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IMPACTS OF THE COVID-19 PANDEMIC ON INTERNATIONAL FERTILITY – A STOCHASTIC PRINCIPAL COMPONENT APPROACH

Background

- COVID-19 pandemic has affected a multitude of areas in life
- Direct effects investigated well: increased mortality, morbidity, healthcare demand
- Understanding of long-term effects, such as worsening mental health due to the NPIs or behavioral effects still limited
  - Less research thus far focused on these aspects
  - Inherent uncertainty since effects only show in the long run (time series lacking thus far)
- Potential long-term effects on behavior after full vaccinations and lifting of NPIs unclear
- Trends in fertility influenced by many factors
  - Previous fertility level
  - socioeconomics of countries
  - Cultural aspects such as gender equality and female education (opportunities)
  - Social and family policy

Motivation

- Potential impacts of pandemic on fertility
  - Biological effect after infection
    - Higher infertility
    - Different timing of births (e.g. premature)
    - Higher risk of stillbirths
    - Higher propensity of neonatal deaths
  - Behaviorial change
    - Changed tempo of births
      - Delay because of insecurity about future
      - prepone births because of better opportunities of home office
    - Changed quantum of births
      - Decreased fertility because of fear of the pandemic consequences and more negative outlook on the future
      - Increased fertility because of intensified contacts between couples living together, including increased sexual and reproductive activity

Motivation

- Fertility response of high-income countries may differ from that of middle- and low-income countries[1]
- We try to quantify differential fertility observed thus far during the pandemic based on an adjusted version of a stochastic approach suggested earlier[2] for excess mortality estimation
- Classification of countries by fertility response to pandemic conditions
- Stochastic projection of long-term impact of pandemic on fertility by country

[1] Aassve, A.; Cavalli, N.; Mencarini, L. et al. (2020): „The COVID-19 pandemic and human fertility.“ *Science* 369(6502): 370-371.

[2] Vanella, P.; Basellini, U.; Lange, B. (2021): „Assessing excess mortality in times of pandemics based on principal component analysis of weekly mortality data – the case of COVID-19.“ *Genus* 77:16.

Data

- Monthly birth numbers since January 2000 of 32 countries: STFF provided by HFD
- End-of-year population estimates since 1999 of females in reproductive age group (13-54) gathered from HMD, WorldBank, and national statistical offices
- Compute monthly pseudo fertility rates (MPFRs) by dividing monthly births by end-of-year fertile female population of previous year:

$$lf_{c,y,m} := ln\left(\frac{B_{c,y,m}}{P_{c,y-1}}\right)$$

⇒ rough adjustment of raw births to population size

Methods

- Check first hypothesis of impact of SARS-CoV-2 on biological fertility, which may appear since the beginning of the pandemic, i.e. January 2020
- problem: we don‘t know how many birth we *would have observed* under normal circumstances
- We only observe births *under pandemic conditions*

⇒ Direct effect of pandemic on fertility not directly observable; question of counterfactuals

- Approach: estimate distribution of births if had not have this unusual observation

⇒ Compare stochastic forecast of births (hypothetical ex-ante development without pandemic) observed births (ex-post with pandemic), including stochastisticy

Methods

- Perform principal component analysis (PCA) on collection of log-MPFR time series of all countries for baseline period January 2000 – December 2019:

$$p_{i,y,m} \coloneqq \sum_{c=1}^{32} \lambda_{i,c} \cdot lf_{c,y,m}$$

- Fit SARIMAX models to time series of PCAs
- Simulate PCs for January – September 2020 via Monte Carlo simulation
- Retransform trajectories for PCs into trajectories of the log-MPFRs
- Exponentiation of log-MPFR trajectories gives trajectories of MPFRs
- Multiply MPFR trajectories by estimates of female fertile population => distribution of births
- Compare forecast of births to observed numbers

Methods

- PC 1 explains 41% of variance of all log-MPFR time series
- Long-term international fertility development; loadings vary between countries
    - Differs by intensity
    - Differs by direction

  ⇒ Modeled by logarithmic function

- High innerannual seasonality

⇒ Modeled by linear combination of cosine function and monthly dummies, as suggested by Vanella et al. (2021)

- Remaining noise based on ACF and PACF identified as $SAR(1)x(1)_{12}$ model

Methods

- PC 2 explains further 27% of variance
- Loadings positive for all countries, except GER, LVA, and LTU
- Long-term negative trend since beginning of 2008

⇒ Negative effect of *Great Recession*[2] on fertility

  - Germany appears robust; increasing fertility due to deceleration of tempo effect and simultaneously successful demography-related social policy measures[3]
  - Trends in Latvia and Lithuania unclear (input very welcome!)

⇒ Modeled by quadratic trend function

- Seasonality modeled by monthly dummies; $SIMA(1,1)x(1,0)_{12}$ for nuisance

[2] Matysiak, A.; Šobotka, T.; Vignoli, D. (2021): „The Great Recession and Fertility in Europe: A Sub-national Analysis.“ *European Journal of Population* 37(1): 29-64.

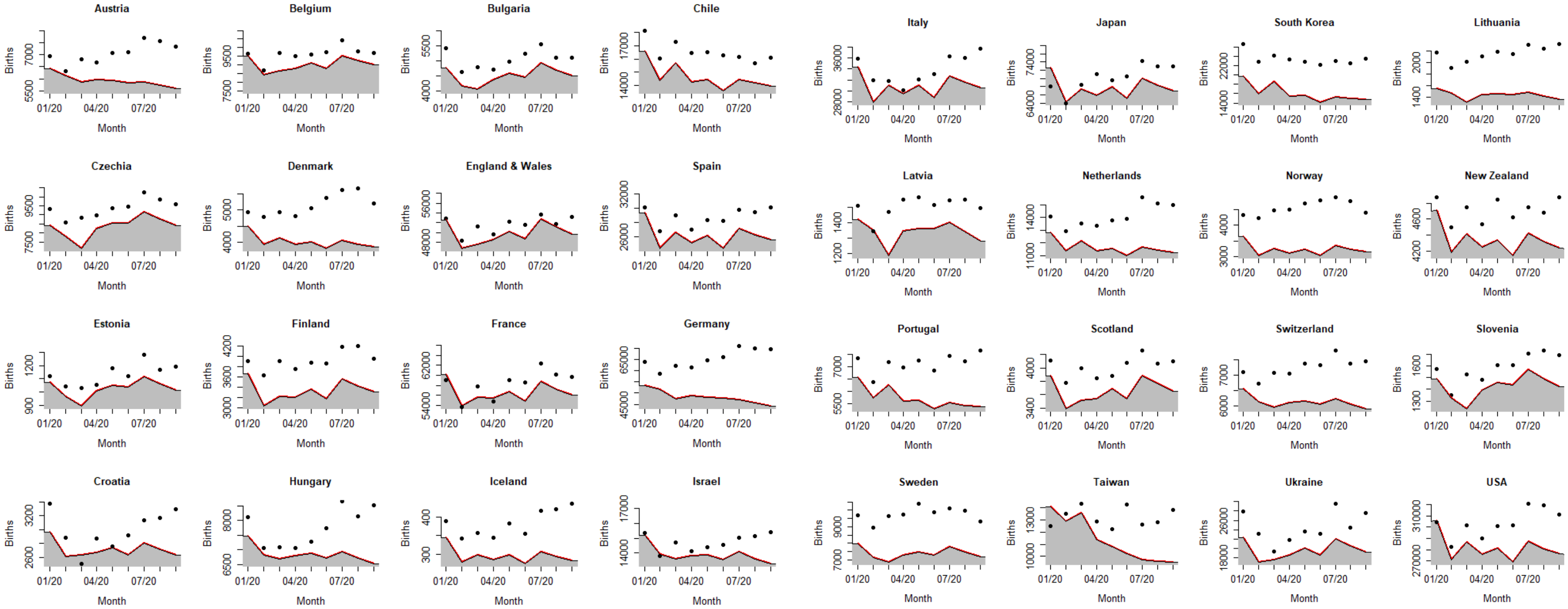
[3] Vanella, P.; Deschermeier, P. (2019): „A Principal Component Simulation of Age-Specific Fertility – Impacts of Family and Social Policy on Reproductive Behavior in Germany.“ *Population Review* 58(1): 78-109.

Methods

- Remaining 30 PCs assumed random walk processes
- Simulations of PCs retransformed as described
- Depending on outcome of first hypothesis test, baseline period is defined

Results

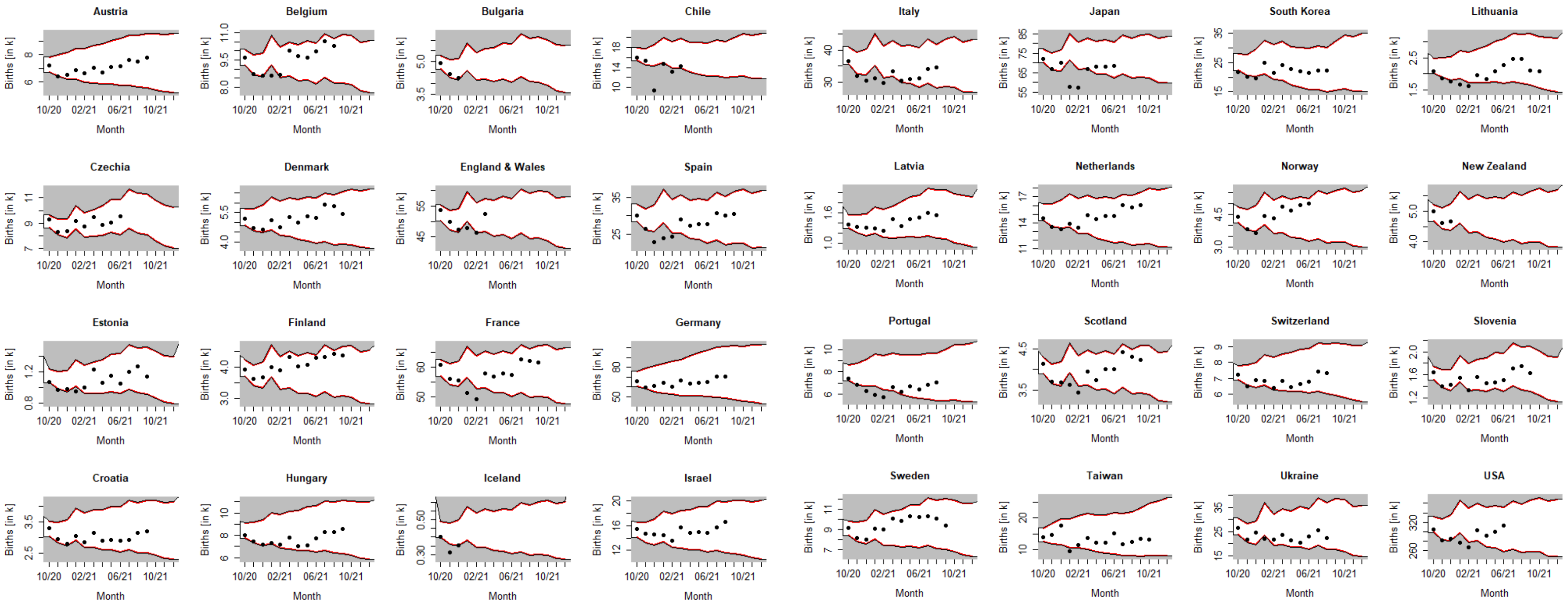
Figure 1. Observed monthly births (dots) against rejection area of one-sided null hypothesis of no increased biological infertility (gray area)



Sources: Human Fertility Database (2021); own computation and illustration

Results

Figure 2. Observed monthly births (dots) against rejection area of two-sided null hypothesis of no differential fertility (gray area)



Sources: Human Fertility Database (2021); own computation and illustration

Results

- No evidence for higher biological infertility because of pandemic

⇒ Forecast October 2020 – December 2021

- Overall fertility response differs very much between countries
  - No increased fertility for any country
  - 18 countries with no statistically significant differences
  - 14 countries show lower fertility: tendency among Mediterranean, Northern European, and East Asian countries

Further steps

- Next, we will develop an approach for adjustment of fertility projections amidst pandemic effects
- For unaffected countries, no adjustment to fertility forecasts necessary
- For countries with substantial differential (i.e. lower) fertility, previous fertility forecast should be adjusted
- Idea: divide observed monthly births by forecasts to and fit distributions of some differential parameter
- E.g., adjust UN WPP by multiplication with simulations of differential parameter, similar as in Bayesian updating
- Include different scenarios on the future development of the parameter based on the literature (e.g., see Berington et al. 2021[4] or Goldstein 2020[5])

⇒ Stochastic fertility projection based on ensemble sampling

[4] Berringten, A.; Ellison, J.; Kuang, B. et al. (2021): „Recent trends in UK fertility and potential impacts of COVID-19." *CPC Working Paper* 95.

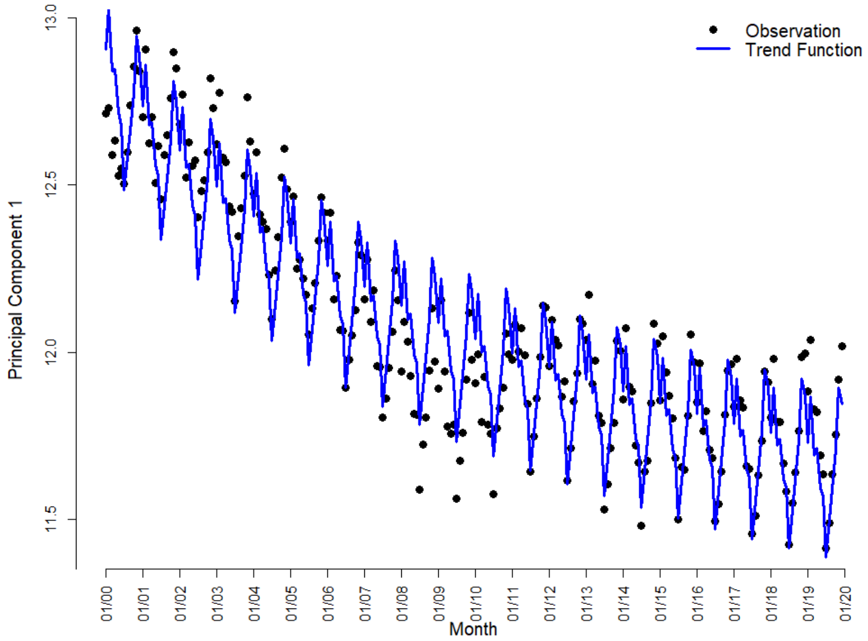
[5] Goldstein, J.R (2020): „Rebirth after Disaster: Models of Post-Pandemic Fertility and Marriage." *Keynote at Wittgenstein Centre Conference 2020,* available at https://www.youtube.com/watch?v=DPWsRG747WM.

Many Thanks! Questions or Remarks?

VANELLA, P.; DESCHERMEIER, P.; GREIL, A.L.: IMPACTS OF THE COVID-19 PANDEMIC ON INTERNATIONAL FERTILITY – A STOCHASTIC PRINCIPAL COMPONENT APPROACH [WORK IN PROGRESS]

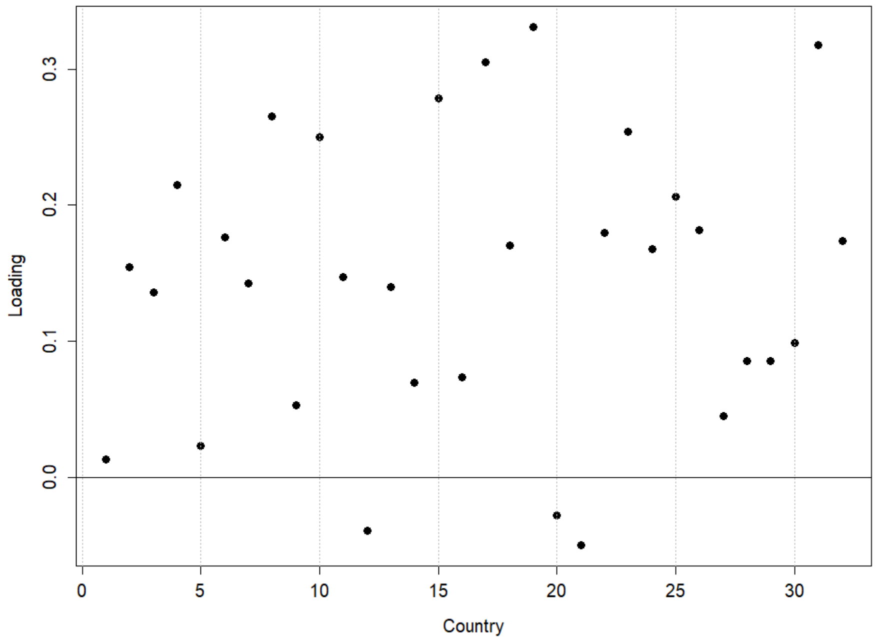
Supplement

Figure 3. Course of principal component 1 for baseline period January 2000 – December 2019



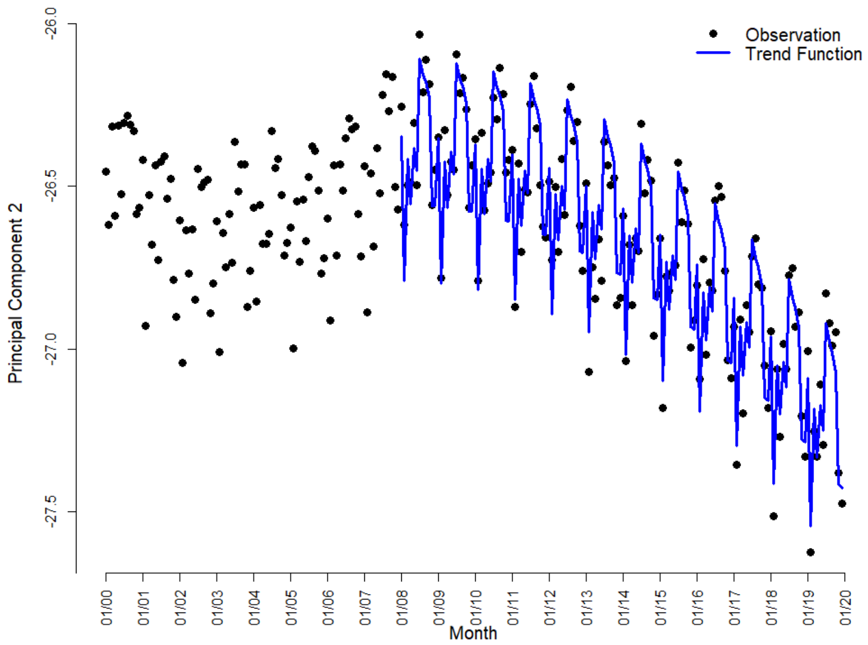
Supplement

Figure 4. Loadings of principal component 2 for baseline period January 2000 - December 2019



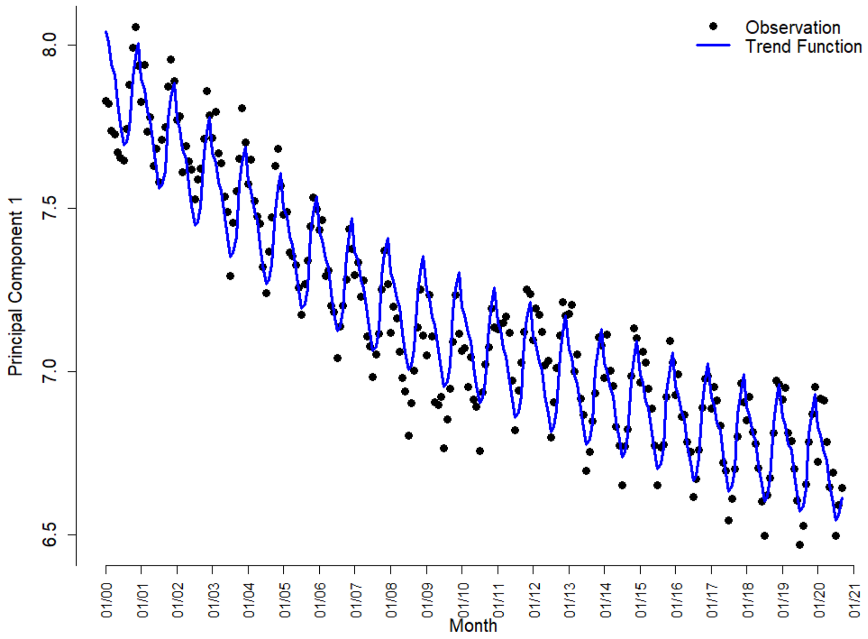
Supplement

Figure 5. Course of principal component 2 for baseline period January 2000 – December 2019



Supplement

Figure 6. Course of principal component 1 for baseline period January 2000 – September 2020



Supplement

Figure 7. Loadings of principal component 2 for baseline period
January 2000 - September 2020

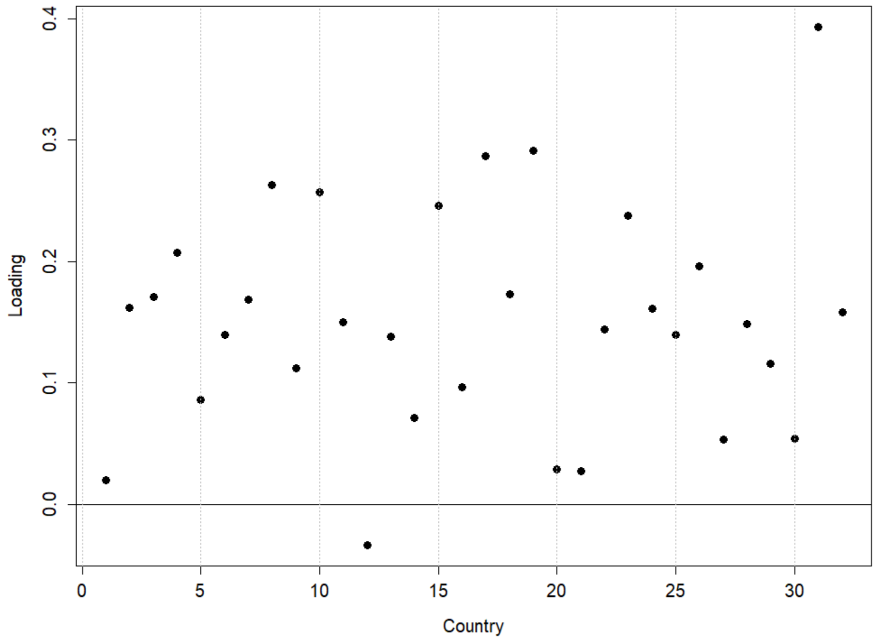


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Figure 8. Course of principal component 2 for baseline period January 2000 – September 2020