Back to normality? Fertility decline in the late phase of the COVID-19 pandemic

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Abstract

This study investigates potential drivers of birth trends in higher-income countries during the COVID-19 pandemic. We focus especially on the later phase of the pandemic, when mobility restrictions were lifted, social life was moving gradually toward "normality" and birth rates dropped unexpectedly in many countries since early 2022. We use monthly birth data for November 2020 – October 2022 from 27 higher-income countries covered by the Human Fertility Database. Panel data regression models are used to test three sets of potential explanations – economic factors, policy interventions (mobility restrictions), and vaccination. In the beginning of the pandemic, birth trends during periods of stricter containment measures differed depending on the level of social trust in the country: birth rates fell in countries with low social trust and they rose in high trust countries. However, in the later phase of the pandemic, the easing of containment measures and increased mobility were associated with declining fertility. Our results reveal a temporary postponement of births associated with the vaccination roll-out in 2021. In addition, increasing inflation rates in the second half of 2021 also contributed to the fall in birth rates in 2022.

Introduction

The COVID-19 pandemic of 2020–2022 contributed to distinct swings in birth rates. The initial shock was linked in most countries to a short-term drop in the number of births around December 2020 to January 2021, followed by an equally brief recovery around March 2021 and a more differentiated development in the subsequent months that varied across countries (Sobotka et al., 2023; Plach et al., 2023; Lappegård et al., 2023; Bailey et al., 2023; Fallesen & Cozani, 2023; Gietel-Basten & Chen, 2023; Gray et al., 2022; Nisen et al., 2022). On balance, the negative impact of the first year of the pandemic on birth trends in most countries was lower than initially expected when considering the unprecedented impact of the COVID-19 and of the government responses to it on everyday lives, on the labour market and social relations (Mayer, 2022).

However, birth rates in most of the higher-income countries saw another shift, an unexpected downturn, since early 2022 (Sobotka et al. 2023; Bujard & Andersson, 2023). In some countries, this drop was substantial, with the number of births in Czechia, Estonia, Finland, Germany, Greece, Hungary, Ireland, Italy, Japan, Netherlands, Norway, Poland, Russia, Singapore, Slovakia, Slovenia, Sweden and Taiwan dropping by 5% or more during January-April 2022 compared with the same months a year before (Human Fertility Database, 2023). The drop in births was also substantial when compared with the number of births conceived in the pre-pandemic period and which occurred in the same months in 2020 (Figure 1).

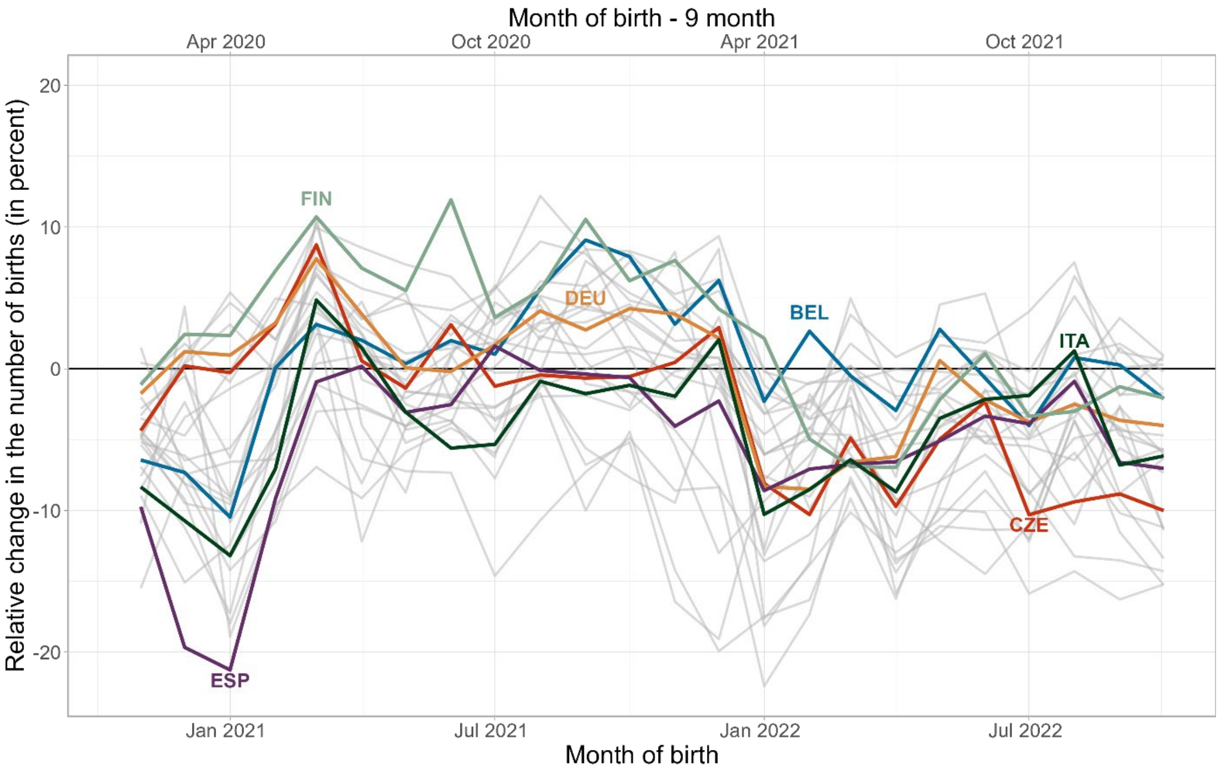
What could be the drivers of the unexpected fall in births starting around January 2022? Going back nine months in time to account for a typical length of pregnancy, we arrive in spring 2021, a time which can be considered as a gradual "return to normality". The disruptive impact of the pandemic diminished markedly in most countries. Lockdowns and social distancing measures were phased out, people's mobility and social contacts again increased and economic and labour market indicators had largely recovered from the initial pandemic shock. This return to normality was also achieved thanks to the COVID-19 vaccination programme, which was gaining momentum at that time and eventually became accessible to the whole population. At the same time, the dark shadows of rising inflation and economic uncertainty, spurred by the Russian invasion of Ukraine and the related surge in energy prices did not affect birth trends until late 2022.

Was the observed shift to lower birth rates in 2022 a sign of a return to pre-pandemic trends of declining fertility? Or was it rather a consequence of more busy work and social life leading to a new wave of birth postponement as people became occupied by other priorities than having children? And is there any association with the COVID-19 vaccination programme that could have led to temporal shifts in birth rates?

Our study aims to analyse the likely drivers of birth trends during the COVID-19 pandemic, trying to disentangle distinct explanations. We consider three main sets factors – economic factors, policy interventions, and vaccination – but we also control for selected other relevant factors identified in the past research. This includes the severity of the pandemic, as measured by excess deaths and the role of the trust in government that could be an important factor mediating behavioural responses to the pandemic policies (Plach et al. 2023). To that aim, we analyse monthly data on births and fertility rates for 27 higher-income countries collected and estimated in the Human Fertility Database (2023) and covering the births until October 2022, conceived prior to the onset of the Russian war against Ukraine.

We first look in more detail at the plausible explanations of rapidly changing birth rates during the pandemic, especially in 2022, and suggests specific hypotheses. Next, we cover the data and methods used and present main findings. Our research gives a strong support to the hypothesis that the vaccination programme resulted in a temporary disruption of birth dynamics – leading to a drop in birth rates during the period when vaccination was gathering pace and reaching the general population of reproductive age. We also find a strong negative impact of inflation on birth rates. Finally, we identify a differentiated impact of the stringency of the pandemic-related measures on birth trends that varied with the stage of the pandemic and level of trust in the country.

Figure 1: Relative change in the number of births compared to the pre-pandemic period, selected countries highlighted.



Source: Human Fertility Database (2023), own computations.

Ups and downs in births rates during the COVID-19 pandemic: selected explanations and hypotheses

Researchers have identified a wide array of factors contributing to the shifts in birth rates during the COVID-19 pandemic (Berrington et al., 2022; Tasneem et al., 2023). We have selected three sets of factors that can be empirically assessed and that may partly explain rapid changes in birth trends since November 2020 (children conceived since February 2020): (1) economic uncertainty, (2) policy interventions restricting mobility and social activities outside the family, (3) the availability of vaccination. Our main focus is on variables that may help understanding the unexpected drop in births starting around January 2022.

The COVID-19 pandemic had a profound impact on labour markets as unemployment surged in many countries at the beginning of the pandemic, contributing to the initial downturn in births (e.g., Kearney and Levine, 2022, for the United States). More broadly, economic uncertainty including worries about unemployment, unstable employment and future income, jumped in the initial stage of the pandemic. In response, some women decided to delay or forego motherhood (Matsushima et al., 2023). After a few months, starting in (late) spring 2020, governments invested massively in job retention and income support schemes to mitigate the negative impact of the pandemic on labour market, household income and economic output. In most of the higher-income countries the unemployment rate returned to pre-pandemic levels by early 2021. However, inflation rates started rising from mid-2021 during the period of economic recovery, increased household spending, and a return to more busy social life. There is ample evidence on the link between economic factors and fertility, where unemployment, inflation, and economic uncertainty mostly depress fertility rates (e.g., Goldstein et al., 2013; Schneider, 2015; Comolli, 2017; Matysiak et al, 2021).

H1: ***Economic uncertainty.*** *Unemployment rate and inflation rate are negatively associated with birth rates during the COVID-19 pandemic. Rising inflation since mid-2021 may partly account for the drop in birth rates in 2022.*

To combat the spread of the virus and to support the economy, governments issued non-pharmaceutical policy interventions, such as work and school closures, travel restrictions, as well as income support and special subsidies for businesses affected by the lockdowns and mobility restrictions. These containment measures led to disruptions in people's social and family life. They also resulted in increased stress, fear of the infection and relationship struggles—factors negatively associated with an intention to avoid pregnancy (Manning et al., 2022). At the same time, economic support cushioned financial pressure and economic uncertainty. Plach and colleagues (2023) studied the associations of these policy interventions with fertility and found that the containment measures led to a postponement of births, while economic support was positively associated with birth rates.

H2A: ***Non-pharmaceutical policy interventions*****.** *Lockdowns and other mobility restricting measures initially contributed to the increased uncertainty about the future as people were forced to rapidly adjust their lifestyle and drastically scale down their face-to-face social contacts outside of the immediate family circle. This unexpected intervention had a negative impact on births.*

With external opportunities for leisure, recreation and socialization limited, people started spending much more time in the home with their romantic partners and families. Working in home office and saving time from not commuting to the workplace might have contributed to a better work-life balance. Opportunity costs of having a child declined. Under favorable circumstances, i.e., when couples were feeling economically and socially secure, some might have enjoyed this slow-down phase in their lives, rethought their priorities and decided to have (a)nother child or, more likely, to have their next planned child earlier (Berrington et al., 2022; Neyer et al., 2022; Lappegård et al., 2023).

H2B: ***Focus-on-home or cocooning effect*****.** *The pandemic and the associated measures might have contributed to a shift of focus toward the domestic life – the "cocooning effect" (Bujard & Andersson, 2023) – which implied that lockdowns and mobility restrictions had a positive effect on birth rates after the initial pandemic shock passed.*

Lappegård et al. (2023) discuss such a positive impact of social restrictions and a more balanced family life in explaining the increase in births in Norway conceived during the first pandemic year, also highlighting high levels of trust Norwegians had towards the public authorities' response to the COVID-19 pandemic (Price et al., 2021). Indeed, Plach et al. (2023) argue that high levels of social trust might mitigate the negative consequences of the pandemic-related uncertainty on fertility. Using pre-pandemic public support as a proxy for social trust, they show that non-pharmaceutical policy interventions were much more strongly associated with falling birth rates in the early phase of the COVID-19 pandemic and their slower recovery in a later phase in low pre-pandemic public support countries.

H2C: ***Return to normality effect*****.** *As lockdowns and other restrictions gradually eased out, especially after the COVID-19 vaccine became widely available in March-June 2021, people resumed many work-related, leisure and socialising activities outside the home. Their priorities again changed, and they might have gotten "too busy" for considering another child. Easing out of the mobility restrictions and the subsequent actual increase in mobility had a negative impact on birth rates.*

Further, we aim to study the association between COVID-19 vaccination and fertility. The drop in birth rates in many countries since early 2022 coincides with the start of the massive vaccination campaign about 9-10 months earlier. A review by Chen et al. (2021) shows that COVID-19 vaccination does not lead to fertility problems or increased adverse pregnancy outcomes. However, there could have been a behavioural response to the vaccination: Bujard and Andersson (2022) speculated that women might had decided to temporarily put pregnancy plans on hold during vaccination to reduce any potential harm to their and their foetus' health. Such a "just in case" decision would not be completely irrational—when vaccines were being developed and introduced in late 2020, national health organisations and associations were hesitant to recommend vaccination during pregnancy until conclusive evidence can be reached that COVID vaccines are perfectly safe for pregnant women.[1] Until early 2021, health authorities including the US Centre for Disease Control and Prevention (CDC) adopted a cautious approach, suggesting that "pregnant women may choose to get any of the vaccines and should discuss risks and benefits with their healthcare providers" (V-safe Pregnancy Registry Protocol updated 18 March 2021; CDC 2021). In mid-2021, only 22 out of 224 countries or territories recommended and 78 permitted (with qualifications) vaccination of pregnant women (Johns Hopkins University, 2023).

Most of the vaccines available in 2021 and 2022 required two doses scheduled 3 to 8 weeks apart (or even longer intervals, especially when the supply of vaccines was still restricted) to complete the full course of vaccination[2]. Women planning to avoid pregnancy around the time of the vaccination and then for another 1-2 months after completing its full first course would therefore have to postpone their pregnancy plans by 2-4 months or even longer. Vaccination programs in most countries were age-graded, typically starting with the oldest population and with the women and men of reproductive age being eligible several months later, in spring or early summer 2021.

H3: avoiding pregnancy during the course of vaccination: *The uptake of the first dose of the COVID-19 vaccines among people of reproductive age in 2021 was negatively associated with birth trends. Later on, the completion of the full course of vaccination (two doses) was associated with a recovery in birth rates.*

Finally, periods of higher infection rates and excess mortality might also be associated with depressed birth rates due to the worries women may have about getting infected while pregnant, a desire to avoid hospitals and healthcare system at the time when they were "overwhelmed" with the infections or to avoid possible exposure to COVID-19 during routine check-ups (Berrington et al., 2023). Some studies found a negative association between reported COVID-19 infections, deaths or overall excess deaths and birth rates, especially in the earlier phases of the pandemic (Kearney & Levine, 2022).

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[1] See, e.g., the "Updated advice on COVID-19 vaccination in pregnancy and women who are breastfeeding" by the Royal College of Midwifes issued on 30 December 2020 (https://www.rcm.org.uk/news-views/news/2020/december/updated-advice-on-covid-19-vaccination-in-pregnancy-and-women-who-are-breastfeeding/), the UK government statement on 7 January 2021 based on Public Health England recommendation (https://www.gov.uk/drug-safety-update/covid-19-vaccines-pfizer-slash-biontech-and-covid-19-vaccine-astrazeneca-current-advice).

[2] For a comparison see e.g., https://www.mayoclinic.org/diseases-conditions/comparing-vaccines.

Data and Methods

We use data from the Short-term Fertility Fluctuations (STFF) data series embedded in the Human Fertility Database (HFD 2023). The STFF data series provides up-to date information on live births by month for a range of higher-income countries. The monthly nature of the STFF data series allows to study fertility changes that may arise in response to sudden shocks and quickly changing and within a calendar year varying conditions, such as the COVID-19 pandemic and the policy measures taken to combat the spread of the virus.

The STFF data series contains two sets of data, crude monthly number of births, and for a selected number of countries, a proxy for monthly total fertility rates (TFR). In order to account for the seasonal pattern of births, the STFF additionally offers calendar and seasonally adjusted monthly series for birth counts and TFRs. For our analysis we select the latter series, where we shift the monthly calendar and seasonally adjusted series of TFR by nine months to around the time of conception. We focus on the time from February 2020 to January 2022 to cover conceptions occurring after the onset of the pandemic to before the Russian invasion into Ukraine. This time span reflects live births from November 2020 to October 2022.

In total, we have data for 27 countries, mostly European[3], plus US, Canada, Israel, Japan and South Korea, resulting in a total of 648 country-months.

Our explanatory variables include various indicators reflecting economic uncertainty, non-pharmaceutical policy interventions (NPI) and related changes in behaviour, as well as indicators on the health emergency and vaccination rollout. For economic uncertainty, we use the seasonally adjusted monthly harmonized unemployment rate (OECD, 2023a) as well as the monthly consumer price index (OECD, 2023b). We include two NPI indices, specifically the stringency index and the economic support index, where the data come from the Oxford COVID-19 Government Response Tracker (Hale et al., 2021). As mentioned above, we hypothesize that the association of containment measures and economic support with fertility during the pandemic varies by the level of social trust. For the latter, we use yearly data on trust in government before the pandemic (2010-2019) from OECD (2023c).

For tracking behavioural changes due to the pandemic, the Economist (2021) has developed a `normalcy index'. The index comprises eight indicators covering three different domains: transport and travel; recreation and entertainment; and retail and work, where each indicator is measured as a percentage of its pre-pandemic level (as the average values of each indicator in January and February 2020). Lastly, data on the vaccination rollout and excess mortality for each country are sourced from OurWorldinData (Mathieu et al., 2020).

The analysis is structured in two ways: First, we assess the correlations of the single explanatory variables with the seasonally adjusted monthly TFR in each country. Second, we adopt a multivariable approach by estimating a linear fixed effects (within) regression model of the relationship between fertility and the explanatory variables, i.e., non-pharmaceutical policy interventions (Plach et al., 2023), economic indicators (e.g., Goldstein et al. 2013; Comolli, 2017) and measures of vaccination rollout:

[3] The European countries included in the analysis are Portugal, Spain, Italy, Greece, Slovenia, Czechia, Poland, Latvia, Lithuania, United Kingdom, Belgium, the Netherlands, France, Austria, Germany, Switzerland, Denmark, Sweden, Norway, and Finland. We do not consider birth data for Russia and Bulgaria in this analysis due to missing data for explanatory variables in these two countries.

$$\begin{aligned}\mathrm{TFR}_{c,t+9} = {} & \beta_1 \cdot \mathrm{HUR}_{c,t} + \beta_2 \cdot \mathrm{CPI}_{c,t} \\ & + \left(\gamma_1^l \cdot \mathrm{Stringency}_{c,t} + \gamma_2^l \cdot \mathrm{Stringency}_{c,t-1} + \gamma_3^l \cdot \mathrm{EcoSupp}_{c,t}\right) \cdot \mathrm{CountryGroup}^l \\ & + \left(\gamma_1^h \cdot \mathrm{Stringency}_{c,t} + \gamma_2^h \cdot \mathrm{Stringency}_{c,t-1} + \gamma_3^h \cdot \mathrm{EcoSupp}_{c,t}\right) \cdot \mathrm{CountryGroup}^h \\ & + \kappa_1 \cdot \mathrm{CumVacc}_{c,t}^1 + \kappa_2 \cdot \mathrm{CumVacc}_{c,t}^2 + \lambda_1 \cdot \mathrm{ExcessMort}_{c,t} + \lambda_2 \cdot \mathrm{Wave}_t^1 + \mu_c + \epsilon_{c,t},\end{aligned}$$

where the dependent variable is the seasonally adjusted monthly $\mathrm{TFR}_{c,t+9}$ per 100 women in country *c* in month-year *t*+9. $\mathrm{HUR}_{c,t}$ denotes the seasonally adjusted monthly harmonized unemployment rate and $\mathrm{CPI}_{c,t}$ indicates the monthly consumer price index, both in country *c* in month-year *t*. For the non-pharmaceutical policy interventions, we include the stringency index, $\mathrm{Stringency}_{c,t}$, representing containment measures, and the economic support index, $\mathrm{EcoSupp}_{c,t}$, in country *c* and month-year *t*. We include the stringency index lagged by one month to allow for changes in fertility timing due to stricter or more lenient containment measures. We do not include the normalcy index in the regression as it is too highly correlated with the stringency index (ρ=-0.88, p<0.001), and the normalcy index is not available for all countries studied.

$\mathrm{CountryGroup}^l$ and $\mathrm{CountryGroup}^h$ are a set of dummy variables distinguishing countries with low versus high level of trust in government. Countries are categorized by employing Partitioning Around Medoids methods (Kaufman & Rousseeuw, 1990).[4] The partitioning shows a notable geographical clustering with East Asian (South Korea, Japan), Southern European (Portugal, Spain, Italy, Greece), Central Eastern European (Slovenia, Hungary, Czechia, Poland, Latvia, Lithuania), Western European (United Kingdom, Belgium, France), as well as Austria, Israel and USA in the group with lower trust in government. Northern European countries (Denmark, Norway, Sweden, Finland) as well as the Irelands, Netherlands, Germany, Switzerland, and Canada form the countries with higher levels of trust in government. The clustering largely overlaps with the one based on pre-pandemic social support derived by Plach et al. (2023). It is only Canada and Ireland with low social support but high trust and conversely, Austria, France, and Belgium with high social support but low trust.

$\mathrm{CumVacc}_{c,t}^1$ denotes the cumulative percentage of the population having received at least one dose of the COVID-19 vaccine in country *c* at the mid of month-year *t*. Similarly, $\mathrm{CumVacc}_{c,t}^2$ gives the cumulative percentage of the population fully vaccinated, which usually required two jabs for most vaccines, in country *c* and at the mid of month-year *t*. Vaccination data are available on a daily or weekly basis. In the latter case, we use interpolation techniques to derive the value mid of the month. While $\mathrm{CumVacc}_{c,t}^1$ is supposed to mark the onset of the vaccination rollout, the estimated coefficient of $\mathrm{CumVacc}_{c,t}^2$ should reflect a potential recovery, if any, associated with the completion of the primary vaccination course in case conceptions were delayed because of the vaccination program.

$\mathrm{ExcessMort}_{c,t}$ represents average excess mortality in country *c* and month-year *t*. It is constructed as a p-score, which corresponds to the difference between the reported number of deaths (HMD, 2023) and projected number of deaths from all causes as a share of the projected number of births (Karlinsky and Kobak, 2021). Excess mortality data are provided on a monthly or weekly basis, which are in the latter case converted into monthly averages. In addition, Wave_t^1 indicates a dummy variable for the first wave of the COVID pandemic, running from February to April 2020, reflecting the high level of uncertainty just after the start of the pandemic.

Lastly, for the error component, μ_c denotes country fixed effects and $\epsilon_{c,t}$ is the error term. We estimate the fixed effects regression by adopting Driscoll and Kraay (1998) standard errors, which are

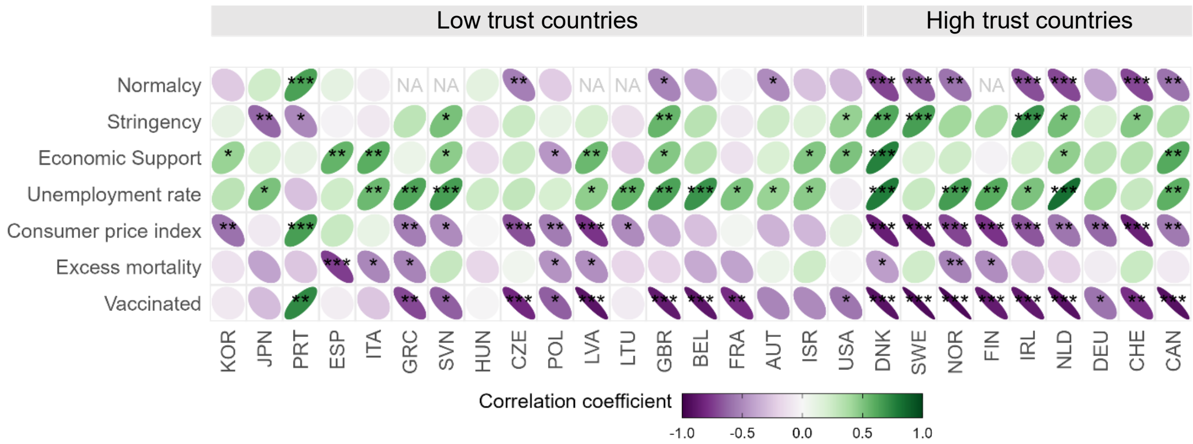
[4] Using different clustering methods, such as k-Means or hierarchical clustering, does not yield different country clustering for the set of countries used in this study.

robust to disturbances being heteroskedastic, autocorrelated, and cross-sectional dependent (Hoechle, 2007).[5] While data and the descriptive analysis was done in R (R Core Team, 2023), Stata was used for the regression analysis (StataCorp, 2023).

First results

Figure 2 summarizes the correlation of the single explanatory variables with the monthly seasonally adjusted TFR, where countries are clustered by level of trust in government. The color and the angle of the ellipses indicate the direction of the correlation: purple, left-rotated ellipses represent a negative correlation and green, right-rotated ones denote a positive correlation, respectively. The darker, the color and the "thinner", the form of the ellipse, the stronger the correlation. White circles indicate that the series of the respective explanatory variable is unrelated with the total fertility rate time series during the pandemic.

Figure 2: Summary of correlation coefficient, ρ, of explanatory variables with monthly seasonally adjusted TFR, by country



Note: Visualization adapted from Cai et al. (2022).

We find that normalcy is mostly negatively correlated with fertility during the pandemic, and particularly significantly among the high trust countries (ρ < -0.7, except of Germany with ρ =-0.4). Conversely, the stringency index is in the majority of countries positively associated with birth trends. Exceptions to this pattern are Japan (ρ = -0.6) and Portugal (ρ =-0.5), where fertility was significantly lower during stricter containment measures.

Governmental economic support was aimed to cushion economic uncertainty of the population and hence is positively correlated with fertility during the pandemic. Strikingly, also the unemployment rate is in almost all countries positively associated with birth trends. The other economic indicator considered in this analysis, the consumer price index, is strongly negatively correlated with childbearing, particularly, in the high trust countries (ρ < -0.6). In low trust countries, the negative association is also visible in the majority of the countries, but mostly at a lower degree.

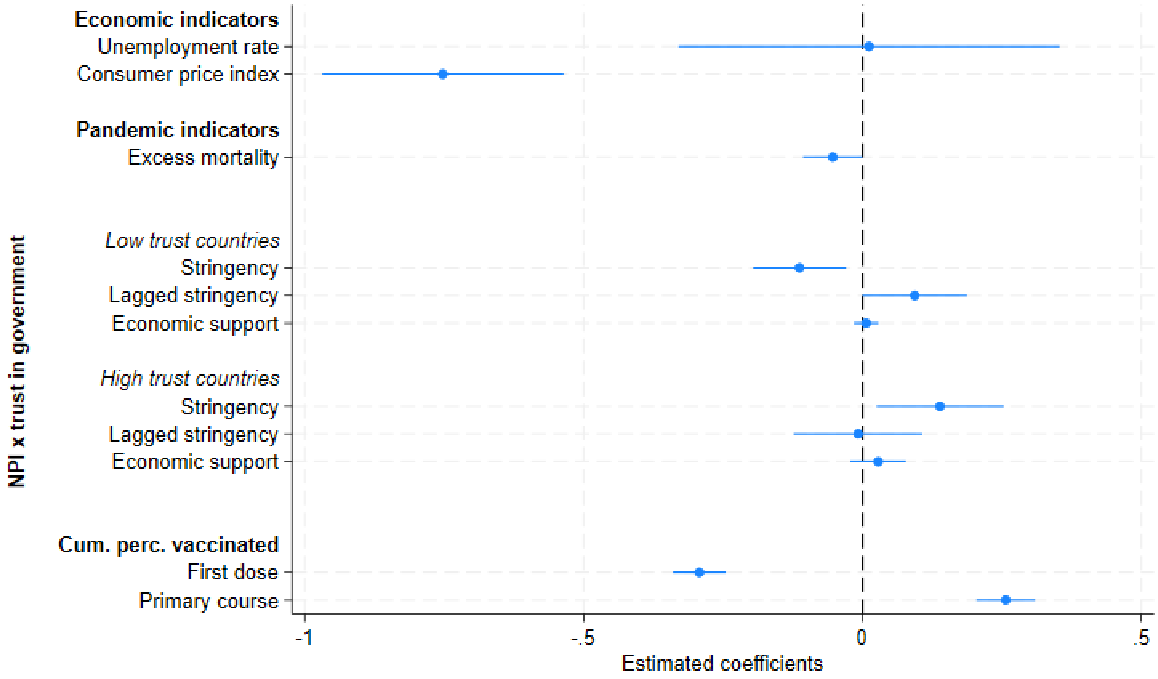
The health crisis, as measured by excess mortality, is only weakly negatively correlated with childbearing in many countries, with the most notable exception of Spain (ρ =-0.7), which was strongly hit by the pandemic, particularly during the first wave. Finally, vaccination rollout is also strongly

[5] The Breusch-Pagan test rejected the null of homoskedasticity. We performed the Woolridge test for serial correlation in panel-data models and the Pesaran's CD test for testing for cross-sectional dependence. Both tests rejected the absence of autocorrelation and cross-section dependence, respectively.

negatively correlated with fertility in all countries apart from Portugal (ρ =0.7). In the multivariable regression analysis, we will examine whether this strong negative link of the vaccination rollout and births is associated with a temporal shift rather in childbearing, as hypothesized before.

Figure 3 plots the estimated model coefficients of the fixed effects regression model of the seasonally adjusted TFR per 100 women, where the model includes economic indicators, NPI in low and high level of trust countries, respectively, as well as indicators for the health emergency and the vaccination rollout. For the economic indicators, we do not find the expected negative association with the unemployment rate (β_1 =0.012, *p*=0.943). However, it was mostly in countries like USA and Canada, where unemployment surged after the onset of the pandemic. Many governments made an unprecedent use of job retentions scheme to mitigate the impact of the pandemic on the labour market. Hence, the unemployment rate is not comparable across countries and might not reflect economic uncertainty during the pandemic in many countries (OECD 2020a). With regard to the consumer price index, the negative link with fertility is also confirmed in the multivariable analysis ($\beta_2 = -0.75$, *p*<0.001). However, consumer price indexes only started to markedly rise toward the end of our observation window, with much steeper increases afterwards in 2022. Hence, inflation may play a crucial role in post-pandemic fertility.

Figure 3: Estimated model coefficients of fixed effect model of monthly seasonally adjusted TFR per 100 women.



Note: The regression model additionally includes a time dummy for the first COVID wave ($\lambda_2 =$ -5.83, 95%CI: -8.44, -3.22)

In countries with low trust in government, stricter containment measures were associated with a statistically significant decrease in fertility (γ_1^l =-0.113, *p*=0.01). The positive coefficient of the lagged stringency variable (γ_2^l =0.094, *p*=0.05) suggests that births were subsequently partly recovered as $\text{Stringency}_{c,t}$ is then positively associated with $\text{TFR}_{c,t+10}$. In contrast, we do not find any evidence of such a containment measures-associated fertility postponement in countries with higher institutional trust. On the contrary, periods of stricter containment measures in high-trust countries were rather associated with a significantly higher total fertility rate (γ_1^h =0.139, p=0.02) without any indication of tempo changes (γ_2^h =-0.008, *p*=0.89). The latter result is in line with the cocooning hypotheses: In favourable situations, i.e., stable partnerships and socially and economically secure, some couples might have experienced a more balanced and less stressful family life during social restrictions, which they might have considered as a favourable time to have children despite the pandemic. Conversely, a ceasing out of measures and more busy social life would be associated with a depressed fertility again. Further below, we will inspect the differences in the association of the containment measures with fertility in low trust versus high trust countries more in depth.

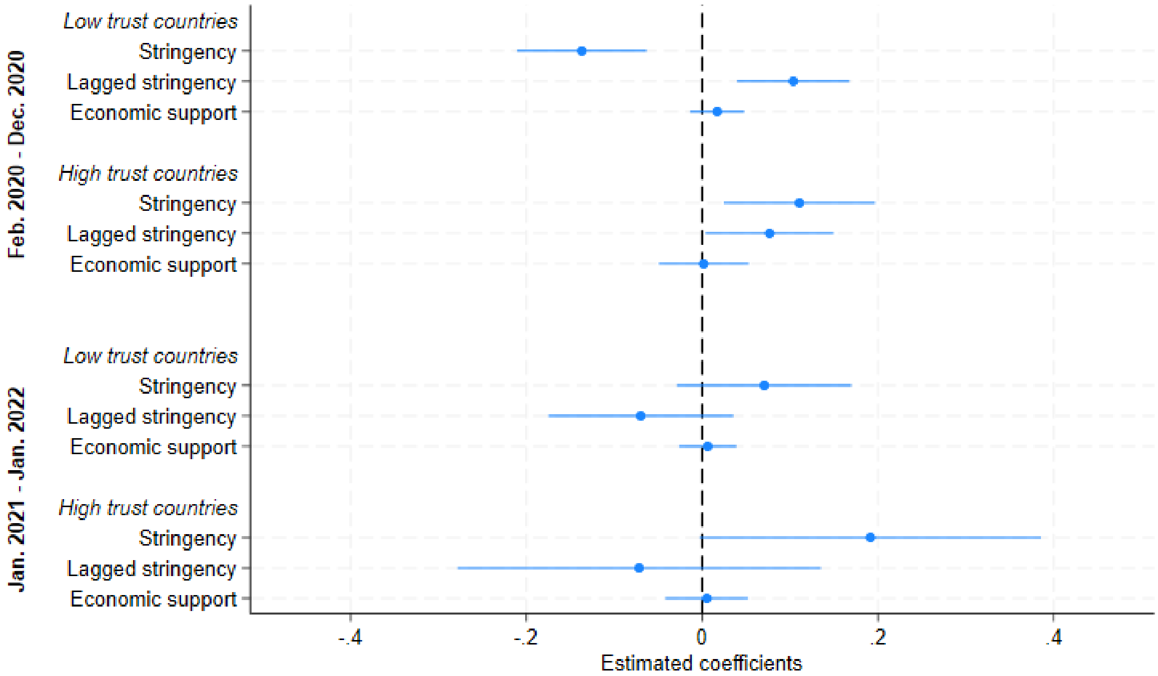
Unlike in the correlation analysis, we do not find any association between economic support and total fertility rates, neither in low (γ_3^l =0.006, *p*=0.55) nor in high trust countries (γ_3^h =0.028, *p*=0.25). While economic support cushioned economic uncertainty and income loss, it seems not to be linked to childbearing during the pandemic when simultaneously considering economic indicators, containment measures, excess mortality and the vaccination rollout.

The health crisis, as measured by excess mortality, is negatively associated with fertility (λ_1 =-0.053, *p*=0.049). However, as uncertainty in the population was presumably strongest just after the onset of the pandemic, a separate time dummy for the months just after the pandemic, February to April 2020, was included in the regression. The estimated coefficient λ_2 is -5.83 (*p*<0.01) which is consistent with a markedly depressed fertility nine months later, i.e., November 2020 to January 2021.

Finally, our results are in line with the hypothesis that the age-graded, two-doses vaccination scheme might have led to a postponement of childbearing and a subsequent recovery of births. When the vaccination rollout gained momentum and the cumulative share of the population having received at least one dose of the COVID-19 vaccine, fertility decreased (κ_1 =-0.29, *p*<0.001). Note that due to the age-graded mode of the vaccination programme with prioritizing the oldest age groups, women in childbearing ages were mostly not eligible to the vaccination yet at the time. However, vaccination was strongly recommended for women with childbearing intentions because of higher risks of severe illness during pregnancy and elevated risks of complications during pregnancy due to a COVID infection (Wei et al., 2021). Consequently, some women may have delayed childbearing until after getting vaccinated. Indeed, we find a statistically significantly positive estimated coefficient of the cumulative percentage of the population having completed the primary vaccination course (κ_2 =0.26, p<0.001), which is almost of the same absolute size as the estimated coefficient for the drop associated with onset of the vaccination rollout.

The vaccination rollout and the prospect of a soon return to normality may have altered the relationship of NPIs and fertility over the course of the pandemic. In a further analysis, we thus differentiate in estimating link of the NPIs and fertility between the early and late phase of the pandemic. Figure 4 displays the estimated coefficients for containment and economic support measure in low and high trust countries for two periods, February 2020 to December 2020 versus January 2021 to January 2022. We corroborate the previously derived pattern of fertility postponement and recovery in low trust countries, but only for the early phase of the pandemic. For conceptions in 2021 to January 2022, the pattern changes and the stringency index tends to be positively associated with fertility like for countries with a higher trust in government. Hence, the return to normality with a ceasing out of containment measures may have contributed to the decline in fertility observed in the late phase of the pandemic in low and high trust countries.

Figure 4: Estimated relationship of non-pharmaceutical policy interventions, by level of trust and period



We plan to extend the analysis in several ways: The first regards the modelling of the vaccination rollout, which we have modelled by including the cumulative percentage of the population with at least on dose and completing the primary course, respectively. We aim to check the robustness of our results by employing alternative specifications for the vaccination scheme.

Furthermore, while stringency gives the implemented containment policies, normalcy measures actual behavior like changes in mobility, workplace attendance and leisure activities. Unfortunately, the normalcy indicator is not available for all countries considered in this analysis. However, we will explore the association of normalcy with fertility for a limited number of countries, where available.

Lastly, we will adopt other indicators of economic uncertainty, like the Economic Policy Uncertainty index (Baker et al. 2016) on a subset of countries, where available.

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