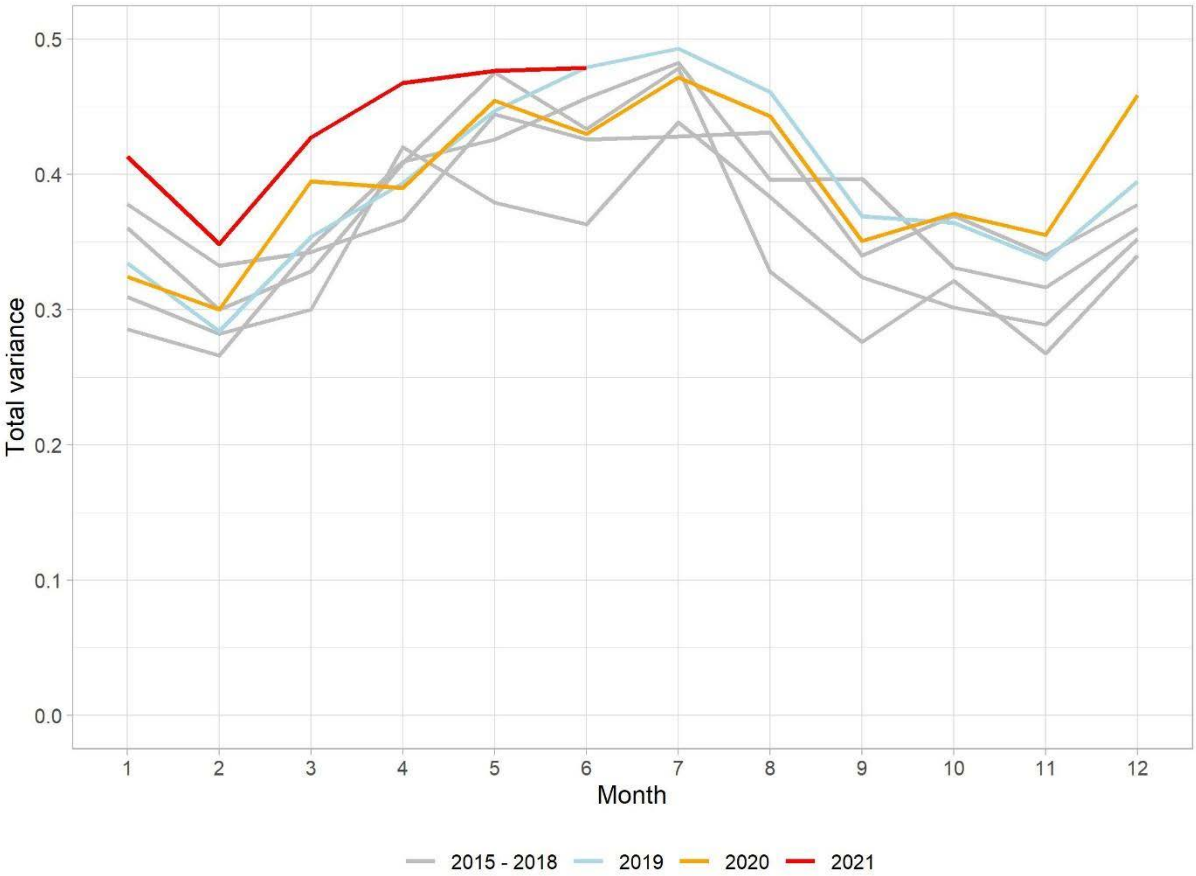


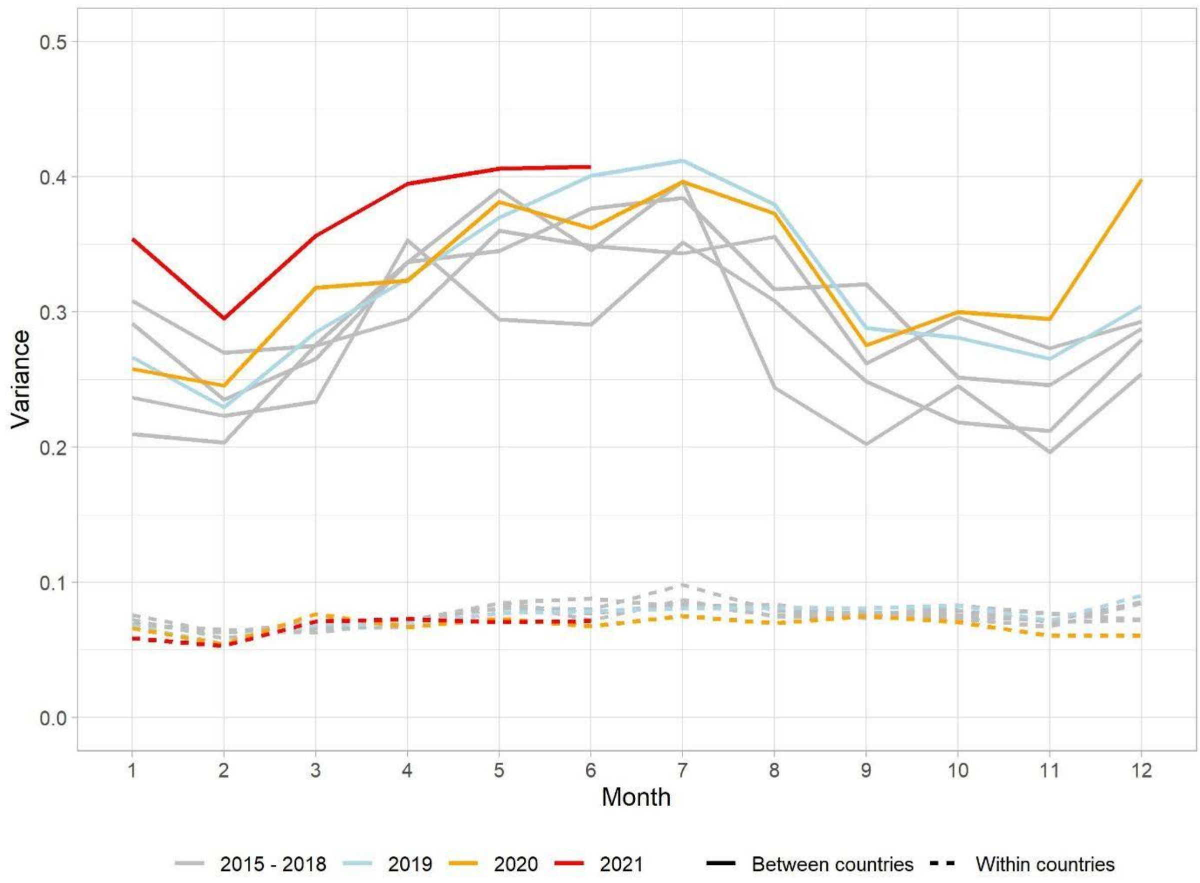
Figure 3, panels a-c:

Monthly Variance in the General Birth Rate across 227 European Regions Between January 2015 and June 2021.

Panel a: Total Variance in the General Birth Rate



Panel b: The Absolute Between (Solid Line) and Between (Dashed Line) Country Variance in the General Birth Rate



Panel c: The Relative Contribution of the Between-Country Component to the Total Variance (Omega Squared) in the General Birth Rate

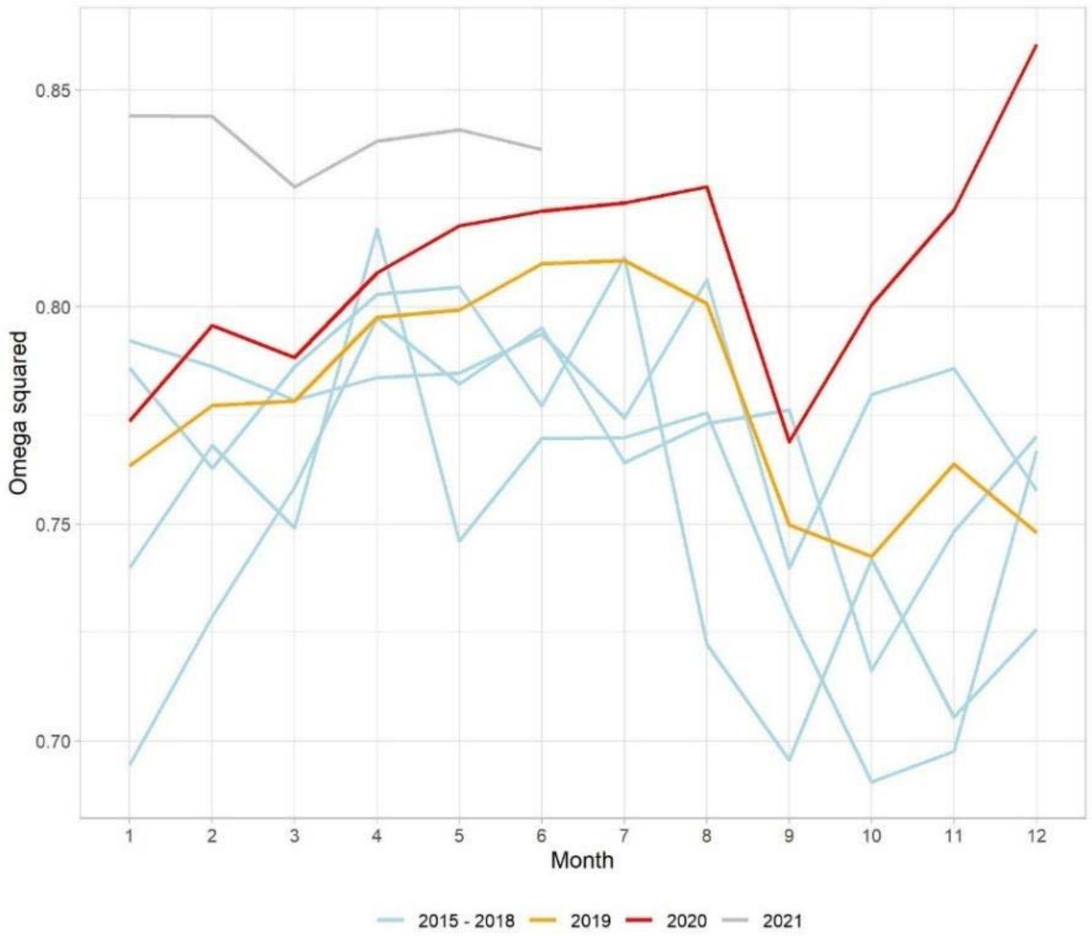


Table 1. Predicting the Fertility Response in a) highly urbanized vs. other regions, and b) by SARS-CoV-2 incidence.

Separate models for Phase 1 (11/2020-1/2021 births), Phase 2 (2/2021-4/2021 births), Phase 3 (5/2021-6/2021 births), and all Phases (11/2020-6/2021 births), country fixed effects

	Model 1	Model 2	Model 3
Phase 1			
Highly Urbanized	-2.128*** (0.471)		-1.765*** (0.491)
SARS-CoV-2 incidence (Feb-May 2020)		-0.923*** (0.254)	-0.652** (0.258)
Phase 2			
Highly Urbanized	-0.638 (0.464)		-0.576 (0.488)
SARS-CoV-2 incidence (Feb-Jun 2020)		-0.201 (0.247)	-0.111 (0.259)
Phase 3			
Highly Urbanized	-0.611 (0.572)		-0.038 (0.603)
SARS-CoV-2 incidence (Feb-Oct 2020)		-1.430*** (0.499)	-1.418*** (0.536)
All Phases			
Highly Urbanized	-1.162*** (0.383)		-0.714* (0.404)
SARS-CoV-2 incidence (Feb-Oct 2020)		-1.335*** (0.337)	-1.106*** (0.359)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: Model 1: country fixed effects & urbanization degree; Model 2: country fixed effects & SARS-CoV-2 incidence; Model 3: country fixed effects, urbanization degree & SARS-CoV-2 incidence. All models estimated separately for the 4 phases.
Note 3: Full tables for all phases and models are located in appendix AB (tables AB1-AB3). They provide details on sample sizes, constant, and additional parameters.

APPENDIX A—ADDITIONAL INFORMATION ON DATA AND METHOD

TABLE AA1 Overview of data on monthly births and female population aged 15-49

Country	Monthly births	Female population 15-49[1]	Notes	Data source
Austria	1.2000-12.2021	2000-2001 (annual), 2002-2020 (quarterly), 2021 (annual), 2022 (1st quarter)	–	Statistics Austria
Belgium	1.1998-8.2021	1998-2021 (annual)	2021 births are preliminary	Statistics Belgium
Bulgaria	1.2007-12.2021	1.2007-1.2022	–	National Statistical Institute (Bulgaria)
Croatia	1.2000-12.2020, 1.2021-6.2021 (estimates)	2001-2021 (annual)	2021 births are preliminary and are estimates[2]	Croatian Bureau of Statistics; Croatian Ministry of Justice and Public Administration
Czechia	1.2000-6.2021	2001-2021 (annual)	2021 births are preliminary	Czech Statistical Office
Denmark	1.2000-6.2021	2000-2007 (annual), 2008-2021 (quarterly)	2021 births are preliminary	Statistics Denmark
Estonia	1.2000-12.2021	2000-2021 (annual)	–	Statistics Estonia
Finland	1.2000-6.2021	2000-2014 (annual), 2015-2021 (monthly)	2021 births are preliminary	Statistics Finland
France	1.2000-6.2021	2000-2021 (annual)	2021 births are preliminary	National Institute of Statistics and Economic Studies (Insee)
Germany	1.2011-8.2021	2011-2021 (annual)	2021 births are preliminary[3]	Federal Statistical Office of Germany (Destatis)
Greece	1.2000-6.2021	2000-2021 (annual)	2021 births are preliminary[4]	Hellenic Statistical Authority (ELSTAT); Ministry of Interior (Greece)
Hungary	1.2000-6.2021	2000-2021 (annual)	2021 births are preliminary	Hungarian Central Statistical Office
Iceland	1.2000-12.2021	2000-2021 (annual)	2021 births are preliminary	Statistics Iceland
Ireland	1.2005-6.2021	2005-2021 (annual)	2019-2021 births are preliminary[5]	General Register Office (Ireland)
Italy[6]	1.2003-10.2021	2002-2021 (annual)	2021 births are preliminary. Births for 2003-2018 are by month of registration, and births for 2019-2021 are by month of occurrence.	Istituto Nazionale di Statistica (ISTAT)
Latvia	1.2000-6.2021	2000-2021 (annual)	2021 births are preliminary	Statistics Latvia

Lithuania	1.2000-8.2021	2000-2021 (annual)	2021 births are preliminary	Statistics Lithuania
Netherlands	1.2000-6.2021	2000-2021 (annual)	2021 births are preliminary	Statistics Netherlands
Norway	1.2000-12.2021	2000-2021 (annual)	–	Statistics Norway
Poland	1.2000-12.2021	1.2003-1.2021	2000-2014 births for NUTS2 regions (but not at the national level) include stillbirths	Statistics Poland
Portugal	1.2000-10.2021	2000-2021 (annual)	2021 births are preliminary	Statistics Portugal
Romania	1.2000-7.2021	2000-2021 (annual)	2020 births are semi-final (by date of occurrence but some late registered births may still be added), and 2021 births are preliminary (by month of registration).	Statistics Romania
Slovakia	1.2003-6.2021	2000-2021 (annual)	2021 births are preliminary. All birth data are by month of registration.	Statistical Office of the Slovak Republic
Slovenia	1.2000-6.2021	2008-2021 (annual)[7]	2021 births are preliminary	Statistical Office of the Republic of Slovenia
Spain	1.2000-7.2021	2000-2021 (monthly estimates)	2021 births are preliminary	National Statistics Institute (INE)
Sweden	1.2000-7.2021	2000-2021 (monthly)	2021 births are preliminary	Statistics Sweden
Switzerland	1.2000-12.2020, 1.2021-9.2021 (estimates)	2000-2021 (annual)	2021 births are preliminary[8]	Swiss Federal Statistical Office
UK, Scotland	1.2000-8.2021	2000-2020 (annual, mid-year)	2021 births are preliminary	National Records of Scotland (NRS)
UK, Northern Ireland	1.2020-8.2021	2000-2020 (annual, mid-year)	2021 births are preliminary	Northern Ireland Statistics and Research Agency (NISRA)

[1] In all countries, data on female population aged 15-49 refer to the beginning of the year (i.e. January 1), the quarter or the month, respectively, except for Ireland where it always refers to the 1st of April, and for Scotland and Northern Ireland in the UK, for which mid-year population estimates were used.

[2] **Croatia**: Births for 2000-2020 are final and come from the CBS. Provisional births for 2021, provided by the Croatian Ministry of Justice and Public Administration, were by month of occurrence but linked to place of birth rather than to mother's place of residence, and they also included births to foreign mothers. For correction of these births, provisional births for 2021 from the CBS were used, which are by month of registration but related to mother's place of residence and exclude births to foreign mothers.

[3] **Germany**: Due to larger shares of population of foreign origin, delayed registrations of births are likely to be more frequent in regions of Berlin, Bremen, Hamburg, Düsseldorf, and Hannover.

[4] **Greece:** Births for 2000-2020 are final and come from the Hellenic Statistical Authority (ELSTAT), whereas preliminary births for 2021 were provided by the Ministry of Interior. However, checking of 2020 data showed that data from both sources are rather consistent.

[6] **Italy**: All data refer to the resident population of Italy.

[5] **Ireland**: Data come from the civil registers, which are provisional in nature and are subject to amendment and correction. Official (and thus final) vital statistics are published by the Central Statistics Office (CSO). According to the CSO, births for 2019-2021 are preliminary.

[7] **Slovenia**: Starting from January 2008, the Statistics Slovenia uses a new definition of population, which makes population data since 2008 not directly comparable to data of previous years.

[8] **Switzerland**: Provisional data on births for 2021 were adjusted for undercount and biases caused by delayed registrations of births, which is especially significant in cantons with large shares of foreigners, such as Lake Geneva region and Zürich. The scaling factor was estimated using data on births for 2019.

TABLE AA2 Sample Descriptives

Country	NUTS2 regions (*n*)	Obs. births[1], Phase 1	Predict. births[2], Phase 1	Fertility resp., Phase 1	Obs. births[1], Phase 2	Predict. births[2], Phase 2	Fertility resp., Phase 2	Obs. births[1], Phase 3	Predict. births[2], Phase 3	Fertility resp., Phase 3	Obs. births[1], Phases 1,2,3	Predict. births[2], Phases 1,2,3	Fertilit y resp., Phases 1,2,3	COVID-19 cases per 100,000 Feb-May 2020	COVID-19 cases per 100,000 Feb-Jun 2020	COVID-19 cases per 100,000 Feb-Oct 2020
Europe	241	927946	961660	-3.51	963299	951565	1.23	661298	665722	-0.66	2552543	2578947	-1.02	na	na	na
Austria	9	19869	20069	-1	20479	20130	1.73	14346	14174	1.21	54694	54373	0.59	187	200	1257
Belgium	11	26030	27484	-5.29	28387	27555	3.02	19574	19269	1.58	73991	74308	-0.43	401	421	3587
Bulgaria	6	13625	14034	-2.91	14507	14380	0.88	9795	10052	-2.56	37927	38466	-1.4	na	na	na
Switzerland	7	20618	20471	0.72	21125	20771	1.71	14357	14684	-2.22	56101	55926	0.31	343	354	1881
Czechia	8	25875	26039	-0.63	27122	26984	0.51	18635	19070	-2.28	71632	72093	-0.64	84	106	3034
Germany	30	152377	151044	0.88	158429	152487	3.9	106975	109168	-2.01	417781	412699	1.23	241	257	702
Germany, East. states	8	31939	31471	1.49	31842	31783	0.19	22093	22705	-2.7	85874	85959	-0.1	129	143	475
Denmark	5	14438	14419	0.13	15044	14654	2.66	10568	10505	0.6	40050	39578	1.19	199	217	825
Estonia	1	2976	3109	-4.28	3279	3252	0.83	2246	2364	-4.99	8501	8725	-2.57	141	150	369
Greece	13	19833	20090	-1.28	20229	19193	5.4	13676	13459	1.61	53738	52742	1.89	21	24	319
Spain	19	73330	83773	-12.47	80618	80646	-0.03	55738	54591	2.1	209686	219010	-4.26	518	540	2774
Finland	4	11213	10355	8.29	12137	10716	13.26	8318	7375	12.79	31668	28446	11.33	126	131	299
France	22	162390	170237	-4.61	163556	162876	0.42	114931	115439	-0.44	440877	448552	-1.71	77	93	2136
Croatia	2	8787	8879	-1.04	8600	8367	2.79	5569	5619	-0.89	22957	22865	0.4	50	63	1210
Hungary	8	21934	22145	-0.95	21984	21321	3.11	14743	14645	0.67	58661	58111	0.95	35	38	766
Ireland	3	13873	13976	-0.74	14578	13444	8.43	9432	9186	2.68	37883	36606	3.49	509	519	1259
Iceland	1	1042	1057	-1.42	1196	1090	9.72	861	754	14.19	3099	2901	6.83	496	501	1336
Italy	20	93499	99152	-5.7	93638	91905	1.89	62417	63220	-1.27	249554	254277	-1.86	384	396	1114
Lithuania	2	5402	5838	-7.47	5749	6047	-4.93	4333	4336	-0.07	15484	16221	-4.54	57	62	604
Latvia	1	3928	4063	-3.32	4069	4202	-3.17	2984	2964	0.67	10981	11229	-2.21	35	38	288
Netherlands	12	40731	39896	2.09	42772	39904	7.19	29518	28032	5.3	113021	107832	4.81	264	286	2002
Norway	7	12024	11697	2.8	13835	12943	6.89	9906	9292	6.61	35765	33932	5.4	100	108	313

TABLE AA2 Sample Descriptives

Country	NUTS2 regions (*n*)	Obs. births[1], Phase 1	Predict. births[2], Phase 1	Excess births, Phase 1	Obs. births[1], Phase 2	Predict. births[2], Phase 2	Excess births, Phase 2	Obs. births[1], Phase 3	Predict. births[2], Phase 3	Excess births, Phase 3	Obs. births[1], Phases 1,2,3	Predict. births[2], Phases 1,2,3	Excess births, Phases 1,2,3	COVID-19 cases per 100,000 Feb-May 2020	COVID-19 cases per 100,000 Feb-Jun 2020	COVID-19 cases per 100,000 Feb-Oct 2020
Poland	16	78808	86230	-8.61	83491	88586	-5.75	55826	60201	-7.27	218125	235017	-7.19	53	75	817
Portugal	7	19085	21122	-9.64	18640	20492	-9.04	13321	14199	-6.18	51046	55813	-8.54	283	369	411
Sweden	8	25298	25530	-0.91	28874	28529	1.21	20532	20019	2.56	74704	74078	0.85	374	657	1278
Slovenia	2	4377	4373	0.09	4344	4448	-2.34	2974	3176	-6.36	11695	11997	-2.52	70	76	1689
Slovakia	4	13620	13681	-0.45	13651	13539	0.83	9629	9348	3.01	36900	36568	0.91	28	31	1100
United Kingdom	5	11025	11426	-3.51	11123	11321	-1.75	8001	7876	1.59	30149	30623	-1.55	322	333	1199

[1] Observed number of births. [2] Predicted number of births.

APPENDIX B—ADDITIONAL INFORMATION ON RESULTS AND ROBUSTNESS CHECKS

Figure AB1 Excess Births by Phases and Cumulative over 11/20-6/21. 50% Confidence Intervals

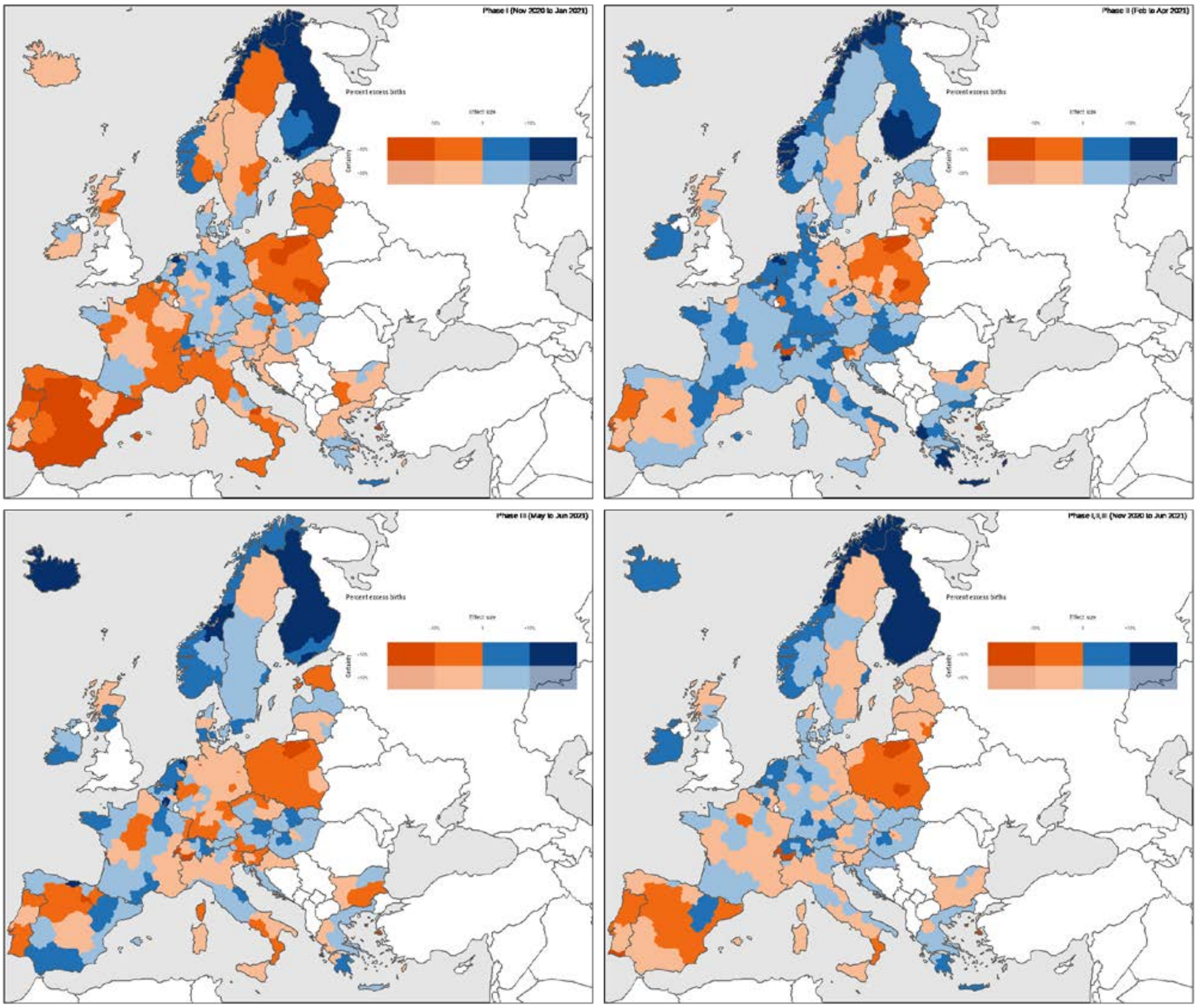
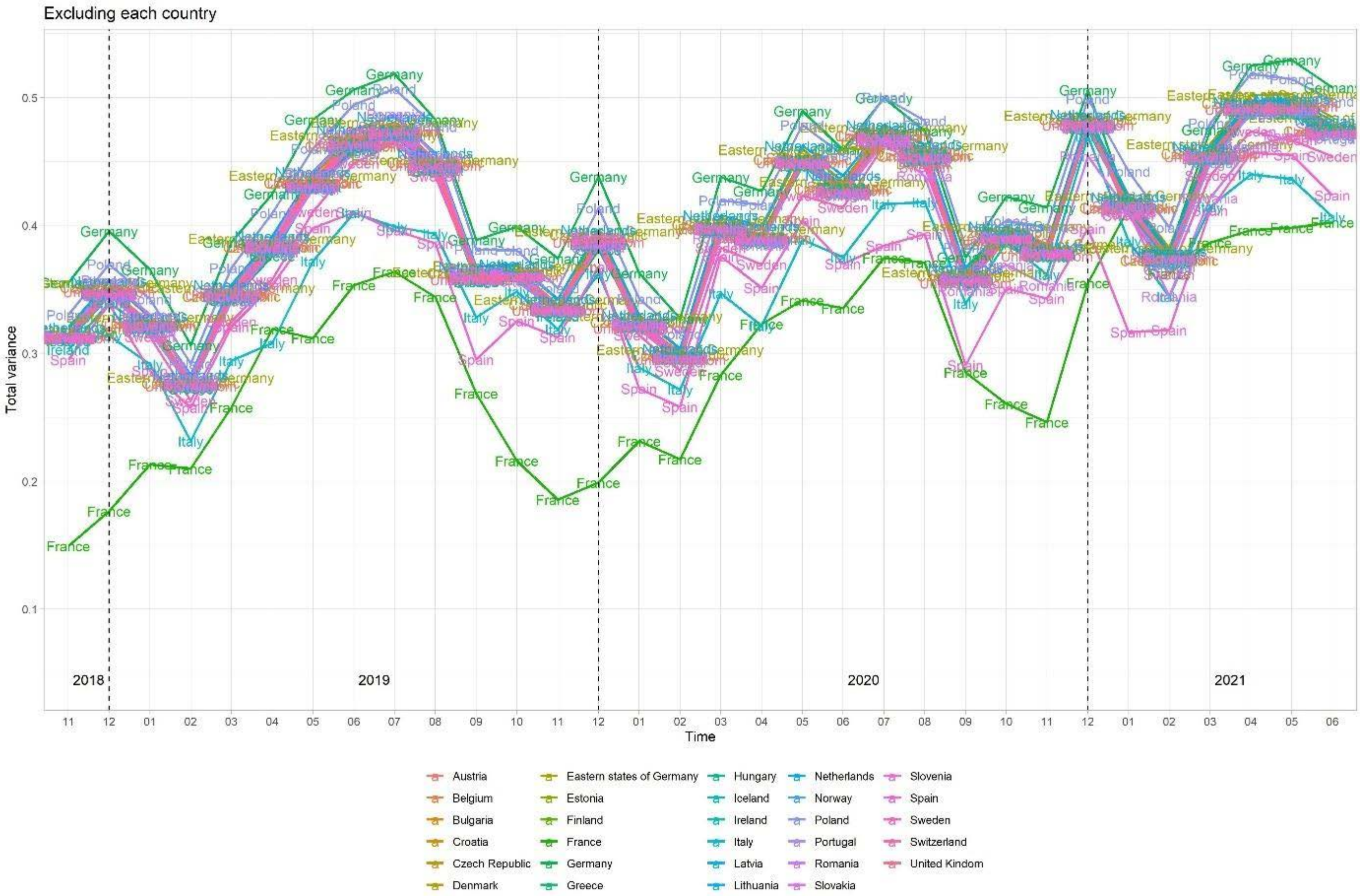


Figure AB2, panels a-d:

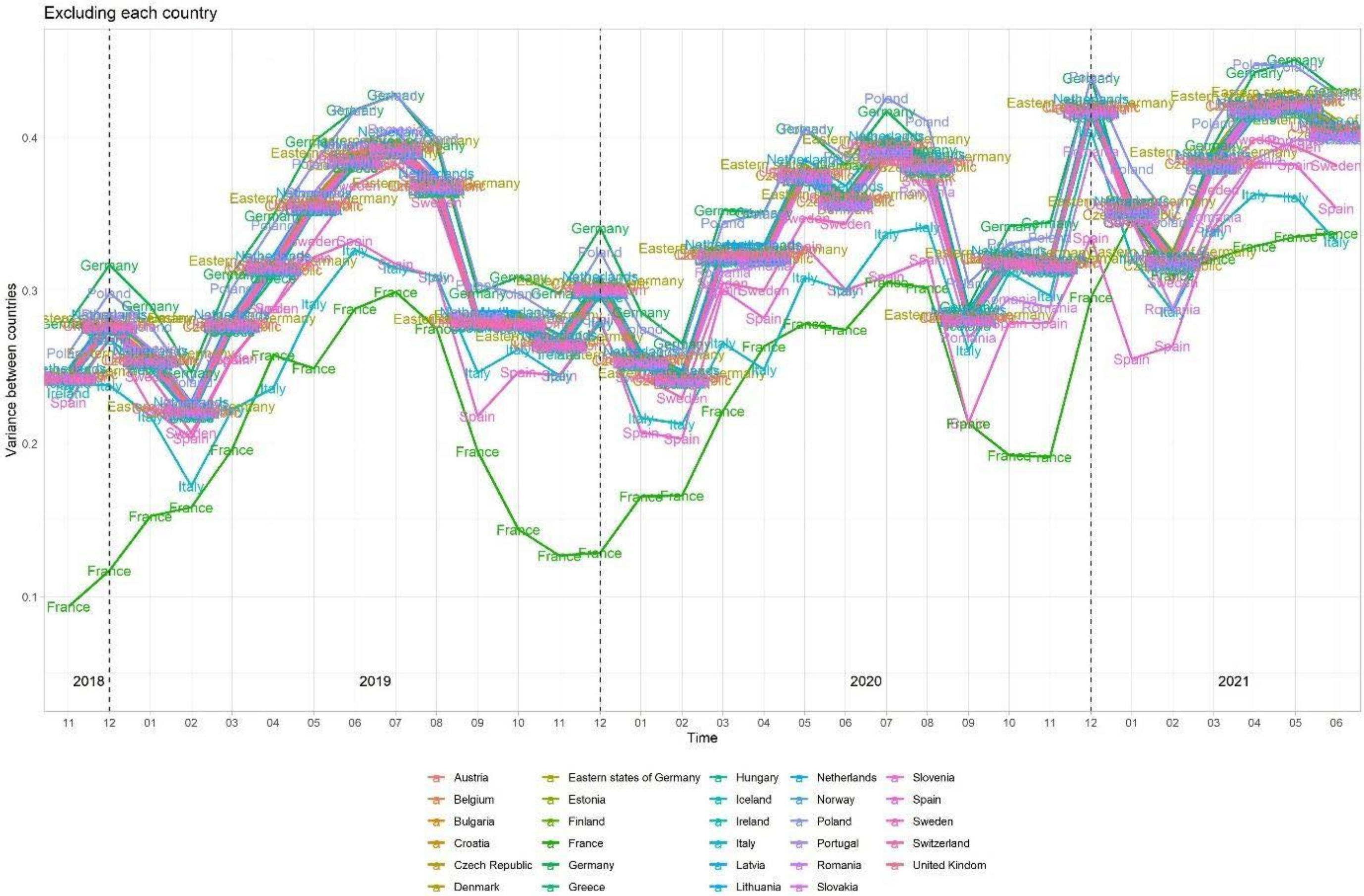
Monthly Variance in Birth Rates across 227 European Regions Between January 2015 and June 2021 for the full sample of regions *under exclusion of each country (as denoted)*.

Panel a: Total Variance of the General Birth Rate



Note: Country names next to each line indicate which country was excluded in the corresponding estimation

Panel b: Absolute Between Country Variance of the General Birth Rate

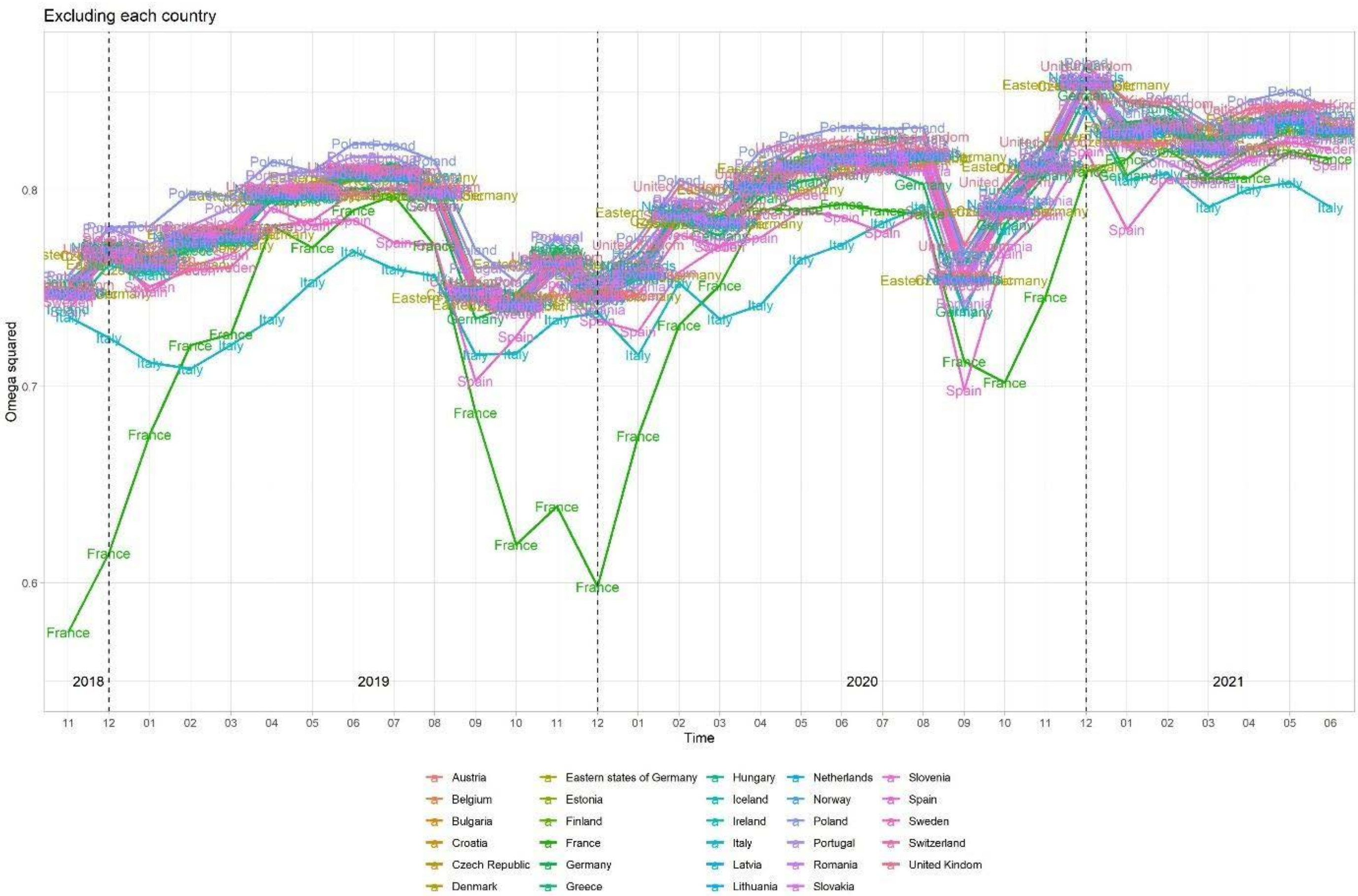


Note: Country names next to each line indicate which country was excluded in the corresponding estimation

Panel c: Absolute Within Country Variance of the General Birth Rate

Note: Country names next to each line indicate which country was excluded in the corresponding estimation

Panel d: The Relative Contribution of the Between-Country Component to the Total Variance (Omega Squared) of the General Birth Rate



Note: Country names next to each line indicate which country was excluded in the corresponding estimation

Figure AB3: Within-Country Variance of the General Birth Rate in 2015-2021

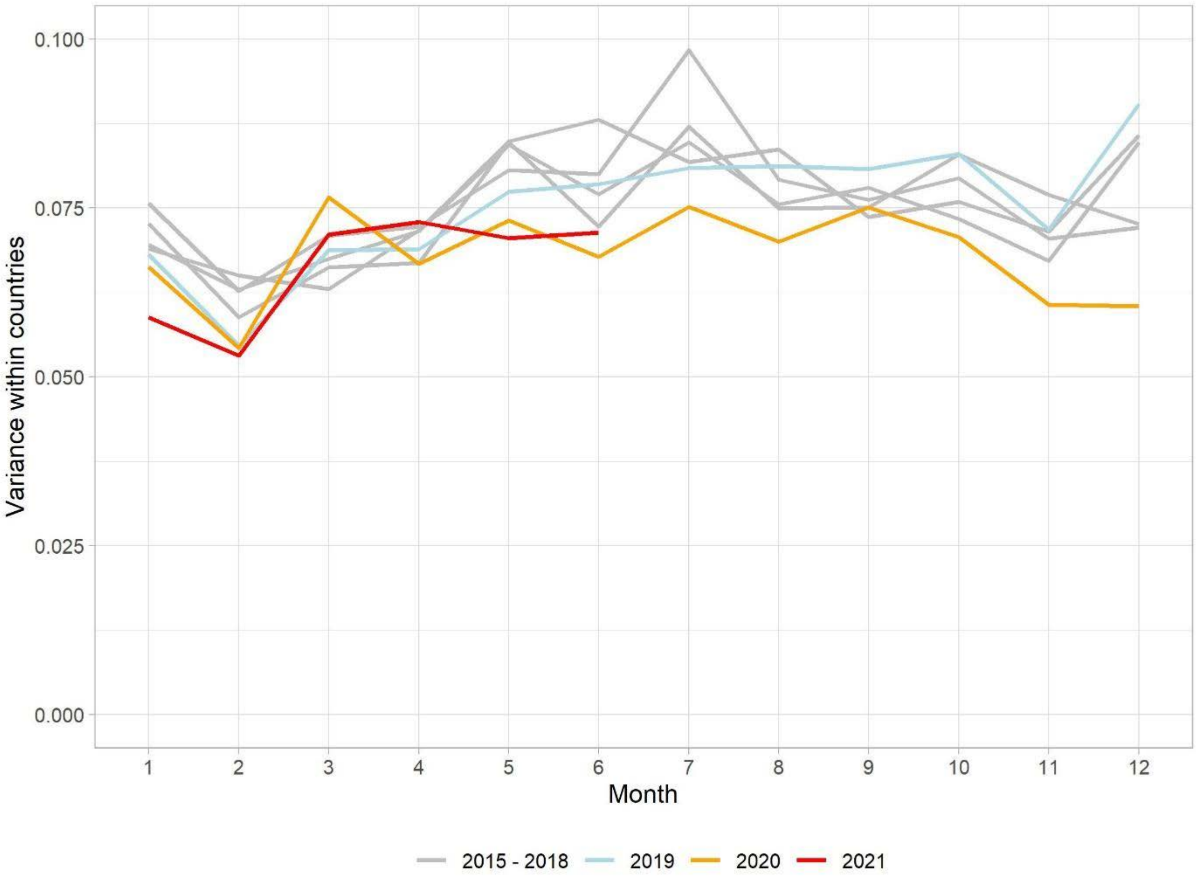


Table AB1a: Predicting the Fertility Response in Phase 1 (11/2020-1/2021 births), no fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
HighDensityRegionCapitalHigh		-0.484		-0.058
		(0.901)		(0.918)
SARS-CoV-2			-0.814***	-0.810***
			(0.300)	(0.307)
Constant	-3.640***	-3.555***	0.422	0.414
	(0.342)	(0.377)	(1.521)	(1.531)
Observations	241	241	234	234
R^2	0.000	0.001	0.031	0.031
Adjusted R^2	0.000	-0.003	0.027	0.022
Residual Std. Error	7,189.696 (df = 240)	7,200.379 (df = 239)	7,155.673 (df = 232)	7,171.083 (df = 231)
F Statistic		0.288 (df = 1; 239)	7.354*** (df = 1; 232)	3.663** (df = 2; 231)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including May 2020 in each region

Table AB1b: Predicting the Fertility Response in Phase 1 (11/2020-1/2021 births), country cluster fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
Nordic	6.763***	7.085***	7.738***	7.871***
	(1.259)	(1.259)	(1.329)	(1.326)
Southern	-3.178***	-3.027***	-1.961**	-1.991**
	(0.803)	(0.801)	(0.954)	(0.951)
Western	3.717***	3.983***	4.591***	4.690***
	(0.742)	(0.746)	(0.849)	(0.847)
HighDensityRegionCapitalHigh		-1.544**		-1.232*
		(0.719)		(0.728)
SARS-CoV-2			-0.757***	-0.675**
			(0.271)	(0.274)
Constant	-4.856***	-4.772***	-1.949	-2.179*
	(0.626)	(0.622)	(1.222)	(1.225)
Observations	241	241	234	234
R^2	0.379	0.391	0.402	0.409
Adjusted R^2	0.371	0.381	0.392	0.396
Residual Std. Error	5,700.084 (df = 237)	5,657.161 (df = 236)	5,657.083 (df = 229)	5,634.217 (df = 228)
F Statistic	48.277*** (df = 3; 237)	37.911*** (df = 4; 236)	38.491*** (df = 4; 229)	31.616*** (df = 5; 228)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: Reference country cluster for country fixed effects: Western-Central
Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including May 2020 in each region

Table AB1c: Predicting the Fertility Response in Phase 1 (11/2020-1/2021 births), country fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
Austria		3.752**	3.315**	3.267**
		(1.617)	(1.669)	(1.623)
Bulgaria		1.527		
		(1.741)		
Croatia		3.259	2.105	2.023
		(2.090)	(2.200)	(2.139)
Czech Republic		4.003**	3.011*	3.022*
		(1.541)	(1.630)	(1.584)
Denmark		5.187***	4.484**	4.631**
		(1.840)	(1.899)	(1.846)
Eastern States of Germany		6.340***	5.541***	5.612***
		(1.396)	(1.461)	(1.420)
Estonia		0.013	-0.157	-0.528
		(3.318)	(3.406)	(3.313)
Finland		13.525***	12.237***	12.542***
		(1.875)	(1.961)	(1.908)
France		0.449	-0.944	-0.741
		(1.160)	(1.282)	(1.248)
Germany		5.606***	5.472***	5.299***
		(1.158)	(1.192)	(1.160)
Greece		3.738**	0.647	1.531
		(1.534)	(1.793)	(1.760)
Hungary		3.485**	1.114	1.594
		(1.575)	(1.783)	(1.738)
Iceland		2.872	3.865	3.153

	(6.139)	(6.290)	(6.119)
Ireland	3.575*	4.500**	3.808*
	(1.956)	(1.998)	(1.952)
Italy	-1.149	-0.968	-1.332
	(1.172)	(1.199)	(1.170)
Latvia	0.968	-0.484	-0.479
	(2.821)	(2.951)	(2.869)
Lithuania	-2.374	-4.055	-3.651
	(2.410)	(2.521)	(2.454)
Netherlands	7.494***	6.875***	7.156***
	(1.376)	(1.415)	(1.378)
Norway	7.472***	6.338***	6.530***
	(1.894)	(1.978)	(1.924)
Poland	-4.351***	-5.632***	-5.693***
	(1.230)	(1.386)	(1.348)
Portugal	-4.545***	-4.887***	-4.863***
	(1.552)	(1.596)	(1.551)
Slovakia	4.207**	2.236	2.532
	(1.883)	(2.044)	(1.989)
Slovenia	4.355	3.521	3.345
	(2.727)	(2.824)	(2.746)
Spain	-7.701***	-7.238***	-7.629***
	(1.195)	(1.220)	(1.191)
Sweden	3.780**	3.931**	3.728**
	(1.555)	(1.593)	(1.549)
Switzerland	5.690***	5.487***	5.484***
	(1.632)	(1.675)	(1.629)
United Kingdom	1.428	1.405	1.314
	(1.879)	(1.926)	(1.873)

HighDensityRegionCapitalHigh		-2.128***		-1.765***
		(0.471)		(0.491)
SARS-CoV-2			-0.923***	-0.652**
			(0.254)	(0.258)
Constant	-3.640***	-4.291***	0.443	-0.525
	(0.342)	(1.081)	(1.869)	(1.837)
Observations	241	241	234	234
R^2	0.000	0.777	0.770	0.783
Adjusted R^2	0.000	0.748	0.740	0.754
Residual Std. Error	7,189.696 (df = 240)	3,610.890 (df = 212)	3,701.007 (df = 206)	3,598.286 (df = 205)
F Statistic		26.410*** (df = 28; 212)	25.509*** (df = 27; 206)	26.484*** (df = 28; 205)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: Reference country for country fixed effects: Belgium
Note 3: Covid: Cumulative SARS-CoV-2 Cases until including May 2020 in each region

Table AB2a: Predicting the Fertility Response in Phase 2 (2/2021-4/2021 births), no fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
HighDensityRegionCapitalHigh		0.633		0.402
		(0.752)		(0.769)
SARS-CoV-2			0.255	0.227
			(0.261)	(0.267)
Constant	1.266***	1.155***	0.058	0.129
	(0.285)	(0.314)	(1.351)	(1.360)
Observations	241	241	234	234
R^2	0.000	0.003	0.004	0.005
Adjusted R^2	0.000	-0.001	-0.0002	-0.003
Residual Std. Error	6,003.684 (df = 240)	6,007.332 (df = 239)	5,993.229 (df = 232)	6,002.634 (df = 231)
F Statistic		0.709 (df = 1; 239)	0.957 (df = 1; 232)	0.614 (df = 2; 231)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including June 2020 in each region

Table AB2b: Predicting the Fertility Response in Phase 2 (2/2021-4/2021 births), country cluster fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
Nordic	7.339***	7.401***	7.939***	7.952***
	(1.189)	(1.200)	(1.270)	(1.274)
Southern	2.839***	2.868***	3.483***	3.481***
	(0.759)	(0.763)	(0.894)	(0.896)
Western	4.724***	4.775***	5.227***	5.238***
	(0.701)	(0.712)	(0.800)	(0.804)
HighDensityRegionCapitalHigh		-0.301		-0.132
		(0.686)		(0.697)
SARS-CoV-2			-0.357	-0.348
			(0.264)	(0.269)
Constant	-2.188***	-2.172***	-0.867	-0.894
	(0.591)	(0.593)	(1.229)	(1.241)
Observations	241	241	234	234
R^2	0.206	0.206	0.207	0.207
Adjusted R^2	0.196	0.193	0.193	0.190
Residual Std. Error	5,384.468 (df = 237)	5,393.671 (df = 236)	5,383.307 (df = 229)	5,394.677 (df = 228)
F Statistic	20.458*** (df = 3; 237)	15.339*** (df = 4; 236)	14.934*** (df = 4; 229)	11.904*** (df = 5; 228)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: Reference country cluster for country fixed effects: Western-Central
Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including June 2020 in each region

Table AB2c: Predicting the Fertility Response in Phase 2 (2/2021-4/2021 births), country fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
Austria		-1.455	-1.518	-1.534
		(1.594)	(1.611)	(1.610)
Bulgaria		-2.369		
		(1.716)		
Croatia		-0.588	-0.733	-0.775
		(2.059)	(2.113)	(2.111)
Czech Republic		-2.794*	-2.941*	-2.946*
		(1.519)	(1.566)	(1.565)
Denmark		-0.462	-0.599	-0.553
		(1.813)	(1.832)	(1.831)
Eastern States of Germany		-3.255**	-3.397**	-3.375**
		(1.375)	(1.409)	(1.408)
Estonia		-2.538	-2.508	-2.628
		(3.270)	(3.289)	(3.287)
Finland		10.086***	9.814***	9.917***
		(1.848)	(1.895)	(1.895)
France		-2.738**	-2.973**	-2.920**
		(1.143)	(1.224)	(1.223)
Germany		0.650	0.658	0.600
		(1.141)	(1.151)	(1.151)
Greece		2.305	1.660	1.944
		(1.512)	(1.721)	(1.736)
Hungary		-0.047	-0.525	-0.365
		(1.552)	(1.721)	(1.725)
Iceland		6.357	6.630	6.400

	(6.050)	(6.073)	(6.070)
Ireland	5.081***	5.340***	5.117***
	(1.928)	(1.928)	(1.936)
Italy	-1.363	-1.281	-1.397
	(1.155)	(1.158)	(1.161)
Latvia	-6.533**	-6.780**	-6.776**
	(2.780)	(2.849)	(2.846)
Lithuania	-8.093***	-8.440***	-8.307***
	(2.375)	(2.434)	(2.434)
Netherlands	4.235***	4.091***	4.181***
	(1.356)	(1.366)	(1.367)
Norway	3.741**	3.517*	3.582*
	(1.867)	(1.911)	(1.910)
Poland	-9.132***	-9.403***	-9.443***
	(1.212)	(1.315)	(1.314)
Portugal	-11.975***	-11.993***	-12.004***
	(1.529)	(1.537)	(1.536)
Slovakia	-2.249	-2.622	-2.526
	(1.855)	(1.971)	(1.971)
Slovenia	-5.645**	-5.753**	-5.811**
	(2.687)	(2.726)	(2.723)
Spain	-3.300***	-3.162***	-3.289***
	(1.177)	(1.178)	(1.181)
Sweden	-2.132	-1.966	-2.081
	(1.532)	(1.540)	(1.542)
Switzerland	-1.383	-1.420	-1.419
	(1.609)	(1.618)	(1.616)
United Kingdom	-4.923***	-4.916***	-4.944***
	(1.852)	(1.860)	(1.858)

HighDensityRegionCapitalHigh		-0.638		-0.576
		(0.464)		(0.488)
SARS-CoV-2			-0.201	-0.111
			(0.247)	(0.259)
Constant	1.266^{***}	3.368^{***}	4.344^{**}	4.012^{**}
	(0.285)	(1.065)	(1.827)	(1.846)
Observations	241	241	234	234
R^2	0.000	0.690	0.686	0.688
Adjusted R^2	0.000	0.649	0.644	0.645
Residual Std. Error	6,003.684 (df = 240)	3,558.607 (df = 212)	3,573.305 (df = 206)	3,569.869 (df = 205)
F Statistic		16.825^{***} (df = 28; 212)	16.642^{***} (df = 27; 206)	16.128^{***} (df = 28; 205)

Note 1: $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Note 2: Reference country for country fixed effects: Belgium

Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including June 2020 in each region

Table AB3a: Predicting the Fertility Response in Phase 3 (5/2021-6/2021 births), no fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
HighDensityRegionCapitalHigh		0.841		0.663
		(0.776)		(0.792)
SARS-CoV-2			0.242	0.183
			(0.386)	(0.393)
Constant	-0.572*	-0.719**	-2.169	-1.876
	(0.295)	(0.325)	(2.721)	(2.745)
Observations	241	241	234	234
R^2	0.000	0.005	0.002	0.005
Adjusted R^2	0.000	0.001	-0.003	-0.004
Residual Std. Error	6,206.052 (df = 240)	6,203.821 (df = 239)	6,205.120 (df = 232)	6,209.120 (df = 231)
F Statistic		1.173 (df = 1; 239)	0.392 (df = 1; 232)	0.546 (df = 2; 231)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including October 2020 in each region

Table AB3b: Predicting 'Deficit/Surplus' Births in Phase 3 (5/2021-6/2021 births), country cluster fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
factor(region)Nordic	8.879***	8.858***	9.184***	9.214***
	(1.239)	(1.251)	(1.283)	(1.299)
factor(region)Southern	3.739***	3.729***	3.684***	3.694***
	(0.791)	(0.795)	(0.833)	(0.837)
factor(region)Western	3.535***	3.518***	3.454***	3.471***
	(0.730)	(0.742)	(0.776)	(0.786)
HighDensityRegionCapitalHigh		0.099		-0.117
		(0.715)		(0.729)
SARS-CoV-2			0.562	0.573
			(0.358)	(0.365)
Constant	-3.831***	-3.837***	-7.729***	-7.798***
	(0.616)	(0.618)	(2.577)	(2.618)
Observations	241	241	234	234
R^2	0.193	0.193	0.193	0.193
Adjusted R^2	0.183	0.180	0.179	0.175
Residual Std. Error	5,609.368 (df = 237)	5,621.009 (df = 236)	5,616.577 (df = 229)	5,628.563 (df = 228)
F Statistic	18.925*** (df = 3; 237)	14.140*** (df = 4; 236)	13.662*** (df = 4; 229)	10.888*** (df = 5; 228)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: Reference country cluster for country fixed effects: Western-Central
Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including October 2020 in each region

Table AB3c: Predicting the Fertility Response in Phase 3 (5/2021-6/2021 births), country fixed effects

	Dependent variable:			
	'Deficit/Surplus' Births			
	(1)	(2)	(3)	(4)
Austria		-0.616	-1.990	-1.983
		(1.962)	(1.991)	(1.998)
Bulgaria		-4.366**		
		(2.113)		
Croatia		-2.796	-4.014	-4.015
		(2.536)	(2.530)	(2.537)
Czech Republic		-4.246**	-4.230**	-4.239**
		(1.870)	(1.831)	(1.840)
Denmark		-1.097	-3.151	-3.135
		(2.232)	(2.308)	(2.327)
Eastern States of Germany		-4.445***	-7.332***	-7.312***
		(1.693)	(1.957)	(1.987)
Estonia		-6.980*	-9.893**	-9.880**
		(4.026)	(4.095)	(4.109)
Finland		10.780***	7.080***	7.109***
		(2.275)	(2.585)	(2.633)
France		-2.078	-2.706*	-2.707*
		(1.408)	(1.402)	(1.405)
Germany		-3.897***	-6.059***	-6.047***
		(1.405)	(1.588)	(1.603)
Greece		0.086	-3.452	-3.423
		(1.862)	(2.207)	(2.261)
Hungary		-1.123	-3.151	-3.140
		(1.911)	(2.016)	(2.028)
Iceland		12.203	11.129	11.126

	(7.450)	(7.321)	(7.339)
Ireland	0.710	-0.492	-0.494
	(2.374)	(2.373)	(2.379)
Italy	-3.067**	-4.637***	-4.633***
	(1.422)	(1.513)	(1.518)
Latvia	-1.314	-4.581	-4.565
	(3.423)	(3.567)	(3.585)
Lithuania	-1.901	-4.291	-4.274
	(2.924)	(2.992)	(3.013)
Netherlands	3.747**	2.904*	2.914*
	(1.670)	(1.661)	(1.673)
Norway	4.531**	1.045	1.071
	(2.299)	(2.574)	(2.612)
Poland	-9.317***	-11.150***	-11.149***
	(1.492)	(1.607)	(1.611)
Portugal	-8.014***	-11.227***	-11.203***
	(1.883)	(2.168)	(2.210)
Slovakia	1.100	-0.341	-0.337
	(2.284)	(2.305)	(2.312)
Slovenia	-8.407**	-9.153***	-9.159***
	(3.308)	(3.258)	(3.267)
Spain	0.233	-0.051	-0.056
	(1.450)	(1.424)	(1.430)
Sweden	0.619	-0.708	-0.701
	(1.886)	(1.914)	(1.921)
Switzerland	-3.898*	-4.844**	-4.837**
	(1.981)	(1.973)	(1.981)
United Kingdom	-0.195	-1.696	-1.686
	(2.280)	(2.301)	(2.312)

HighDensityRegionCapitalHigh		-0.611		-0.038
		(0.572)		(0.603)
SARS-CoV-2			-1.430***	-1.418***
			(0.499)	(0.536)
Constant	-0.572*	1.988	13.352***	13.268***
	(0.295)	(1.312)	(4.236)	(4.453)
Observations	241	241	234	234
R^2	0.000	0.560	0.574	0.574
Adjusted R^2	0.000	0.502	0.519	0.516
Residual Std. Error	6,206.052 (df = 240)	4,381.521 (df = 212)	4,299.519 (df = 206)	4,309.952 (df = 205)
F Statistic		9.625*** (df = 28; 212)	10.298*** (df = 27; 206)	9.882*** (df = 28; 205)

Note 1: *p<0.05, **p<0.01, ***p<0.001

Note 2: Reference country for country fixed effects: Belgium

Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including October 2020 in each region

Table AB4a: Predicting the Cumulative Fertility Response in Phases 1 + 2 + 3 (11/2020-6/2021 births), no fixed effects

	Dependent variable:			
	y			
	(1)	(2)	(3)	(4)
HighDensityRegionCapitalHigh		0.304		0.677
		(0.673)		(0.668)
SARS-CoV-2			-1.204^{***}	-1.264^{***}
			(0.326)	(0.331)
Constant	-1.075^{***}	-1.128^{***}	7.434^{***}	7.732^{***}
	(0.255)	(0.282)	(2.295)	(2.314)
Observations	241	241	234	234
R^2	0.000	0.001	0.056	0.060
Adjusted R^2	0.000	-0.003	0.052	0.052
Residual Std. Error	5,370.821 (df = 240)	5,379.749 (df = 239)	5,232.979 (df = 232)	5,232.669 (df = 231)
F Statistic		0.204 (df = 1; 239)	13.686^{***} (df = 1; 232)	7.357^{***} (df = 2; 231)

Note 1: $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$
Note 2: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including October 2020 in each region

Table AB4b: Predicting the Cumulative Fertility Response in Phases 1 + 2 + 3 (11/2020-6/2021 births), country cluster fixed effects

	Dependent variable:			
	y			
	(1)	(2)	(3)	(4)
Nordic	7.575***	7.706***	7.014***	7.078***
	(0.997)	(1.003)	(1.007)	(1.019)
Southern	0.712	0.774	0.808	0.828
	(0.636)	(0.638)	(0.654)	(0.656)
Western	4.017***	4.125***	4.160***	4.198***
	(0.587)	(0.595)	(0.609)	(0.616)
HighDensityRegionCapitalHigh		-0.629		-0.252
		(0.573)		(0.572)
SARS-CoV-2			-1.023***	-0.999***
			(0.281)	(0.286)
Constant	-3.602***	-3.568***	3.500*	3.350
	(0.495)	(0.496)	(2.022)	(2.053)
Observations	241	241	234	234
R^2	0.303	0.307	0.339	0.340
Adjusted R^2	0.294	0.295	0.327	0.325
Residual Std. Error	4,512.021 (df = 237)	4,510.080 (df = 236)	4,406.975 (df = 229)	4,414.743 (df = 228)
F Statistic	34.352*** (df = 3; 237)	26.087*** (df = 4; 236)	29.354*** (df = 4; 229)	23.439*** (df = 5; 228)

Note 1: *p<0.05, **p<0.01, ***p<0.001
Note 2: Reference country cluster for country fixed effects: Western-Central
Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including October 2020 in each region

Table AB4c: Predicting the Cumulative Fertility Response in Phases 1 + 2 + 3 (11/2020-6/2021 births), country fixed effects

	Dependent variable:			
	y			
	(1)	(2)	(3)	(4)
Austria		0.690	-0.501	-0.377
		(1.316)	(1.344)	(1.339)
Bulgaria		-1.433		
		(1.417)		
Croatia		0.242	-0.677	-0.710
		(1.701)	(1.708)	(1.700)
Czech Republic		-0.654	-0.494	-0.648
		(1.254)	(1.236)	(1.233)
Denmark		1.462	-0.424	-0.129
		(1.497)	(1.558)	(1.559)
Eastern States of Germany		-0.029	-2.639**	-2.267*
		(1.136)	(1.321)	(1.331)
Estonia		-2.737	-5.238*	-5.001*
		(2.700)	(2.764)	(2.754)
Finland		11.554***	8.138***	8.689***
		(1.526)	(1.745)	(1.764)
France		-1.430	-1.911**	-1.921**
		(0.944)	(0.946)	(0.941)
Germany		1.281	-0.628	-0.397
		(0.942)	(1.072)	(1.074)
Greece		2.206*	-1.085	-0.532
		(1.249)	(1.490)	(1.515)
Hungary		0.954	-0.828	-0.621
		(1.282)	(1.361)	(1.359)
Iceland		6.656	5.871	5.816

	(4.996)	(4.943)	(4.918)
Ireland	3.339**	2.435	2.400
	(1.592)	(1.602)	(1.594)
Italy	-1.843*	-3.149***	-3.066***
	(0.953)	(1.022)	(1.017)
Latvia	-2.378	-5.210**	-4.916**
	(2.296)	(2.408)	(2.402)
Lithuania	-4.306**	-6.491***	-6.158***
	(1.961)	(2.020)	(2.019)
Netherlands	5.309***	4.470***	4.658***
	(1.120)	(1.121)	(1.121)
Norway	5.432***	2.251	2.731
	(1.542)	(1.738)	(1.750)
Poland	-7.396***	-8.793***	-8.767***
	(1.001)	(1.085)	(1.080)
Portugal	-8.215***	-11.176***	-10.704***
	(1.263)	(1.464)	(1.481)
Slovakia	1.002	-0.197	-0.120
	(1.532)	(1.556)	(1.549)
Slovenia	-2.704	-3.182	-3.291
	(2.219)	(2.199)	(2.189)
Spain	-4.202***	-4.335***	-4.428***
	(0.972)	(0.962)	(0.958)
Sweden	0.838	-0.318	-0.192
	(1.265)	(1.292)	(1.288)
Switzerland	0.577	-0.274	-0.157
	(1.328)	(1.332)	(1.327)
United Kingdom	-1.359	-2.709*	-2.523
	(1.529)	(1.554)	(1.549)

HighDensityRegionCapitalHigh		-1.162***		-0.714*
		(0.383)		(0.404)
SARS-CoV-2			-1.335***	-1.106***
			(0.337)	(0.359)
Constant	-1.075***	0.169	10.560***	8.973***
	(0.255)	(0.880)	(2.860)	(2.984)
Observations	241	241	234	234
R^2	0.000	0.736	0.742	0.746
Adjusted R^2	0.000	0.701	0.708	0.711
Residual Std. Error	5,370.821 (df = 240)	2,938.360 (df = 212)	2,902.798 (df = 206)	2,887.923 (df = 205)
F Statistic		21.065*** (df = 28; 212)	21.942*** (df = 27; 206)	21.489*** (df = 28; 205)

Note 1: *p<0.05, **p<0.01, ***p<0.001

Note 2: Reference country for country fixed effects: Belgium

Note 3: SARS-CoV-2: Cumulative SARS-CoV-2 Cases until including October 2020 in each region