Aggregate-level measures and methods in contemporary fertility research

Tomáš Sobotka

VIENNA INSTITUTE OF DEMOGRAPHY

Workshop "Measurements and Methods in Demography"

Berlin, 16 October 2009

INTRODUCTION

Low fertility in Europe: How to measure it?

MISMATCH: Advances and possibilities in fertility measurement not matched with the actual data availability

DEMOGRAPHIC DIMENSIONS of analyses:

- Period (years, months) vs. Cohort (birth & parity cohorts)
- Tempo vs. Quantum
- Birth order, age of mother, duration since previous birth

More factors can be added: region, multiple births, men's fertility, education level, country of origin, partnership status

PRACTICE: it (almost) all comes down to the period *Total Fertility Rate* (TFR)

The TFR dominating fertility analysis in the post-WWII era

- Simple computation: sum of age-specific rates
- ‘Synthetic cohort’ concept, intuitive interpretation (‘*children per woman*’)
- Updated annually (or more often), long time series available for all developed countries

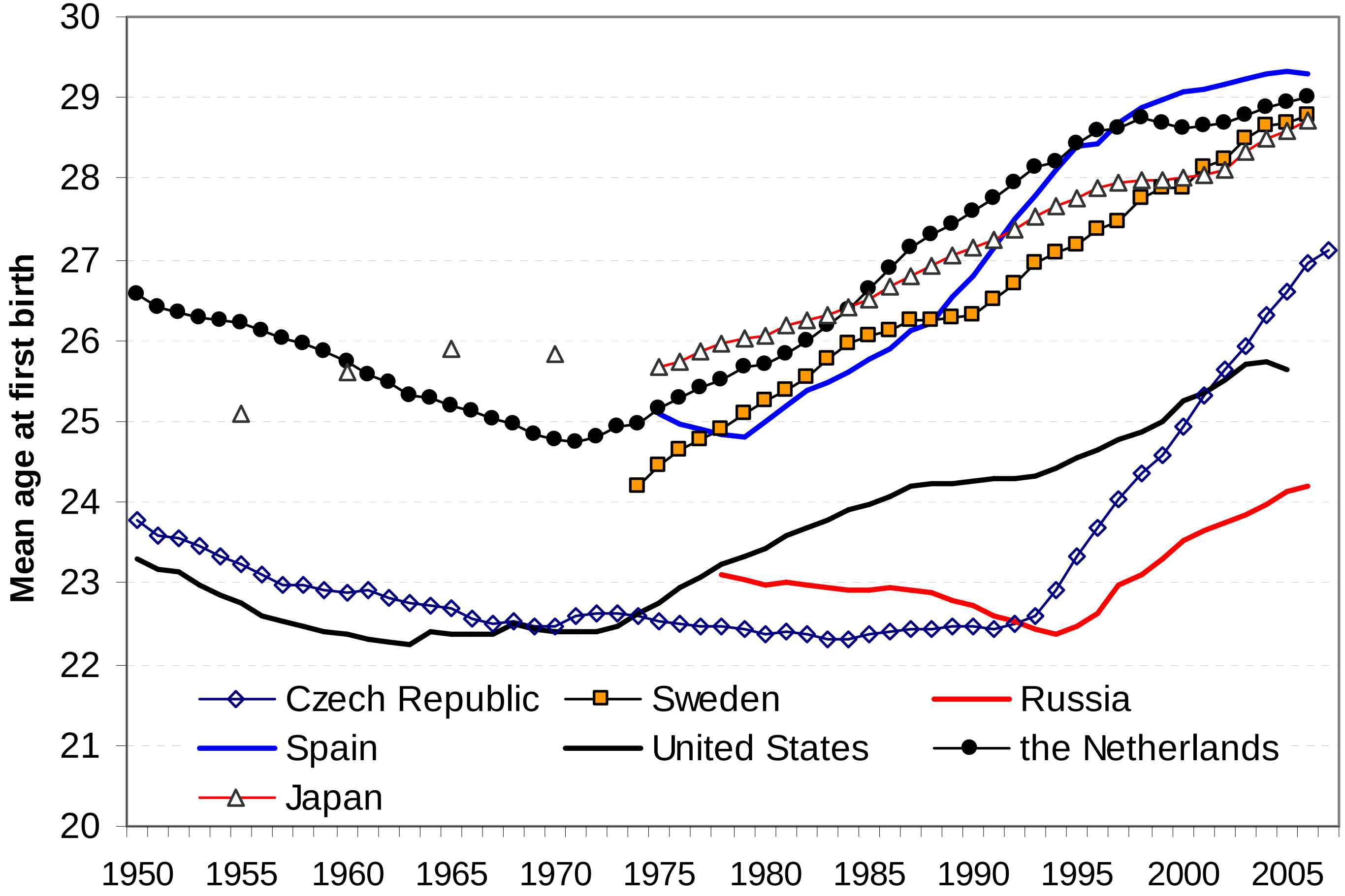
Alternatives seemingly less ‘attractive’:

- Long ‘waiting time’ for cohort fertility series
- Missing exposure population in parity-specific analysis
- Other indicators available only for limited number of countries & periods
- Other indexes often less easily understandable or more difficult to construct

What's wrong with the period TFR?

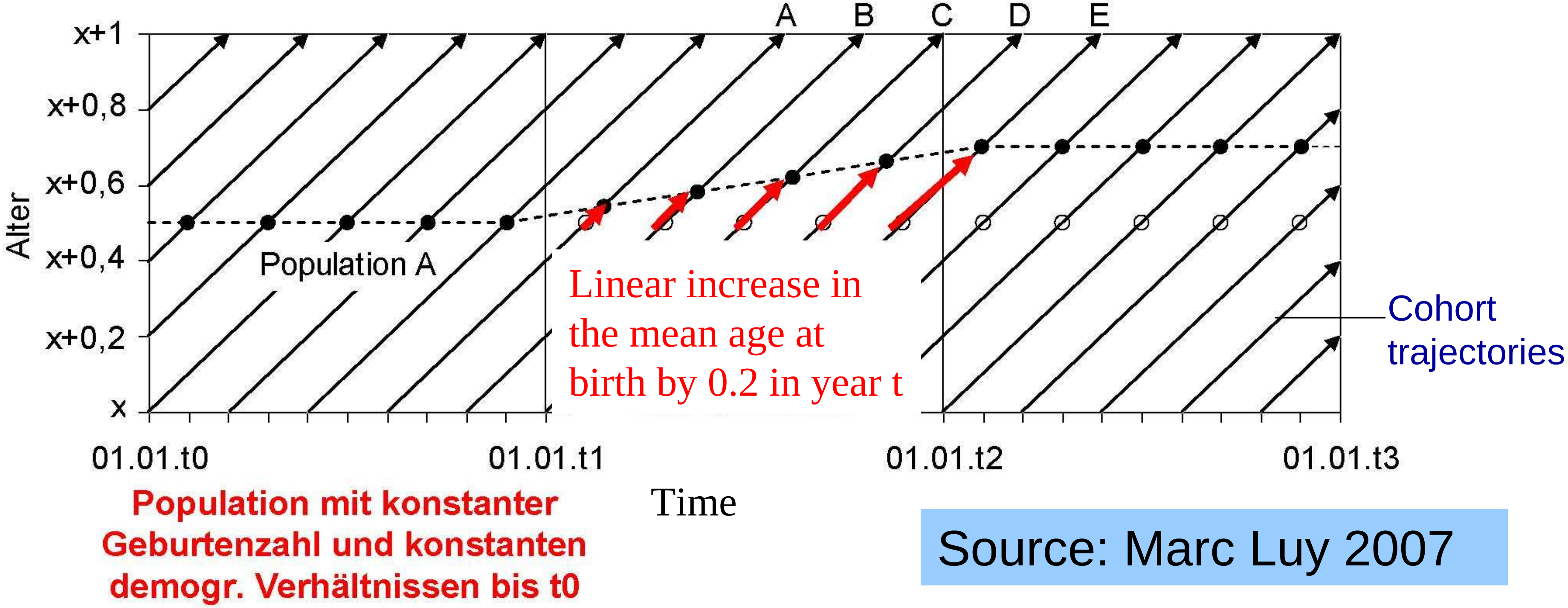
- Controls for some 'key' factors (age & population size), but not for others (parity, duration since the last birth, tempo effects)
- Assumes that children can be born all at once; even women with 3 children are 'at risk' of having first child
- Strongly affected by 'tempo effects' (postponement or advancement of births)
- The 'children-per woman' interpretation is potentially misleading
- Can give incorrect policy messages

Why timing matters?



The 'postponement transition' (Kohler-Billari-Ortega 2002):
Mean age of mothers at first birth in Europe, US and Japan

Tempo effect and the distortions in the total fertility rate: an illustration

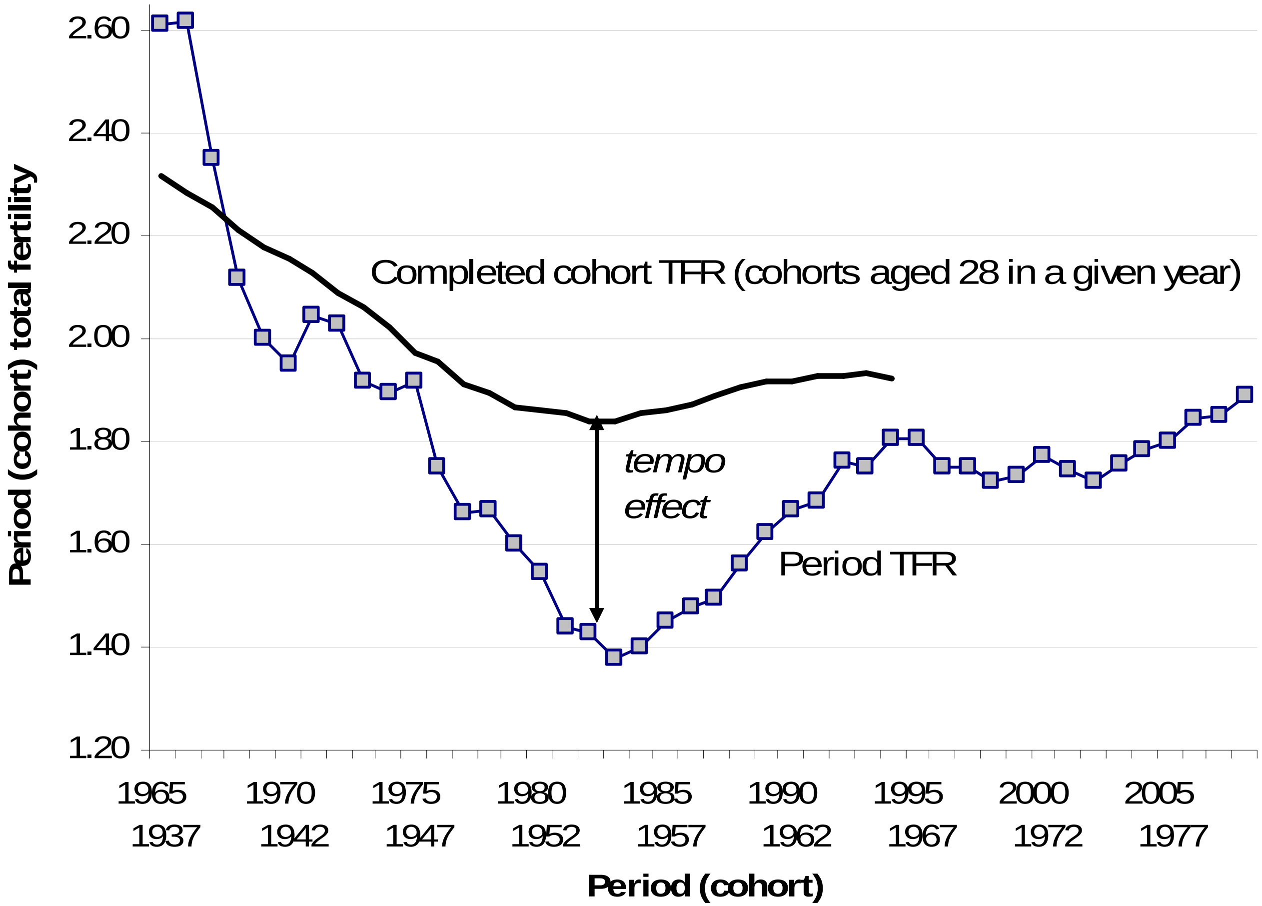


Source: Marc Luy 2007

Tempo effects not just minor disturbances: they may be strong and prevail over long periods of time

Tempo effects: long-term distortion in the period TFR

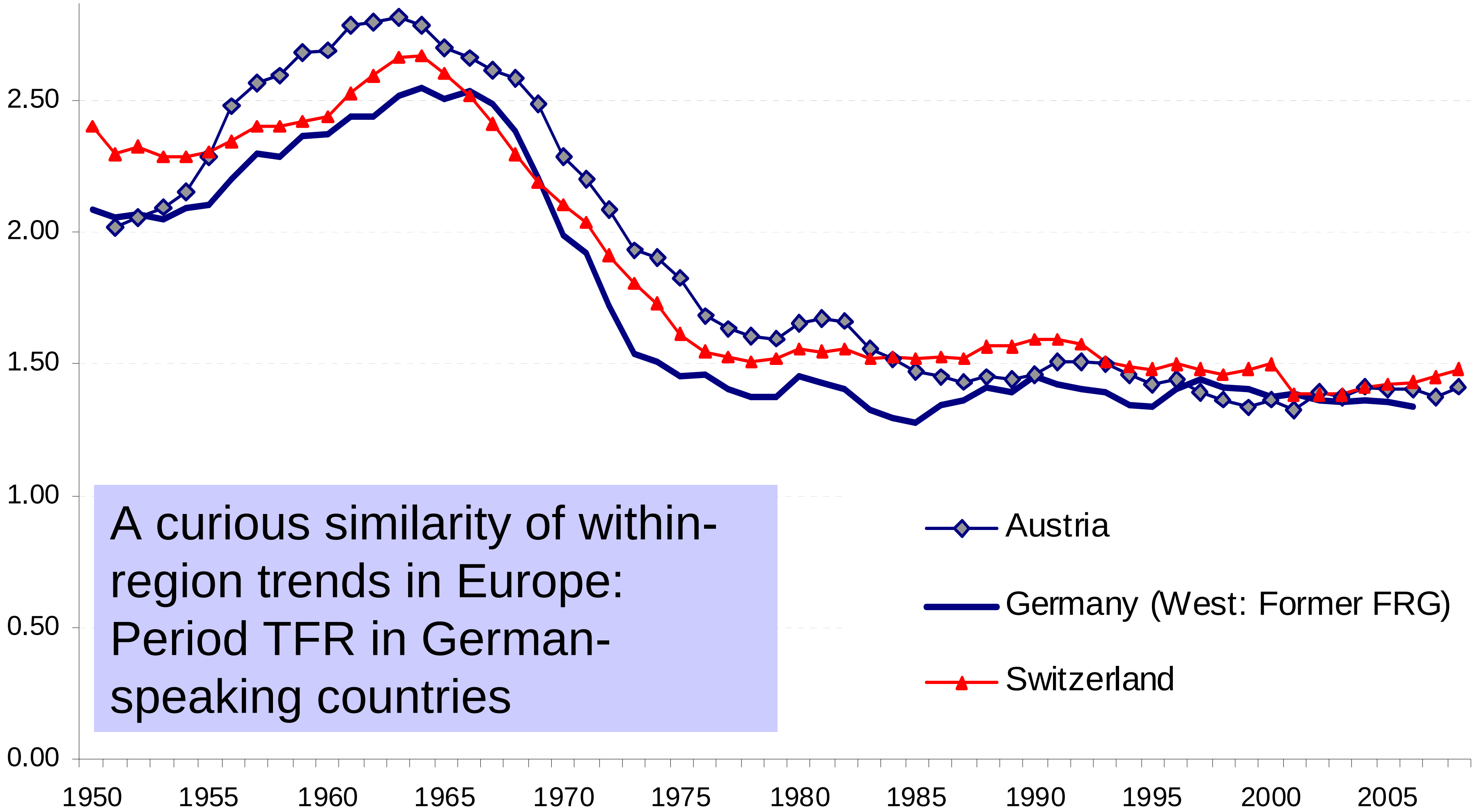
Period TFR (1970-2008) and completed cohort TFR (1942-1964) in Denmark



Data sources: Council of Europe (2006), and own computations from EUROSTAT (2006-9)

Should period TFR be 'dumped'?

Not necessarily & not always: It (still) often provides useful & readily available information



AGENDA

‘Mainstream’ measures and available alternatives: Issues, examples and illustrations

- Cohort analysis: No troubles with the timing?
- Period analysis: A wild array of indicators
  - Parity dimension, fertility tables
  - Tempo-adjusted measures
- Parity cohorts: Bridging period and cohort analysis?
- Emerging issue: How to bring migration in the analysis?

Illustrations: Low and ‘lowest-low’ fertility in Austria and Europe

1) COHORT ANALYSIS: No tempo distortions

BIRTH COHORTS:

- ‘Completed’ cohort TFR (*CTFR*): no tempo effects
- No interpretation ambiguity: *CTFR* = real number of children per woman
- Some measurement difficulties: cumulating cohort fertility over long periods of time vs. children ever born
- Easy division by birth order:

  CTFR = sum of order-specific CTFR*i*

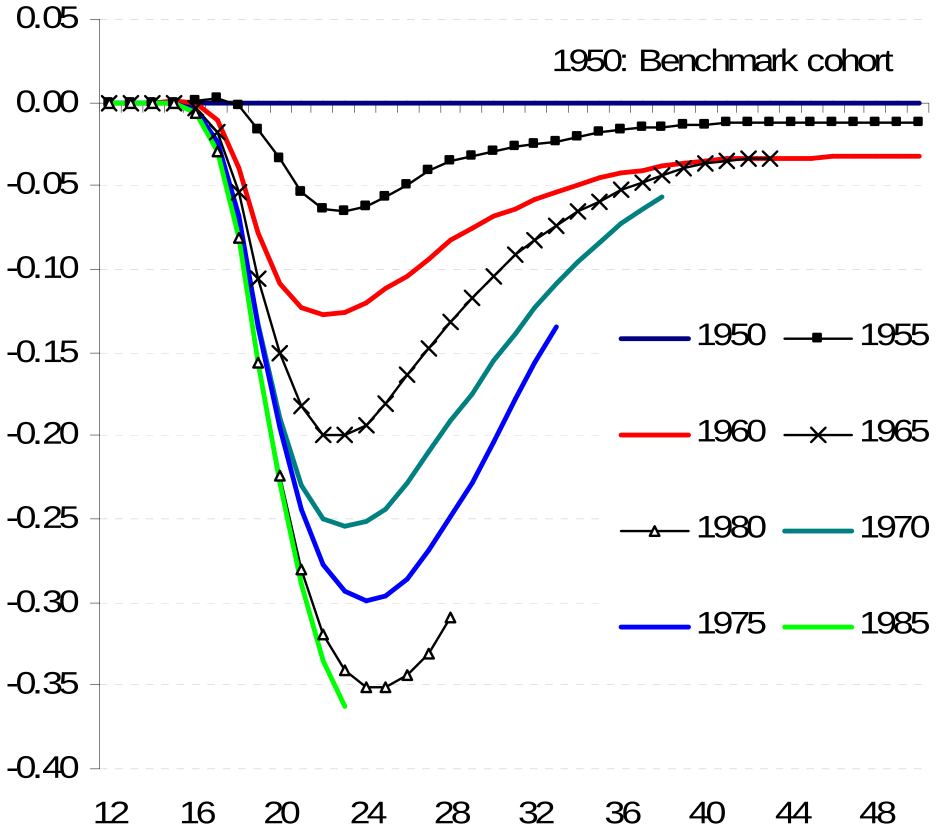
  Parity Progression Ratios: $PPR_{i,i+1} = CTFR_{i+1} / CTFR_i$
- BUT: ‘long waiting time’ (age 40 at least…)

Important issues in COHORT ANALYSIS

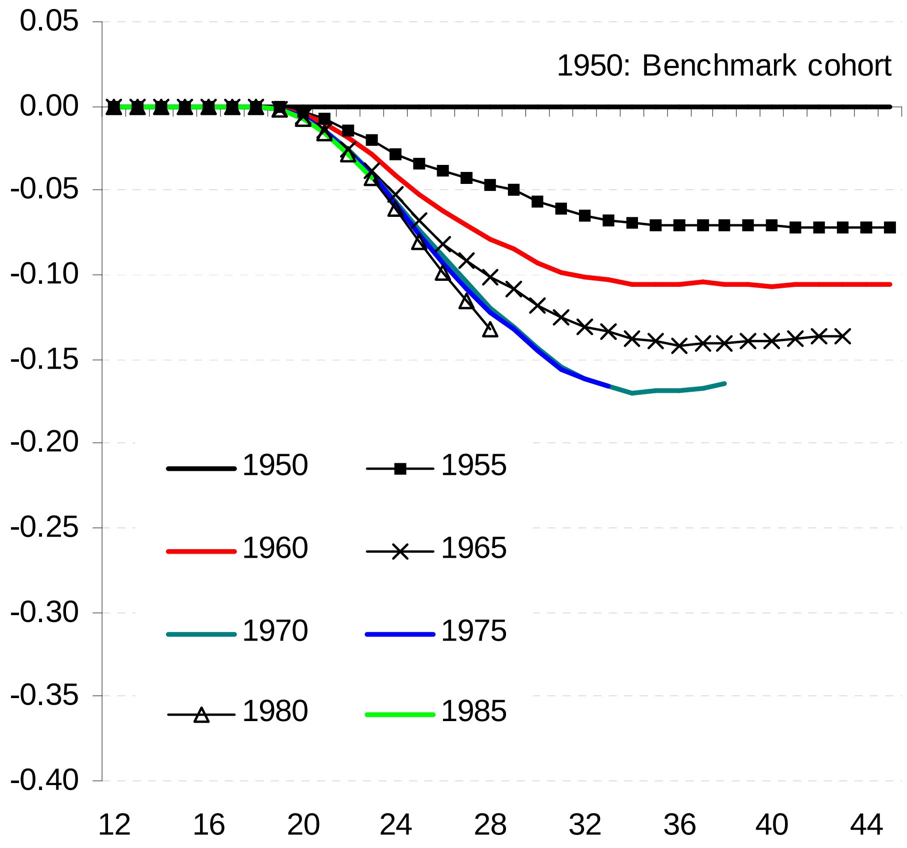
1) Analysing patterns of cohort ‘postponement’ and ‘recuperation’: Examples from Austria

(work with K. Zeman, T. Frejka, R. Lesthaeghe)

Cohort 'postponement' and 'recuperation': Age-specific 'deficits' related to one benchmark cohort



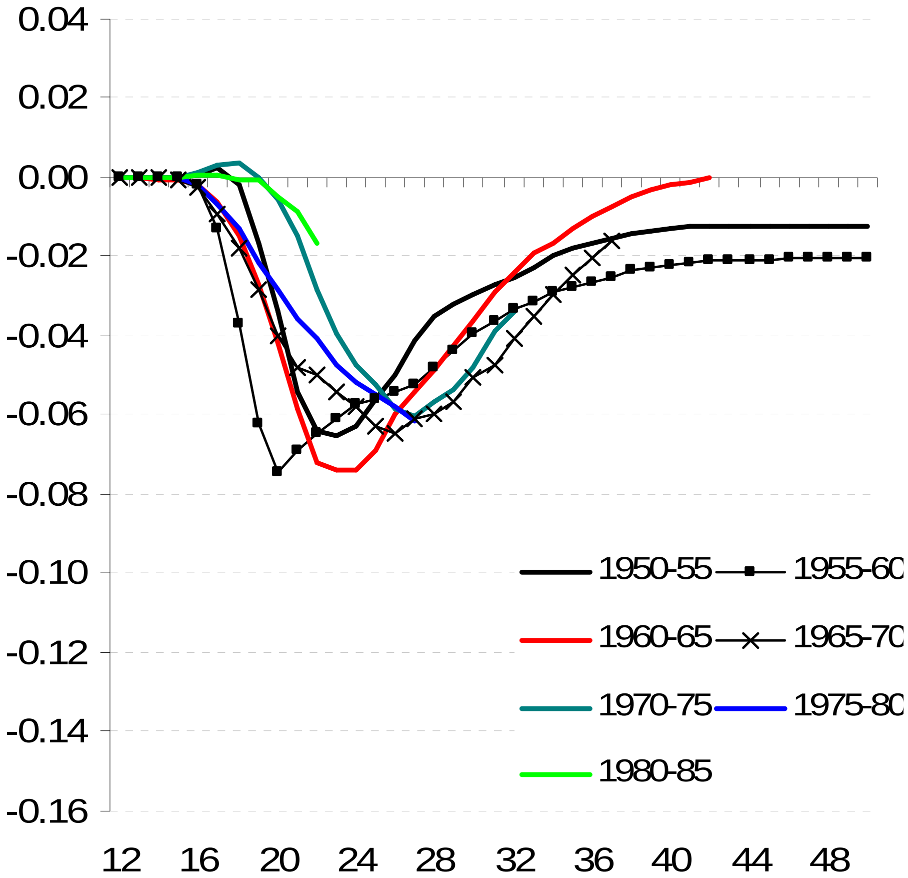
First births



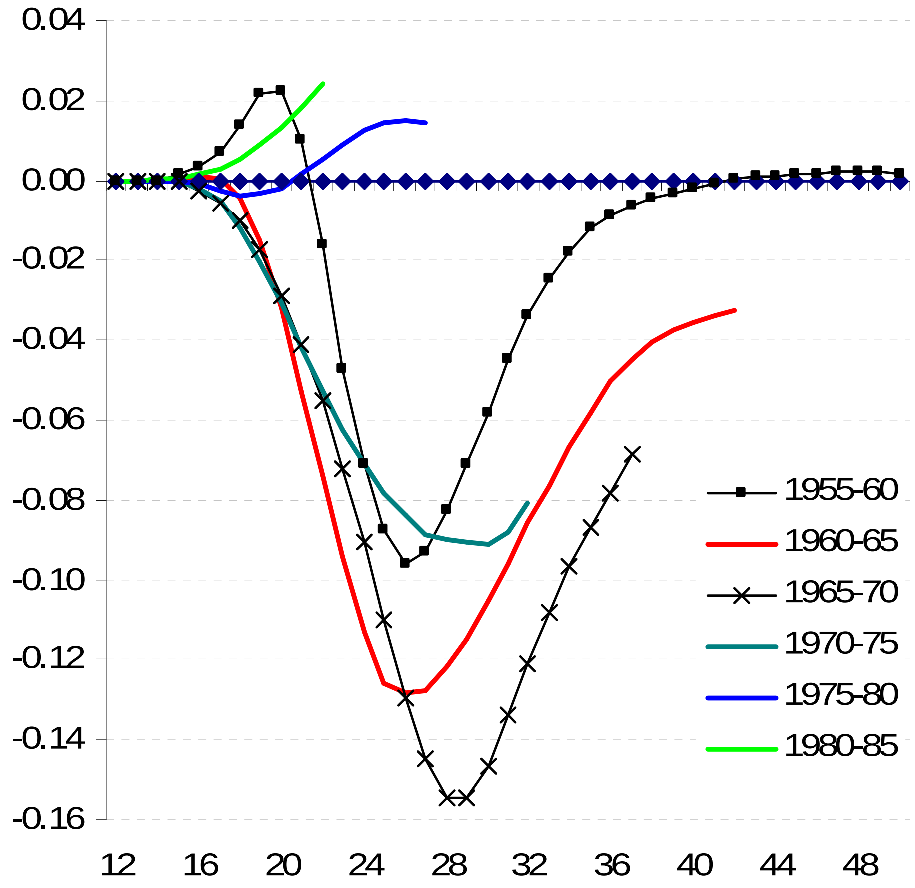
Third+ births

Cohort ‘postponement’ and ‘recuperation’ - Moving benchmark: Age-specific ‘deficits’ related to the last previous cohort

---

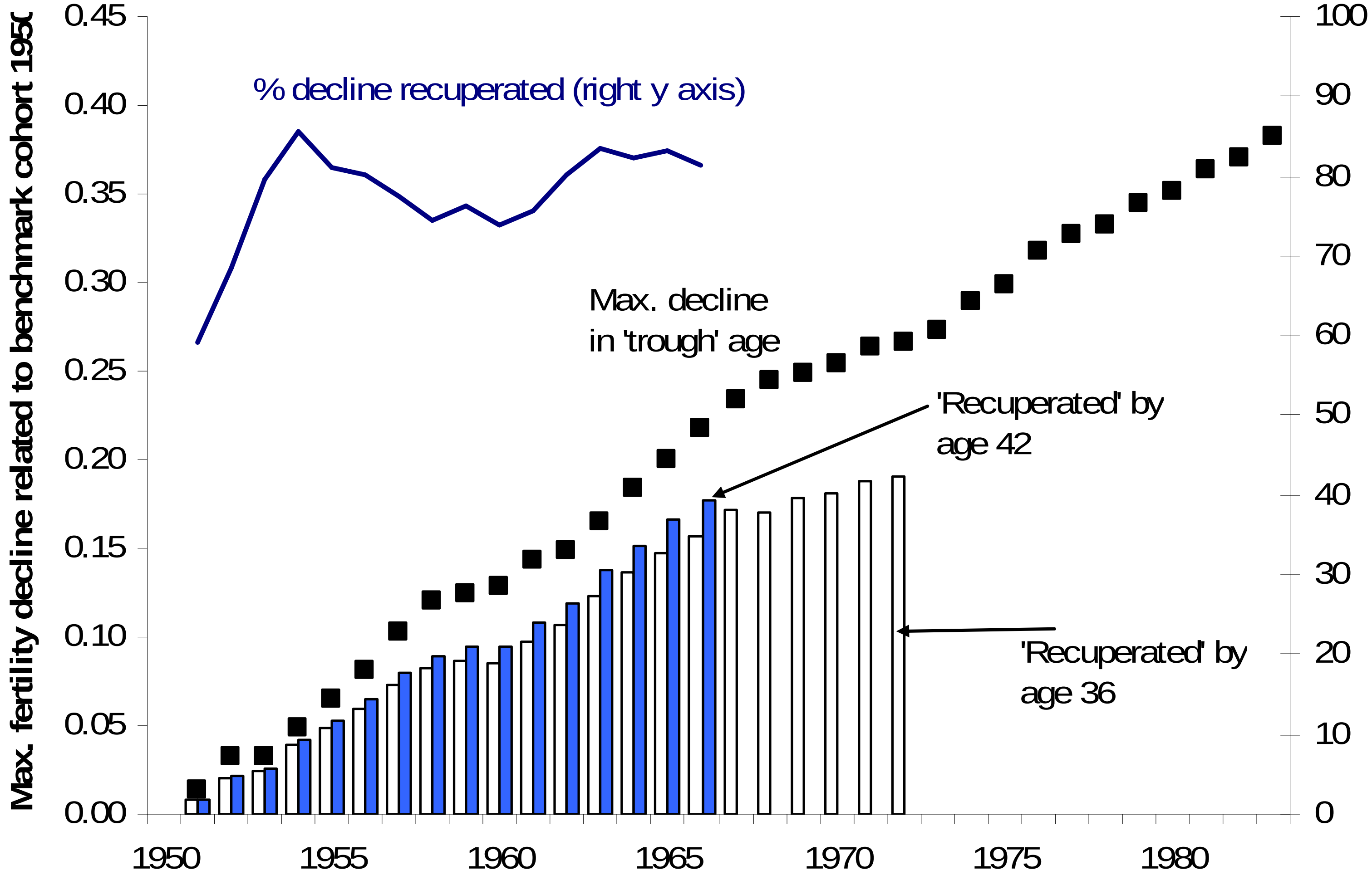


AUSTRIA: First births



SPAIN: First births

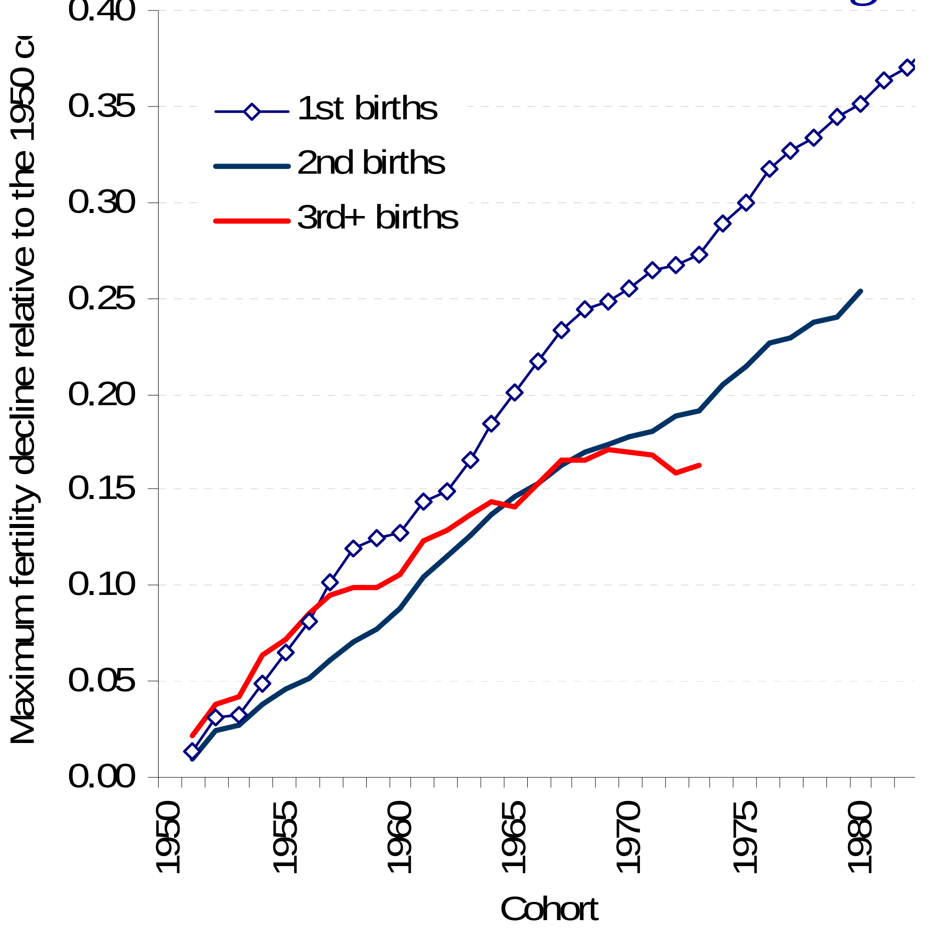
Cohort 'postponement' and 'recuperation': Summary analysis related to the 'benchmark cohort' initiating postponement



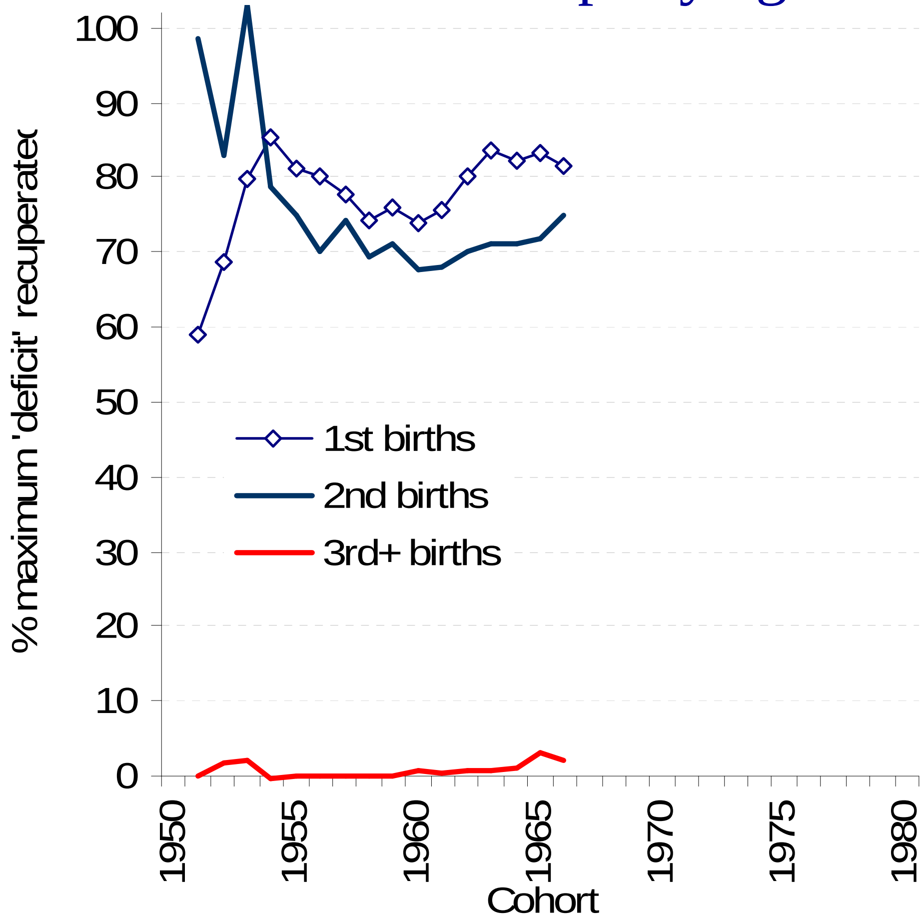
AUSTRIA: First births; cohorts 1950-83 (benchmark cohort 1950)

Cohort ‘postponement’ and ‘recuperation’: Summary analysis related to the ‘benchmark cohort’ initiating postponement

Maximum decline in ‘trough’



% decline ‘made up’ by age 42



AUSTRIA: Order-specific differences in delay and ‘recovery’

Important issues in COHORT ANALYSIS

2) Projecting completed fertility of cohorts in reproductive ages

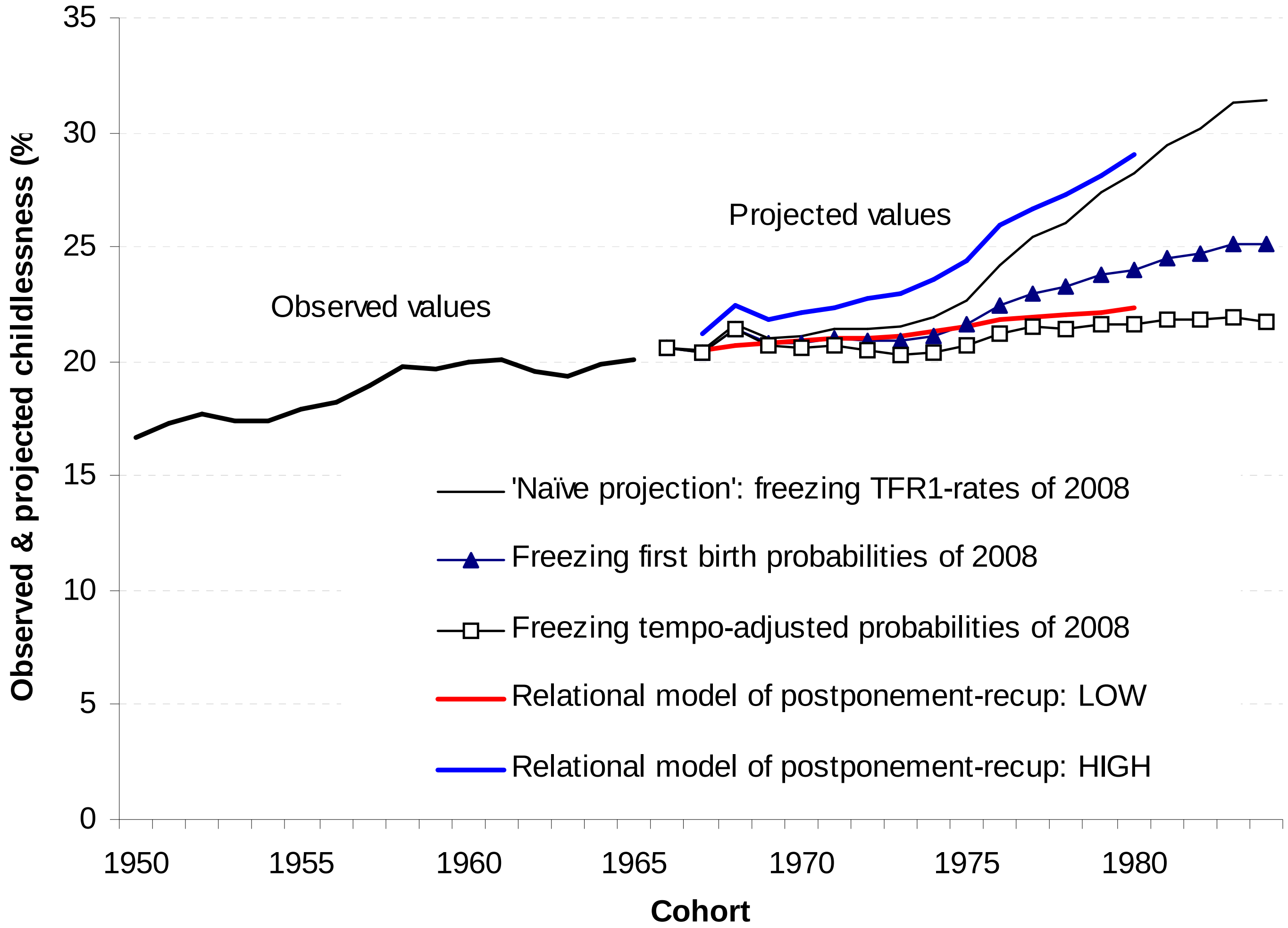
Different approaches:

- Combining cohort fertility up to date with most recent period rates (‘freezing’ most recent rates)
- Completing most recent cohort fertility trajectories: trends analyses, regression models…
- Using model fertility schedules

Key to realistic projections:

- Separate fertility trajectories by birth order
- Take timing shift (‘recuperation’) into account

Cohort fertility projections: Childlessness in Austria



2) PERIOD analysis: Beyond the TFR

- How to measure the 'underlying' period fertility levels?
  - *No unambiguous alternative to the TFR*

Two major alternatives:

1) Shift to the more sophisticated, **parity-specific measures** (indicators controlling for age & parity or parity & duration since the previous birth); *also distorted by tempo effects*!

2) **Adjustment approach:** Attempts to correct the period measures for tempo distortions (e.g., Bongaarts-Feeney (1998), Kohler-Ortega (2002)); *not universally accepted*!

PERIOD analysis: Parity-specific measures

Controlling for the parity distribution of the female population

- Takes away one obvious distortion in the TFR
- Data hurdle: Many countries lacking data on births by 'true' birth order and parity distribution (often birth order within marriage!)

Important distinction: non-exposure rates by birth order (type 2 rates, incidence rates) vs. parity-specific rates (type 1 rates: occurrence-exposure rates, probabilities, 'conditional' rates)

Example: 1st births at age 27

Type 1 rates (exposure): first births related to childless women only:

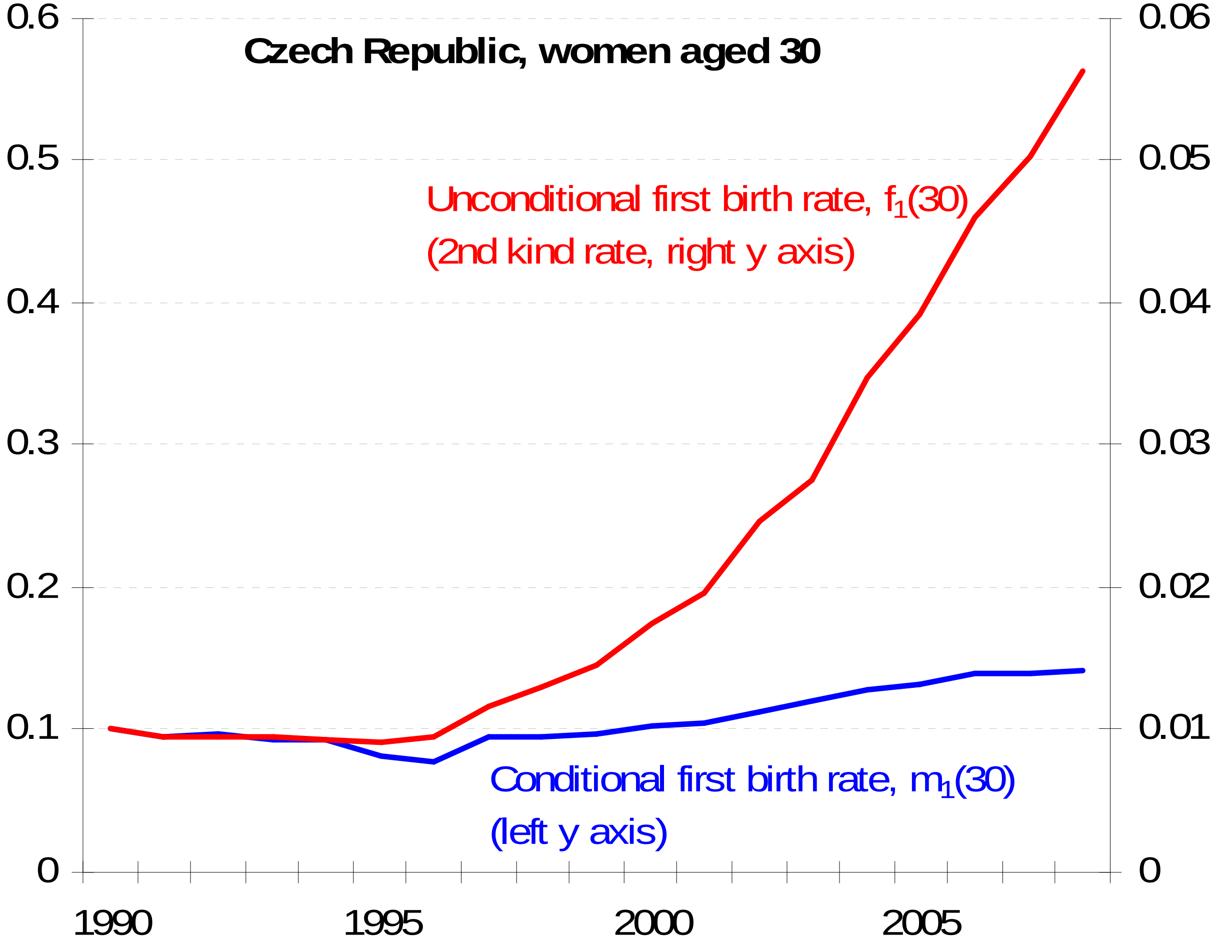
$m_{i=1}(27) = B_{i=1}(27) / P^{F}_{i=0}(27)$

Type-2 rates (non-exposure, TFR-type rates): first births related to all women of a given age: $f_{i=1}(27) = B_{i=1}(27) / P^{F}(27)$

i = parity of the woman or birth order of the child

PERIOD analysis: Parity-specific measures

Controlling for parity may give very different insights



First birth rates change at age 30, Czech Republic 1995-2008:

Unconditional rates ($f_1(30)$): Factor 6.2

Parity-specific rates, $m_1(30)$: Factor 1.7 (+74%)

% childless: 13% in 1995, 43% in 2008

PERIOD analysis: Parity-specific measures

Parity-specific indicators: Layers of analysis

Two major dimensions: Age & duration since the previous birth

- Time elapsed since the previous birth more important than age for women with 1+ children (Ní Bhrolcháin 1992) (common assumption in multiplicative regression models)
- Duration (birth interval) analysis explored further in the next talk
- Schedules of age-parity specific rates can be used to construct multistate (increment-decrement) fertility tables

PERIOD analysis: Fertility tables by age & parity

Period fertility tables (FT): model childbearing history of synthetic cohorts of women

- Huge analytical potential, many functions

Key inputs of FT controlling for age & parity: age-parity distribution of women, live births by birth order and age

Mortality tables: timing = life expectancy main output;

Fertility tables: quantum (fertility index, conditional fertility rates / probabilities)

Selected functions:

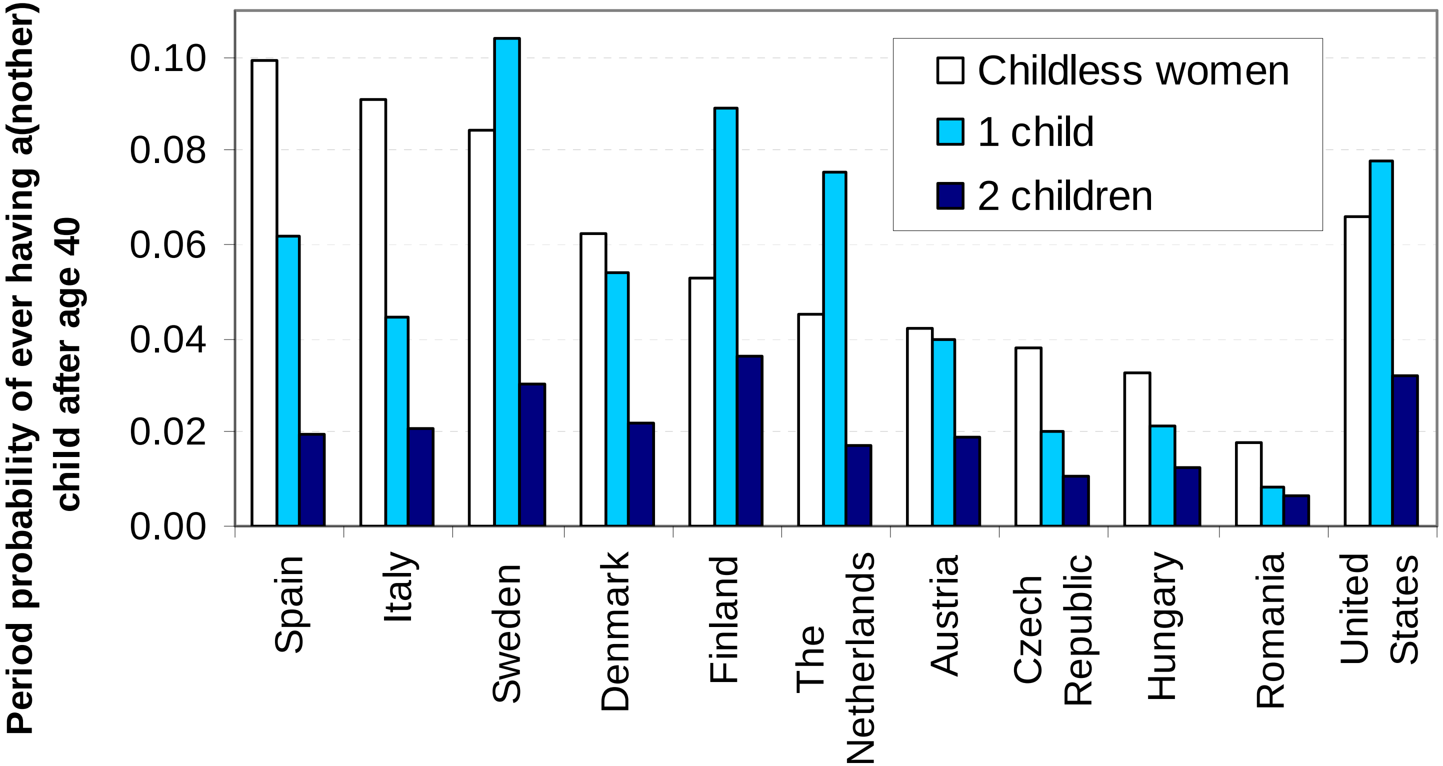
$q_i(x,y)$: probability of having an *i*-th birth in age interval [*x*, *y*)

$Q_i(x)$: 'Lifetime' probability of having an *i*-th birth when at parity i-1 at age x

$PATFR_i$: Period fertility index for birth order *i* (Ralu and Toulemon 1994)

Period fertility tables & indicators: Illustrations

Example 1: Parity-specific fertility differences at advanced reproductive ages

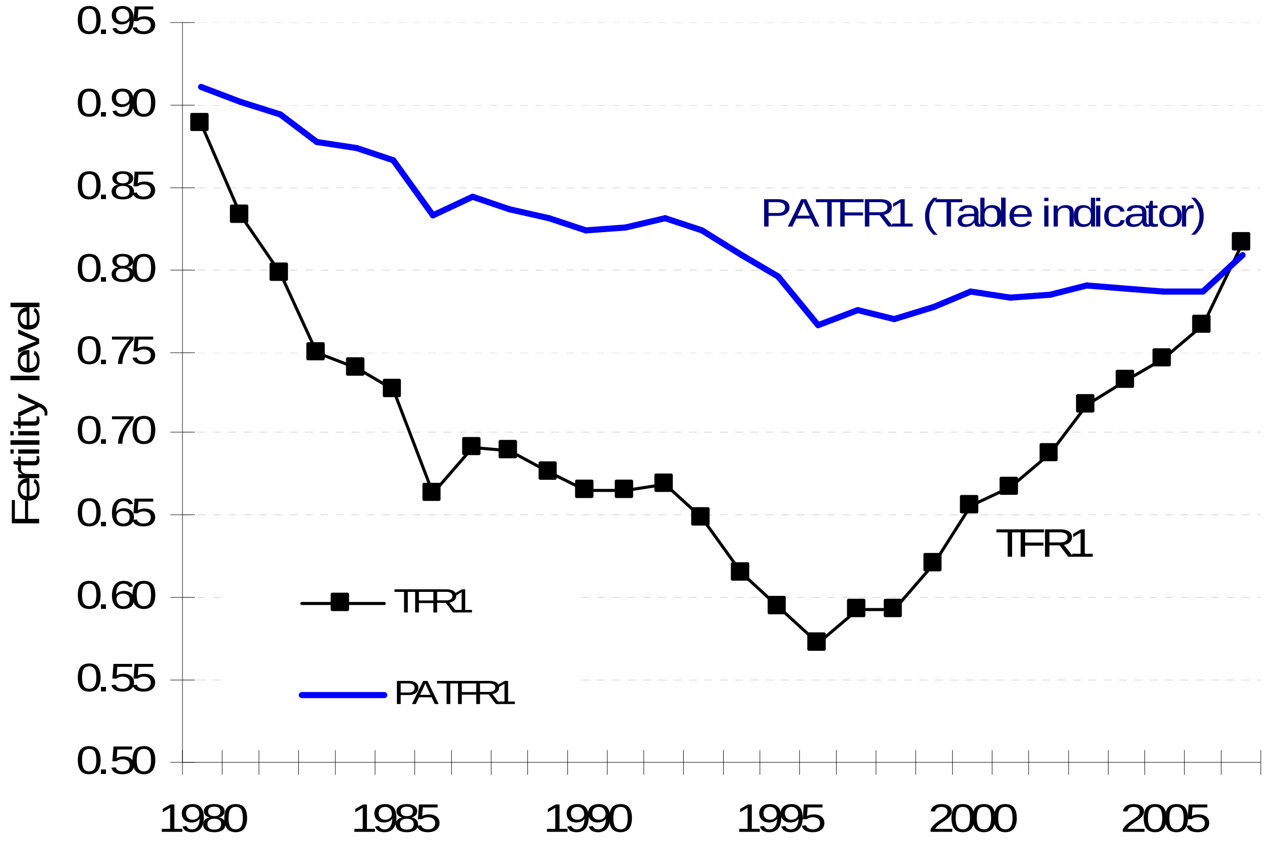


Data sources: computations based on Eurostat (2006), NCHS (2005), Statistics Austria, CZSO, CBS Statline (2005), and CNPS

Q_i (40): Conditional ('Lifetime') probability of having another child by parity at age 40 (women in selected countries, ca. 2004)

Period fertility tables & indicators: Illustrations

Example 2: A sharp increase in first birth rates in Spain



1996-2007:

PATFR1: +6%

TFR1 +43%

Period fertility: Tempo adjustment

Tempo effects in period fertility rates: Major issues

- Is tempo effect a distortion? Or an integral part of period fertility indicators?
- Can we distinguish ‘tempo’ and ‘quantum’ effects in period rates?
- Should we try to filter out tempo effect? (Redefinition of period indicators and rates in a ‘synthetic cohort’: from ‘current rates’ to ‘current conditions’ (Bongaarts 2009)
- (Tempo)-Adjusted measures are just trying that!

Period fertility: Tempo adjustment

Tempo effects: Adjustment explosion

The idea of adjusting period fertility stems from Ryder's 'translation' of cohort rates to period rates and back

- Bongaarts and Feeney (1998; BF): adjusting order-specific TFRi (Before them, Murphy (1994) tried with the overall TFR)
- Kohler and Philipov (2001): age-specific adjustments in unconditional rates by birth order, *fi(x)*
- Kohler and Ortega (2002): age-specific adjustments in parity-specific rates (*PATFRi*)
- Other attempts: Yamaguchi-Beppu 2004, Schoen (2004): Average Cohort Fertility…

BF clearly most successful

Period fertility: Tempo adjustment

The successful march of the BF adjustment

Methodological superiority? NO: problematic assumptions; critical discussion about the usefulness of BF approach

BUT: Data availability, easy computation, easy understanding, and... BF came first!

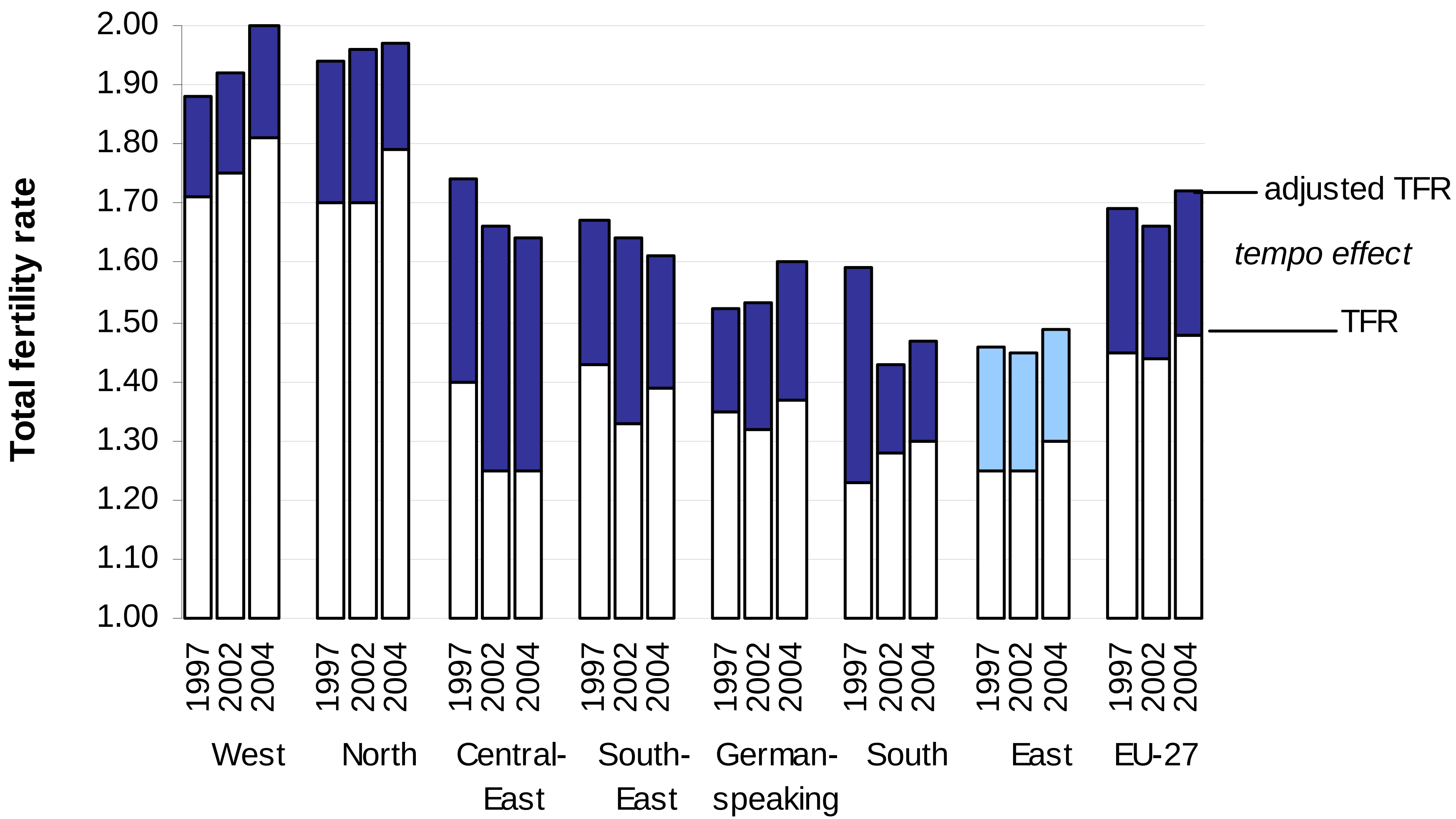
BF adjustment ideas now catching up in mortality analysis (= adjusting tempo, not quantum indicators)

Tempo-adjusted TFR:

$adjTFRi = TFRi / (1-ri(t));$ $adjTFR = \Sigma\, adjTFRi$

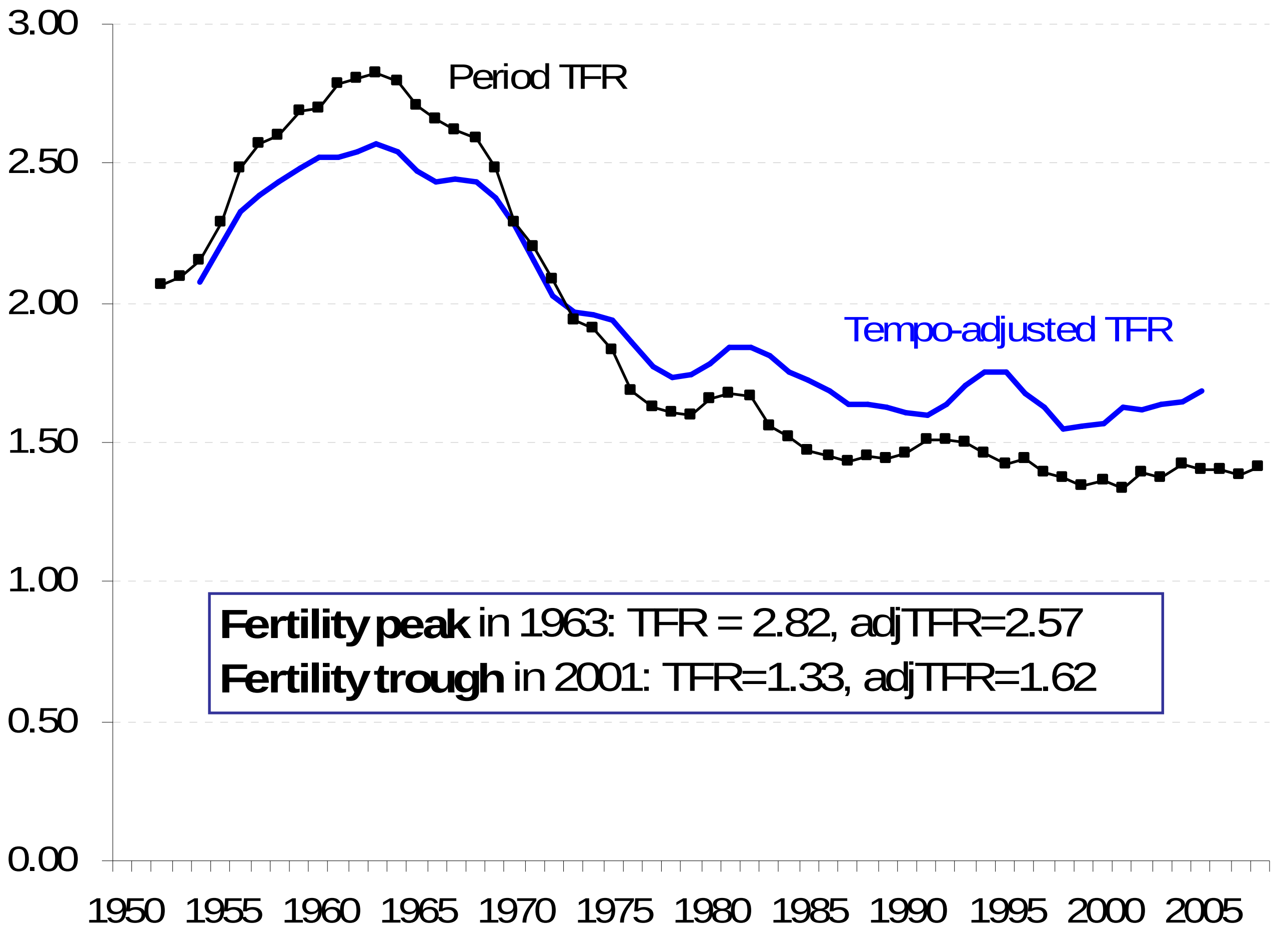
Where *ri(t)* is the change in the mean age at childbearing at birth order *i*: $ri\ (t) = MACi\ (t+1) – MACi\ (t-1) / 2$

Period fertility contrasts in Europe: A view with the adjusted TFR



Sources: Sobotka 2004, VID 2006 and 2008

Post-war period fertility in Austria: TFR vs. adjTFR



Baby booms and busts in part fuelled by tempo effects (advancement vs. postponement of births)

Sources: Statisics Austria, Eurostat, Geburtenbarometer, Computations by T. Sobotka & Anna Stastna

3) Parity cohorts: Bridging period and cohort analysis?

Parity cohort: A group of women (men) who had an *i-th* child at the same time (year, month); e.g. parity 1 cohort of 2000

ANALYSIS: Following their subsequent childbearing

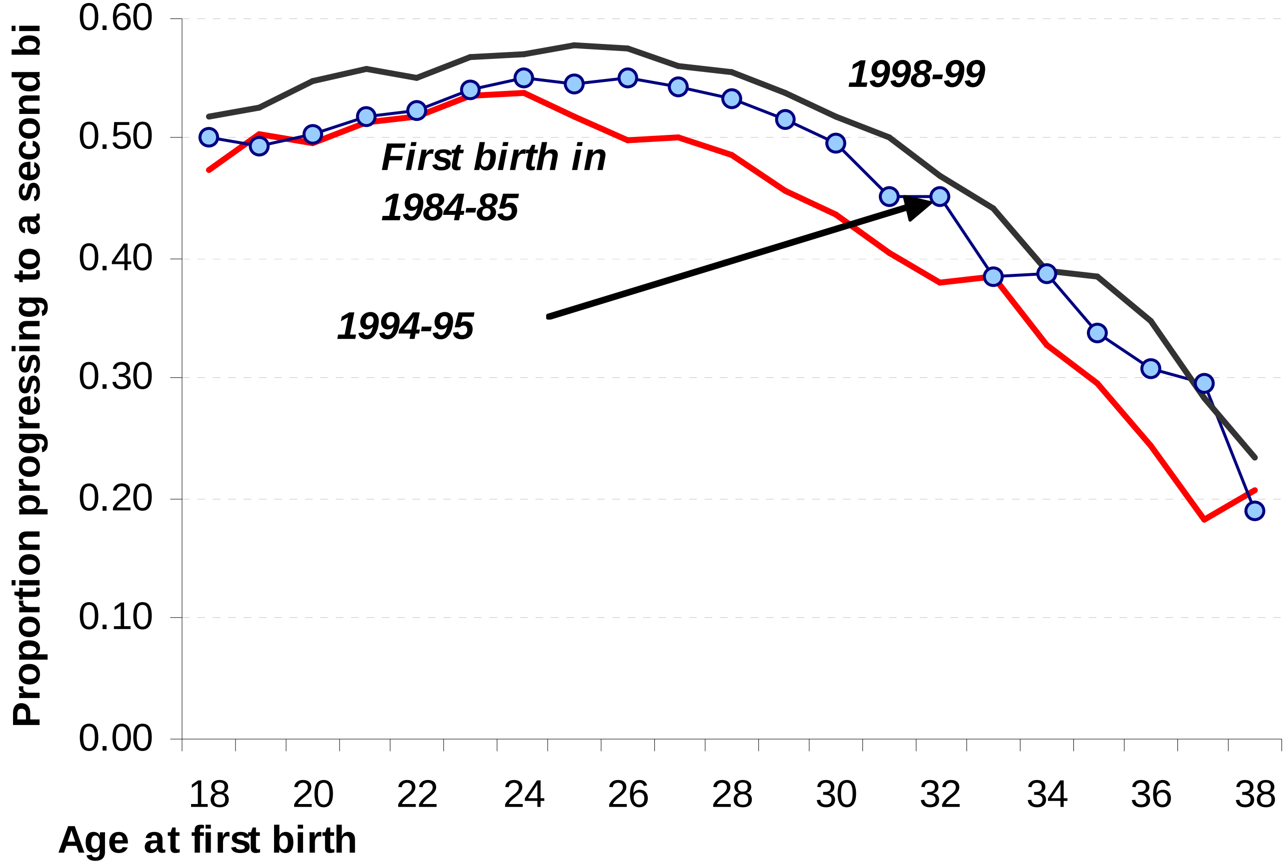
Tempo: birth intervals

Quantum: parity progression rates (PPRs), cumulative progression after 1 year, 2 years, ….

Why interesting?

- cohort analysis, but with a short 'waiting time'
- although birth intervals of 20-30 years occur, most subsequent births within 2-5 years
- stable birth intervals in many countries; high predictability of parity progressions after 5 years of observation

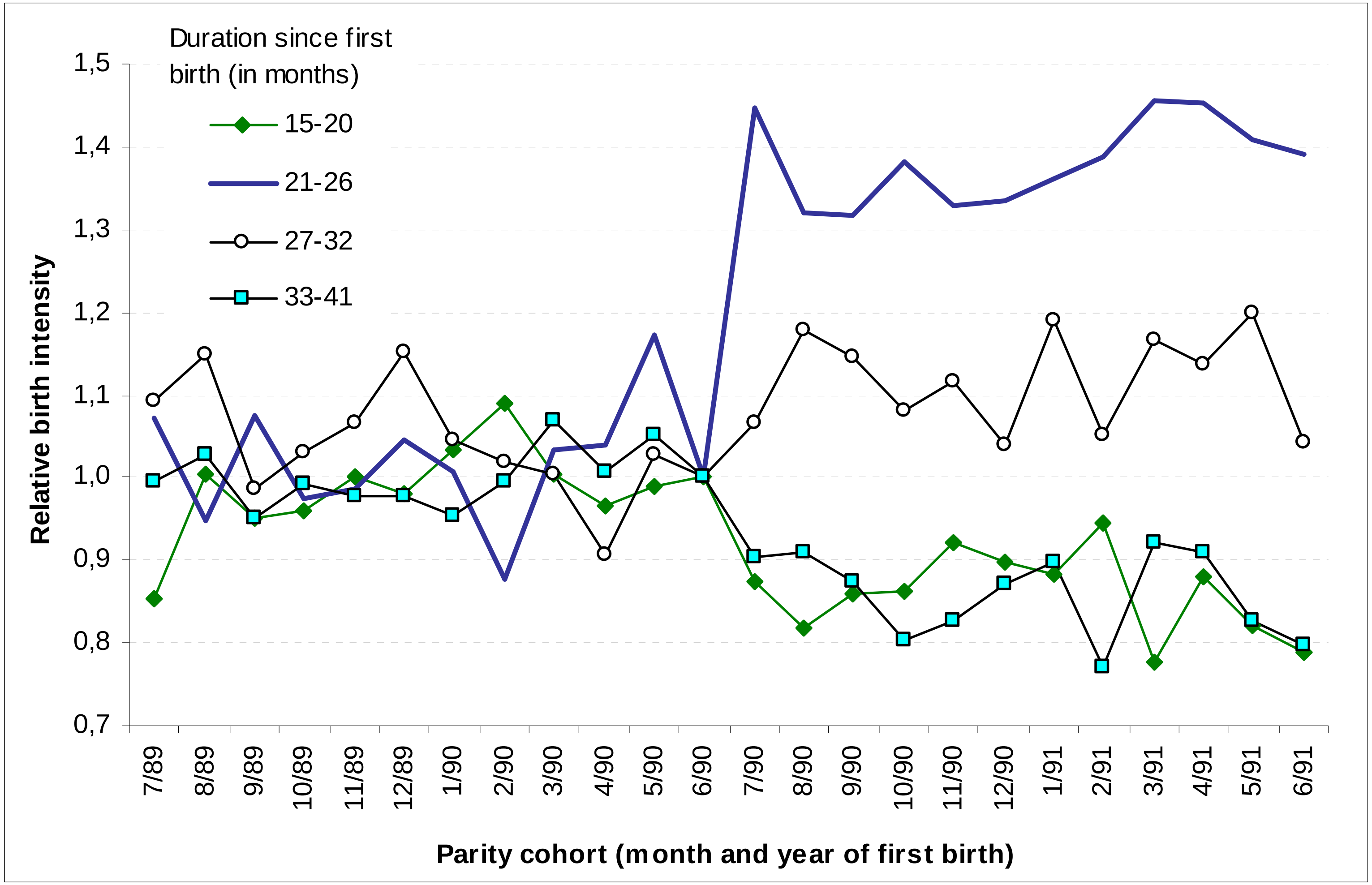
Parity cohorts: Illustrations



Progression rate to second birth 4 years after the first one, Austria, women having first birth in 1984-1999

Parity cohorts: Prolongation of parental leave and second births in Austria

Second birth rates by duration since last birth, Parity-1 monthly cohorts (Rates relative to the June 1990 parity 1 cohort)



Source:

Šťastná and Sobotka 2009

4) Fertility, migration and population replacement: How to bring migration in the analysis?

Importance of immigration:

Need to rethink traditional concepts of replacement fertility

Hyrenius (1951): *Reproduction and replacement*

> Different measures of ‘migratory fertility’, replacement rates with migration etc. discussed and developed (Daguet 1995, Calot & Sardon 2001, Smallwood & Chamberlain 2005, Preston 2007, Alho 2008, Ediev 2008….)

Replacement migration may occur even in societies with sustained very low fertility rates (Spain, Switzerland)!

Replacement migration: PERIOD perspective - an illustration for Austria

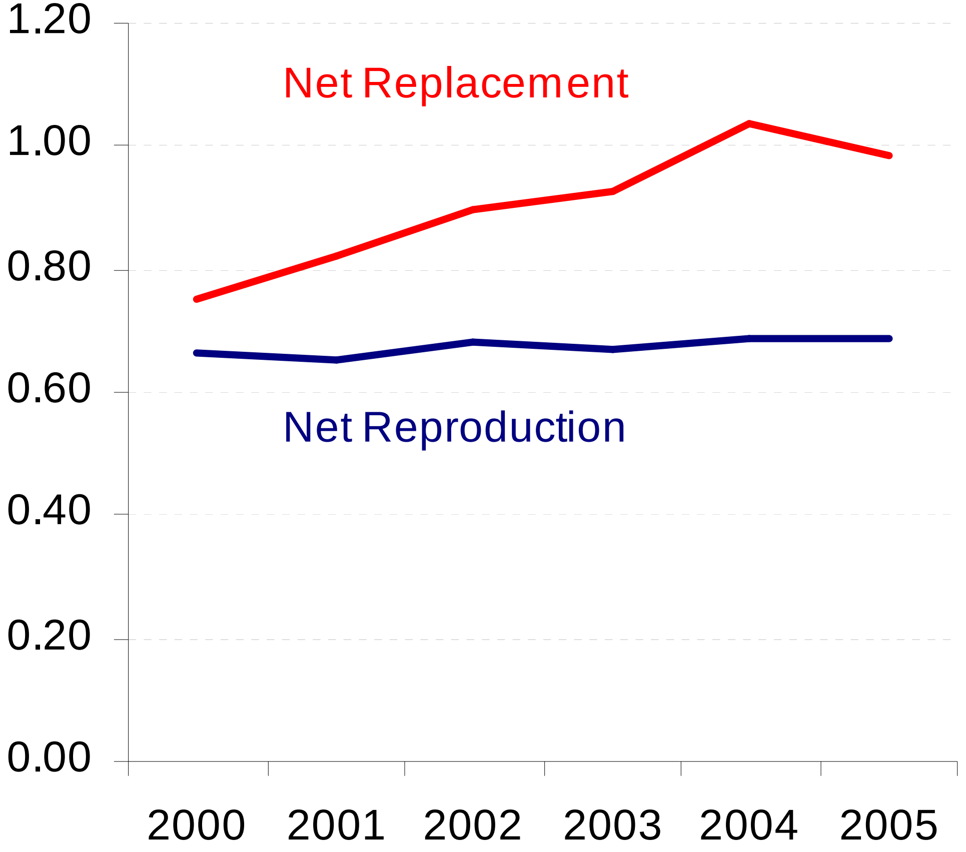
Net reproduction rate in Austria, 2004-2005	
TFR	1.41
survivors at age 30	98971
survivors at age 50	97265
Table number of female children born	68237
Net Reproduction Rate	**0.682**
Intrinsic rate of population growth	-1.32%

Now, let's expose the initial synthetic cohort of 100,000 baby girls to female net migration rates by age in 2004-2005

Net replacement rate in Austria, 2004-2005		
TFR	1.41	
Table population at age 30	151110	(+53%)
Table population at age 50	167323	(+72%)
Table number of female children born	101098	(+48%)
Net Replacement Rate	**1.011**	
Intrinsic rate of population growth	0.04%	

Replacement migration

Net Reproduction and Net Replacement in a period view, Austria, 2000-2005



- this analysis underestimates the impact of immigration!

Replacement migration: COHORT perspective

Measuring longer impact of immigration:

GRE (=Gross REplacement rate):

tracing changes in the relative cohort size of females from birth on

At birth: *GRE(t) = GRR(t) (Gross Reproduction Rate) =*

*= TFR * (female live births / all live births)*

At age 30 (final GREF):

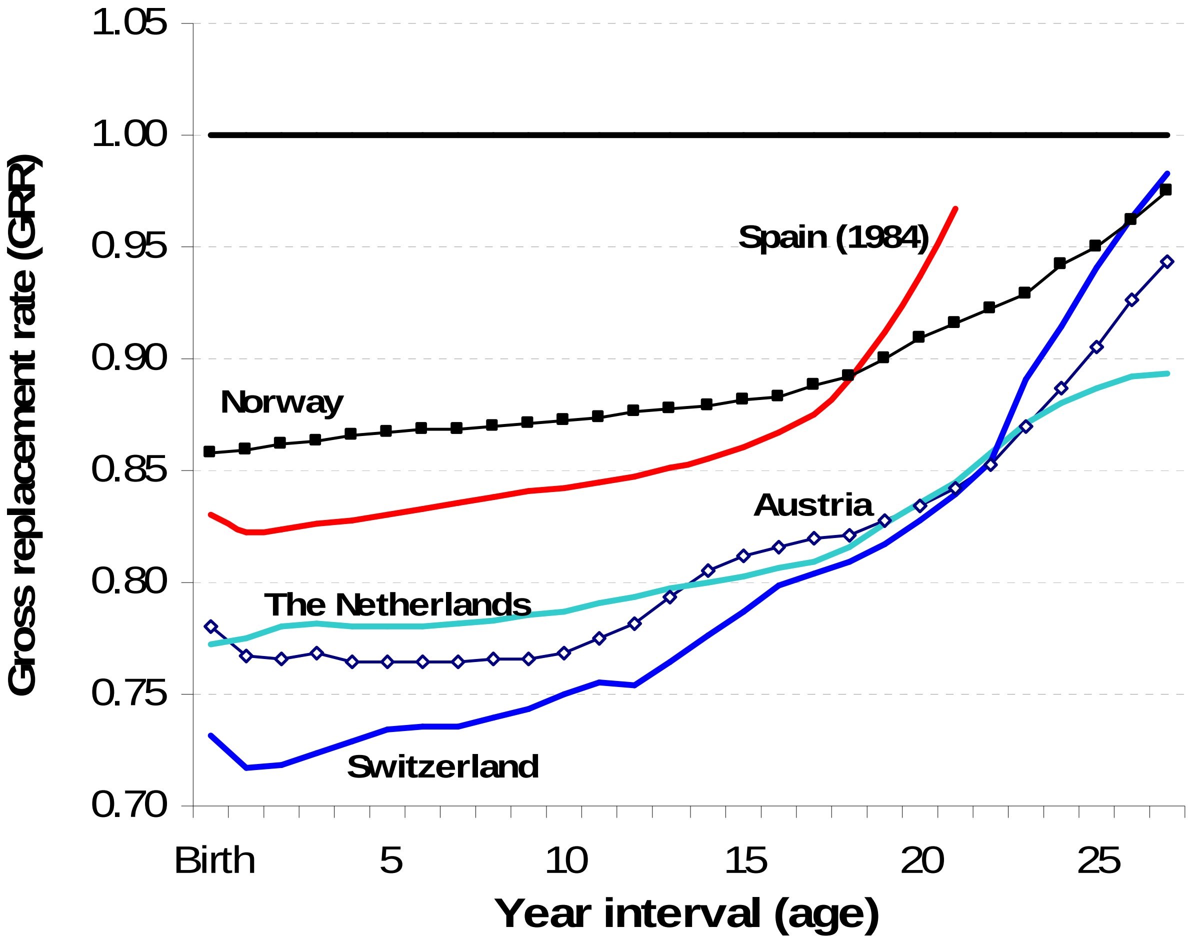
*GREF(t) = PF(t+30)/PF(t) * GRR(t)*

Advantage: Easy computation, accessible data

Interpretation: summarises both the effects of migration and mortality on the relative size of female cohorts before reaching their prime childbearing age

Replacement migration: Gross Replacement Rate – an illustration

5 countries: GRE for 1978 (1984 for Spain)



Younger cohorts: further decline in the GRE at age 0 and faster subsequent increase

Source: Computations in Sobotka (2008)

CONCLUSIONS: Going beyond the period TFR

Models of period fertility: Discussed indicators are models of behaviour; abstract, hypothetical and loaded with assumptions

TFR somewhere in the middle in the complexity of period measures

- Live births
- Crude birth rate (controlling for population size)
- Period TFR (controlling for size and age structure)
- Table PATFR (controlling for size, parity composition and age structure)
- Parity Progression Ratios (controlling for size, parity composition and duration)
- Kohler-Ortega adjusted PATFR Table PATFR (controlling for size, parity composition, tempo effect and age structure)

Period TFR was a great innovation in 1907, when Kuczynski proposed it at a congress … in Berlin. Now time to disseminate a range of other measures! (Human Fertility Database)

What indicators should be used?

One does NOT fit all: The choice of fertility measures should be determined by the research question asked (Ní Bhrolcháin 2008)

- Some questions addressing cohort issues (e.g., the gap between intended and achieved family size)
- Some questions pertaining to specific birth orders or age groups: “What portion of ‘postponed’ first births occurred later in life?”
- Some questions concerned about timing: “Did the past economic crises cause a genuine decline in fertility rates or ‘just’ fertility postponement?”

What indicators should be used?

Key issues in low-fertility countries

Parity matters: Understanding parity-specific fertility behaviour key for understanding fertility differences and trends across regions (e.g., huge parity differences in cohort postponement & ‘recuperation’)

Timing matters: Tempo effects (mostly due to ‘postponement’) can lead to wrong interpretations of trends, levels and cross-country differences

- Both also paramount for projection-making, both period & cohort

Migration matters: Population change in many countries increasingly driven by migration – how to put migration in the picture?

What indicators should be used?

No one indicator of choice, a bouquet of indicators should be published and used in parallel

- Less TFR, especially in comparative & policy-relevant analyses
- Avoid ‘children per woman’ interpretation in the TFR
- More prominence to duration-specific rates

We need data, data and … more data (especially Germany!)

- Future data & methods important areas:
  - Fertility and migration combined (population replacement)
  - Men’s fertility
  - Monitoring of fecundity, infertility, time to conception
  - Partnership and fertility (marriage is obsolete?)
  - Fertility recuperation & determinants

Period TFR may give misleading messages

- Fertility rates in Europe higher when other indicators used
- Recent TFR increase largely fuelled by the slowing-down in fertility postponement (Goldstein-Sobotka-Jasilioniene 2009)
- Fertility ‘quantum’ (levels) often more stable than the ‘roller-coaster’ TFR suggests

Limits of the macro-level analysis?

- Detailed and complex indicators pushing the limits of the macro analysis; getting close to individual-level research