Addressing Policy Questions with Formal Demography (with Examples in R)

Roland Rau
University of Rostock & Max Planck Institute for Demographic Research

Formal Demography Workshop, UC Berkeley

09 June 2022

Universität Rostock
Traditio et Innovatio

MAX-PLANCK-INSTITUT FÜR DEMOGRAFISCHE FORSCHUNG
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Three Goals of This Presentation:

1. Address policy questions with formal demography.
2. Present software to try to answer those questions.
3. Show that formal demography is fun!

Toolbox for Today: Stable Population Theory

- Age-specific but time-invariant fertility & mortality
- No migration
- Female-only population

Q: But isn't this quite unrealistic?

RR: This snapshot in time still allows us to learn a lot about the inherent population dynamics, even if fertility & mortality do not remain constant over time.

Source: Scott Liebenson (Original Picture) https://commons.wikimedia.org/wiki/File:LAPD_Memorial_Day_Checkpoint.jpg, License:CC BY-SA 2.0

One Example: Elterngeld ("Parental Allowance") in Germany

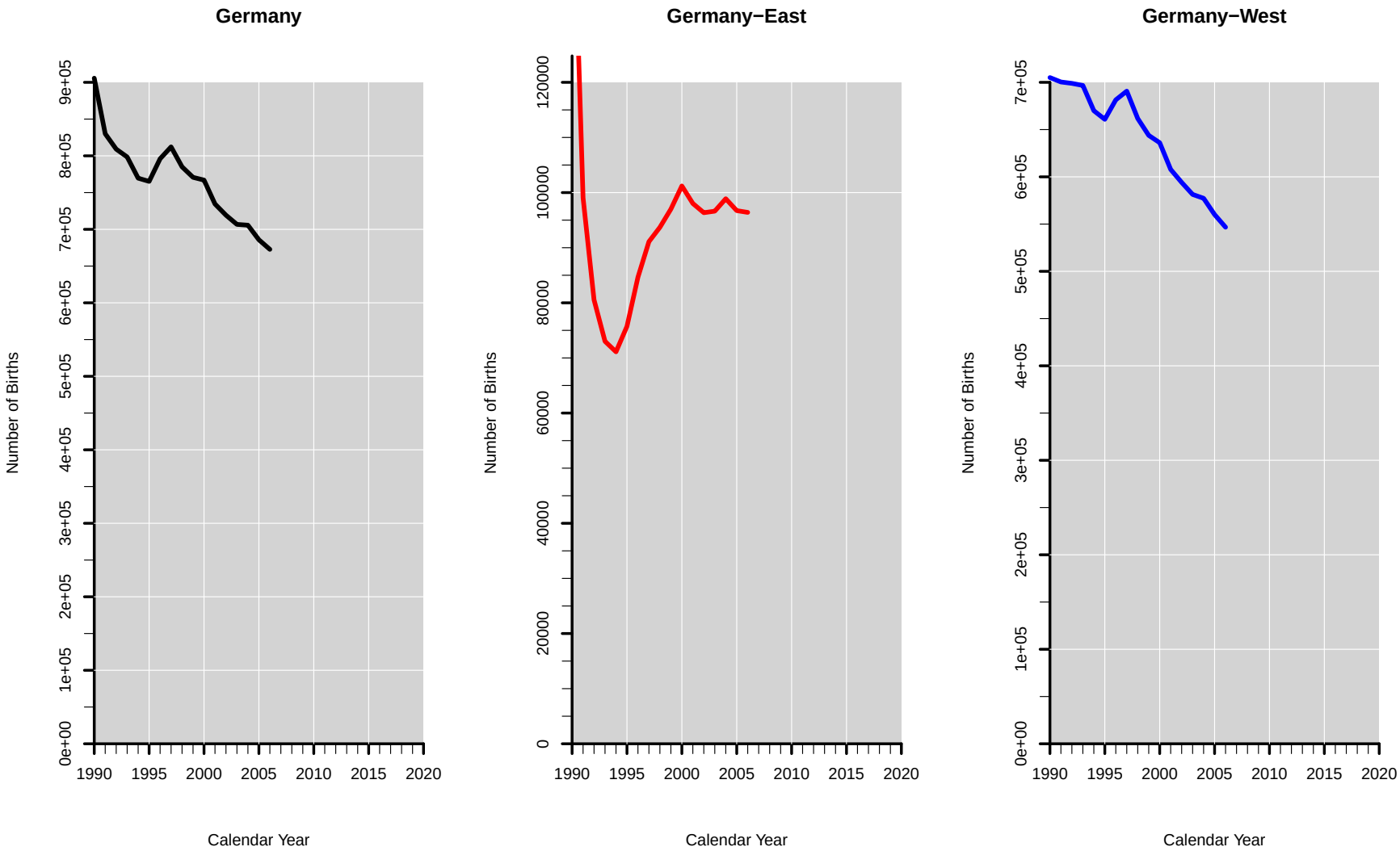
Description:

- Introduced for children born on 01 January 2007 and thereafter
- Limited to 12 months after the birth of the child (or 14 if both partners participate)
- Financial transfer, about 65% of your last net income (min. €300, max. €1800)
- and many more modifications, changes over time, ...
  but I hope you get the main idea

Goals: see Bujard (2013, p. 134, but my (RR) translation from German)

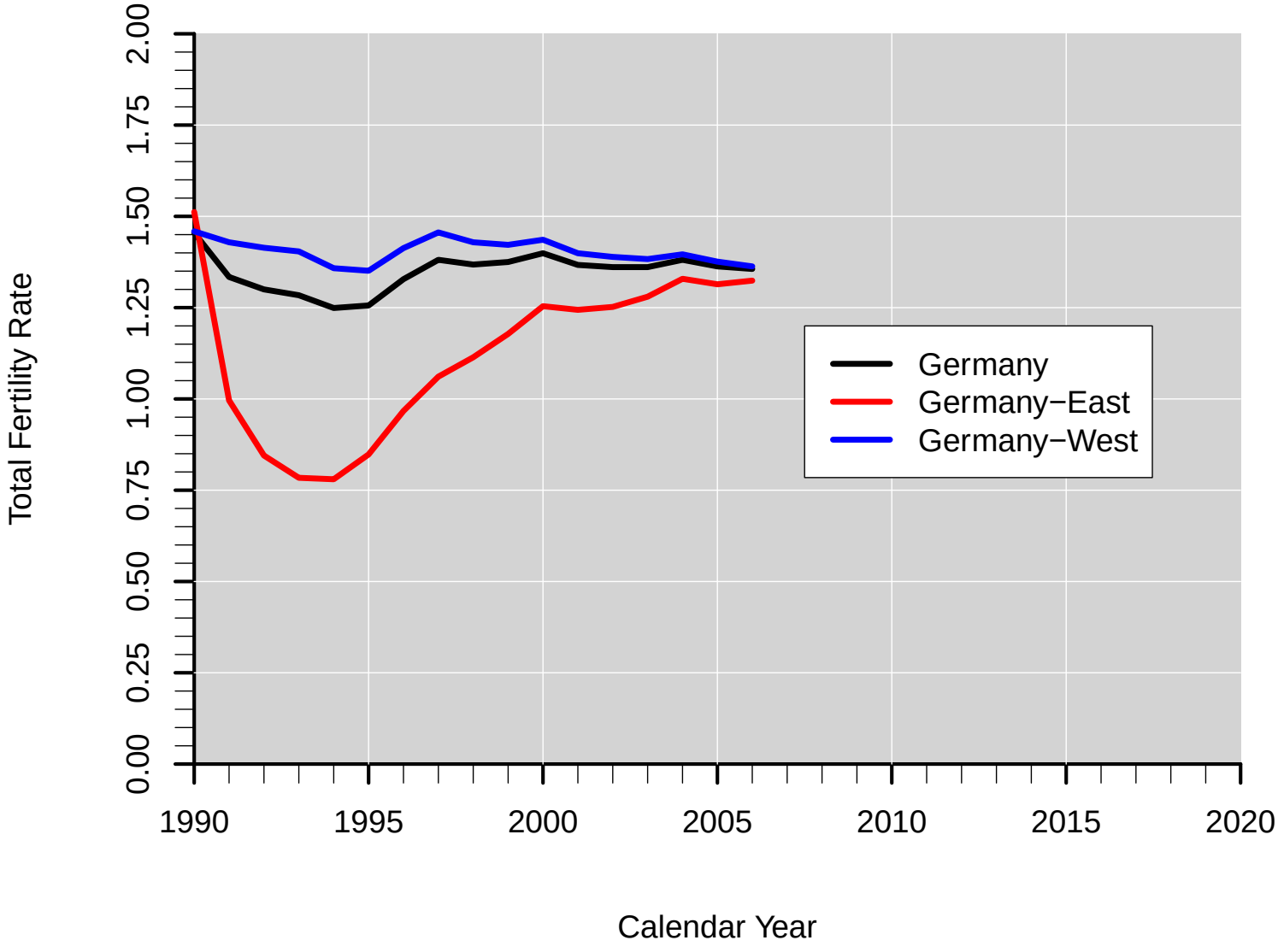
- Ensure continuous income for both partners
- More time for the family
- Increase labor force participation of women
- Equalization (?) (Gleichstellung of women and men)
- **increase fertility rate**

Births 1990–2006



Source: Own illustration based on data from the Human Fertility Database

TFR 1990–2006



Source: Own illustration based on data from the Human Fertility Database

Policy Evaluation

Question to you:
How long does it take until the policy reform takes effect?

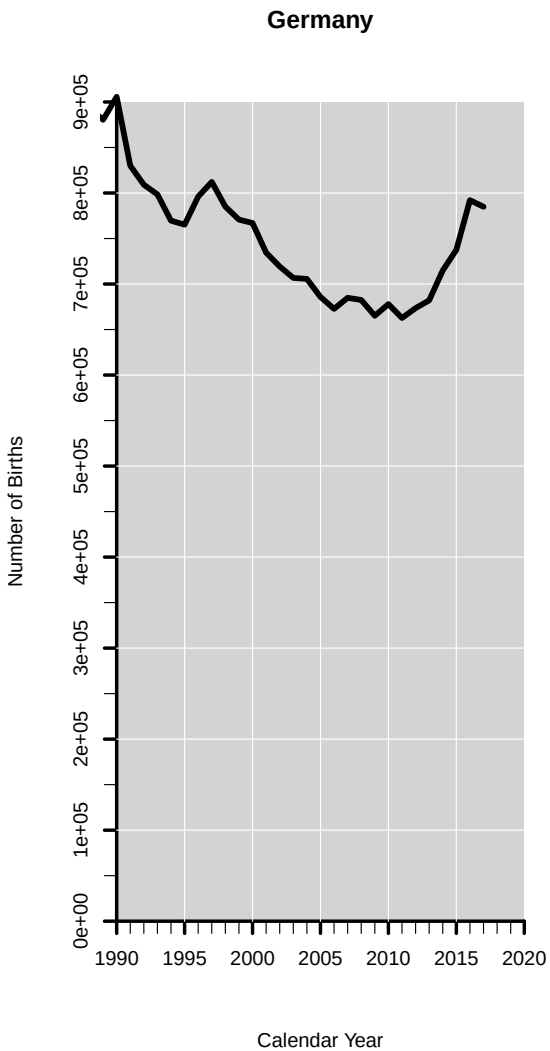
Immediate response from those who have postponed births in the past? Slow effect? . . . ?

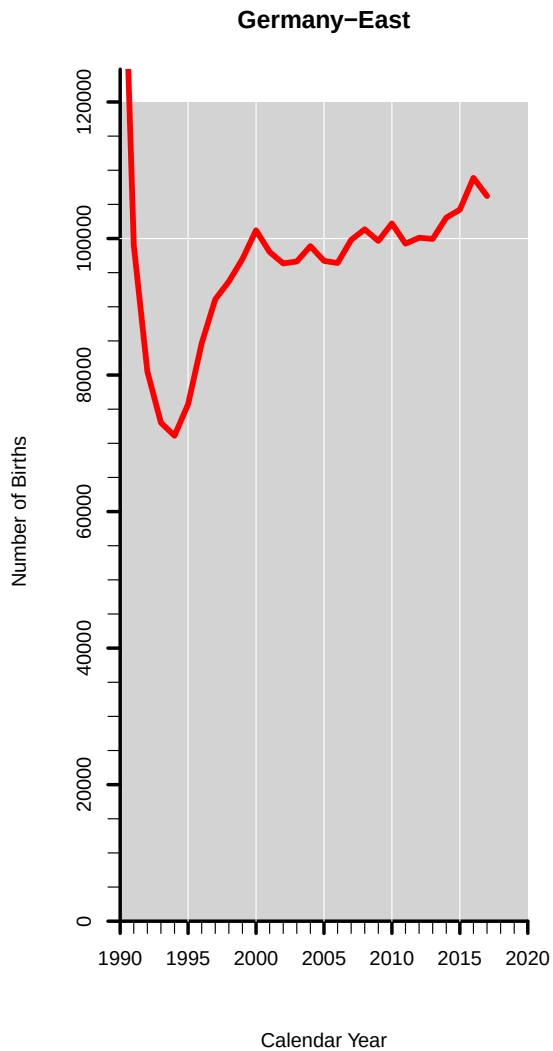
Please note that this is not a real, comprehensive policy analysis: We focus only on one of the goals, disregard any financial aspects, disregard any analysis of causality, disregard that one implicit goals was to encourage mothers with an academic background to have more children, . . .

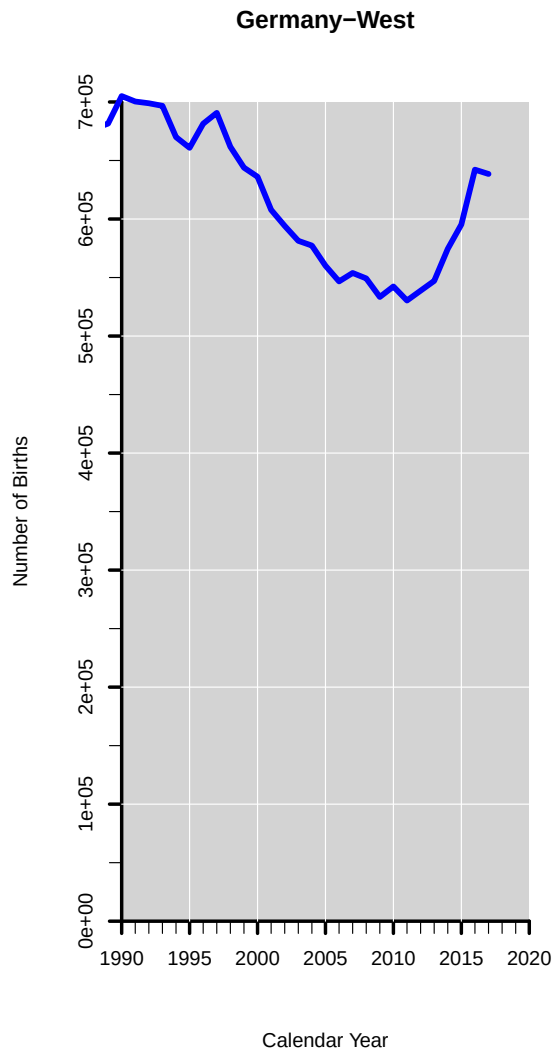
Time-Horizon: 2006–2011

I selected the year 2011 to prepare my slides. Obviously, we can take any other year.

Births 1990–2017

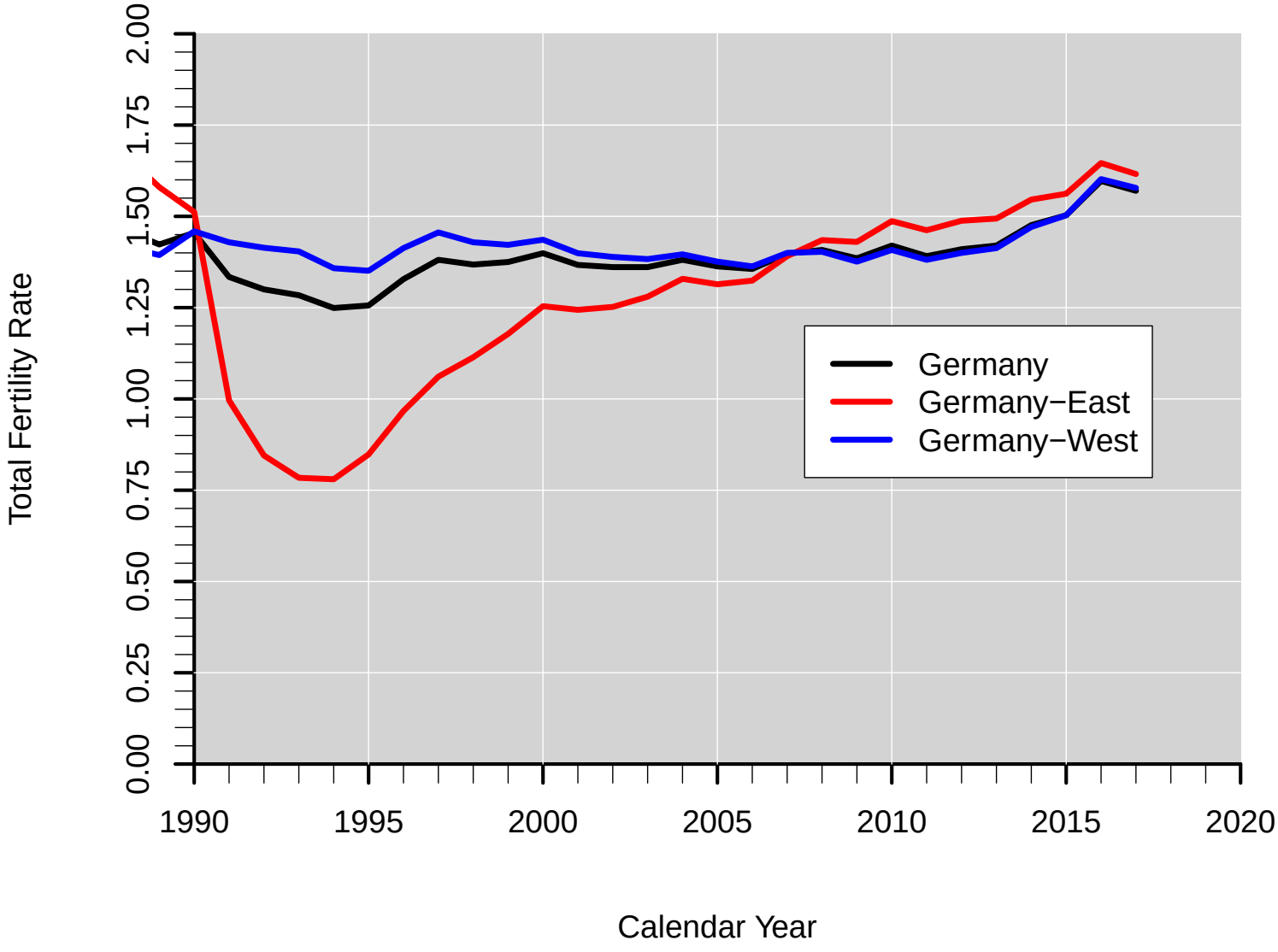






Source: Own illustration based on data from the Human Fertility Database

TFR 1990–2017



Source: Own illustration based on data from the Human Fertility Database

Since the stable population model is a female-only model, it makes no sense to look at the TFR.
Instead we look at the net reproduction number (NRR).
First, we need to load several packages and their dependencies. Unless they have already been installed, we need to do this now:

```
install.packages("HMDHFDplus", repos="https://cran.wu.ac.at/")

## Installing package into
'/home/roland/R/x86_64-pc-linux-gnu-library/4.2'
## (as 'lib' is unspecified)
```

The packages I use developed are on gitlab, that is why we need the package remotes

```
install.packages("remotes", repos="https://cran.wu.ac.at/")

## Installing package into
'/home/roland/R/x86_64-pc-linux-gnu-library/4.2'
## (as 'lib' is unspecified)
```

```
library(HMDHFDplus)
library(remotes)
```

```
install_gitlab("rolandrau/AnnualWorldPopulation")
install_gitlab("rolandrau/WorldPopQuery")
install_gitlab("rolandrau/ProjMatRawData")
install_gitlab("rolandrau/StablePop")
```

```
library(AnnualWorldPopulation)
library(WorldPopQuery)
library(ProjMatRawData)
library(StablePop)
```

```
Germany06 <- stablepopHMDHFD(country="DEUTNP", year=2006,
  HMD.user=myHMD.user,
  HMD.pw=myHMD.pw,
  HFD.user=myHFD.user,
  HFD.pw=myHFD.pw)

Germany11 <- stablepopHMDHFD(country="DEUTNP", year=2011,
  HMD.user=myHMD.user,
  HMD.pw=myHMD.pw,
  HFD.user=myHFD.user,
  HFD.pw=myHFD.pw)
```

The Net Reproduction Rate NRR, R_0

```
Germany06$NRR
```

```
## [1] 0.6527283
```

```
Germany11$NRR
```

```
## [1] 0.6696617
```

How will it affect the long term growth rate? (or rather shrinkage rate)

```
Germany06$growth.rate
```

```
## [1] 0.9857921
```

```
Germany11$growth.rate
```

```
## [1] 0.9870099
```

```
Germany11$growth.rate - Germany06$growth.rate
```

```
## [1] 0.001217742
```

Will it have a positive effect on the OADR in the long-term?

Where are we now?

```
OADR2006.now <- sum(Germany06$age.structure.now[-(1:65)]) /
                sum(Germany06$age.structure.now[16:65])
OADR2011.now <- sum(Germany11$age.structure.now[-(1:65)]) /
                sum(Germany11$age.structure.now[16:65])
OADR2006.now

## [1] 0.3497854

OADR2011.now

## [1] 0.361843
```

And in the long term (right eigenvector)?

```
OADR2006.longterm <- sum(Germany06$age.structure.stable[-(1:65)]) /
                     sum(Germany06$age.structure.stable[-(16:65)])
OADR2011.longterm <- sum(Germany11$age.structure.stable[-(1:65)]) /
                     sum(Germany11$age.structure.stable[-(16:65)])
OADR2006.longterm

## [1] 0.7699841

OADR2011.longterm

## [1] 0.7598802
```

What we know for sure (in the absence of migration) is that Germany's population will continue to shrink — even if it was possible to return instantaneously to replacement-level fertility; i.e. the case of the classical population momentum (e.g. Keyfitz, 1971; Preston and Guillot, 1997).

```
Germany06$Momentum.PrestonGuillot

## [1] 0.836836

Germany06$Momentum.bruteforce

## [1] 0.8368467

Germany06$MomentumRecursive

## [1] 0.8368498

Germany11$Momentum.PrestonGuillot

## [1] 0.8133222

Germany11$Momentum.bruteforce

## [1] 0.8134687

Germany11$MomentumRecursive

## [1] 0.8133454
```

If . . .

- . . . our goal was to change the long term growth rate and
- . . . if it was possible to influence fertility via public policy and
- . . . if the costs were identical at all ages . . .
- . . . if we looked at proportional changes (i.e. change age-specific fertility by a certain proportion)
- . . . and . . .

Which age would you select?

Which age would you select?

One possibility is the so-called elasticity analysis of the dominant eigenvalue (which is the long-term growth rate).[1]
The elasticity matrix **E** is defined for a projection matrix **A** with rows i and columns j as:

$$\mathrm{E} = \frac{a_{ij}}{\lambda} \frac{\partial \lambda}{\partial a_{ij}}$$

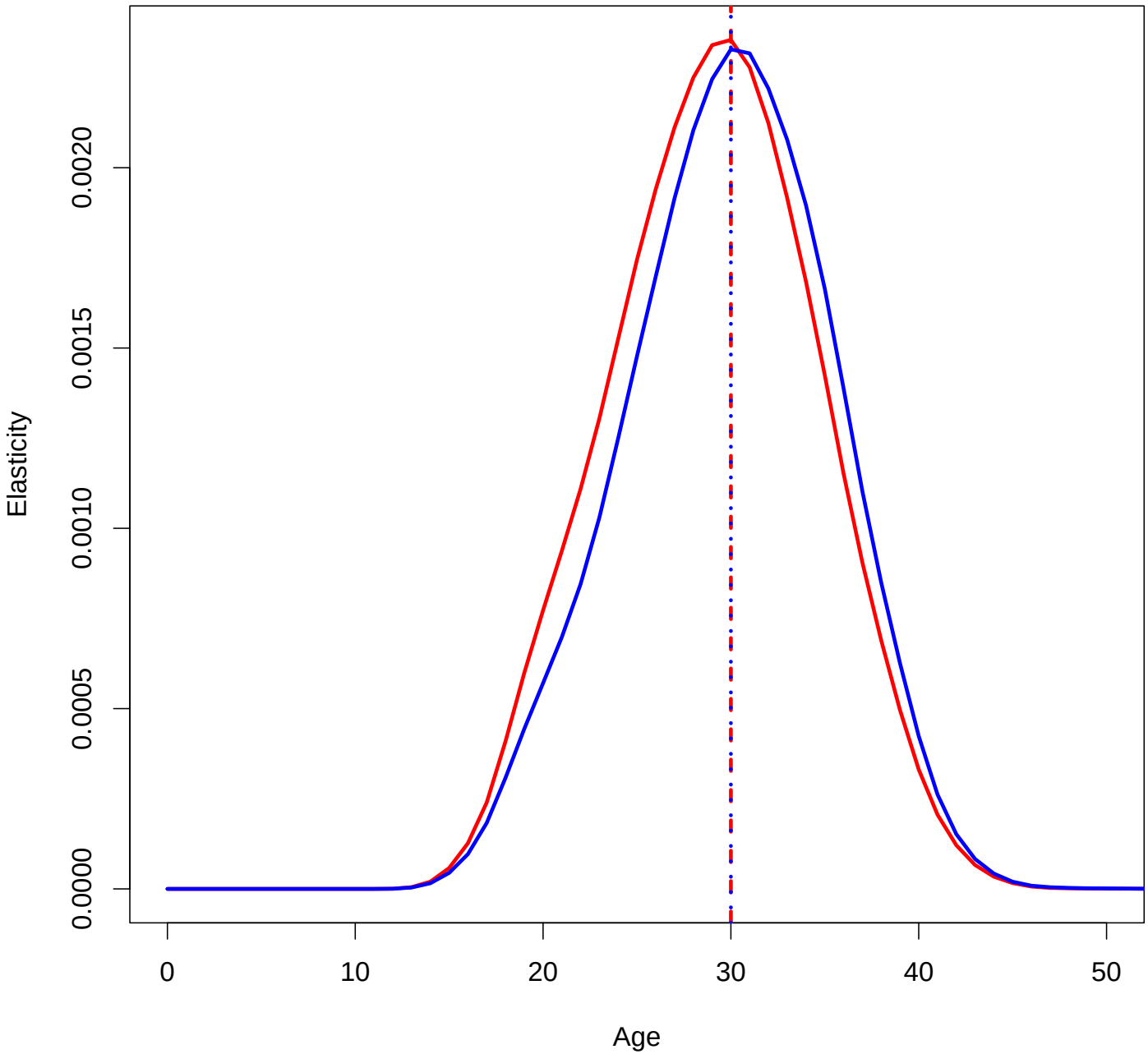
The component can be access via:

```
Germany06$growth.rate.elasticity
Germany11$growth.rate.elasticity
```

[1] Please check Chapter 9 of Hal Caswell's (2001): *Matrix Population Models* for an in-depth treatment.

```
graphics.off()
pdf("elasti-plot.pdf", height=10, width=10, pointsize=16)
plot(x=0:110, y=Germany06$growth.rate.elasticity[1,], xlim=c(0,50),
   type="l", col="red", xlab="Age", lwd=3, ylab="Elasticity")
abline(v=30, lwd=3, lty=2, col="red")
lines(x=0:110, y=Germany11$growth.rate.elasticity[1,], col="blue",
      lwd=3)
abline(v=30, lwd=3, lty=3, col="blue")
dev.off()

## null device
##           1
```


Elasticity
0.0000
0.0005
0.0010
0.0015
0.0020
0
10
20
30
40
50
Age

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1. Address policy questions with formal demography. (?)
2. Present software to try to answer those questions. (?)
3. Show that formal demography is fun! (?)

References

Bujard, M. (2013). Die fünf Ziele des Elterngelds im Spannungsfeld von Politik, Medien und Wissenschaft. The five goals of the new German parental leave benefit in the focus of politics, media and science. *Zeitschrift für Familienforschung 25*(2), 132–153.

Caswell, H. (2001). *Matrix Population Models. Construction, Analysis, and Interpretation. Second Edition*. Sunderland, MA: Sinauer.

Keyfitz, N. (1971). On the Momentum of Population Growth. *Demography 8*, 71–80.

Preston, S. H. and M. Guillot (1997). Population dynamics in an age of declining fertility. *Genus 53*(3–4), 15–31. Reprinted in Genus, Vol. 65, p. 83–98.