A microsimulation model for population projections in official statistics

WiC Colloquium

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Independent statistics for evidence-based decision making

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Background

- Microsimulation is not new (Orcutt, 1957, Orcutt et al., 1961)
- Neither is its use for population projections (Van Imhoff and Post, 1998)
- Many applications (e.g. LSD-C model (Bélanger et al., 2018), Demosim (Statistics Canada, 2022), MOSART (Andreassen et al., 2020), DESTINIE (Blanchet et al., 2011), MikroSim (Münnich et al., 2021)) → several NSIs have microsimulation models in their “toolbox”
- Still, **official population projections** are **rarely computed** using **microsimulation methods**
- **Cohort component method** remains **standard model**

Cohort-component method (CCM)

The **cohort-component method** is the standard tool for the production of **population projections** in **official statistics**

- computationally simple
- does not require a broad range of input data
- well established in the literature

However, it cannot:

- account for complex and dynamic (demographic) processes
- model interactions between individuals
- produce results for a variety of individual-level characteristics (only aggregates)

Microsimulation for population projections

In the microsimulation, individual life-courses are simulated over time

→ build on the **characteristics of individuals** instead of cohorts

→ simulation of (somewhat) **realistic life paths**

→ can model **complex** (demographic) **processes and interactions**

Method

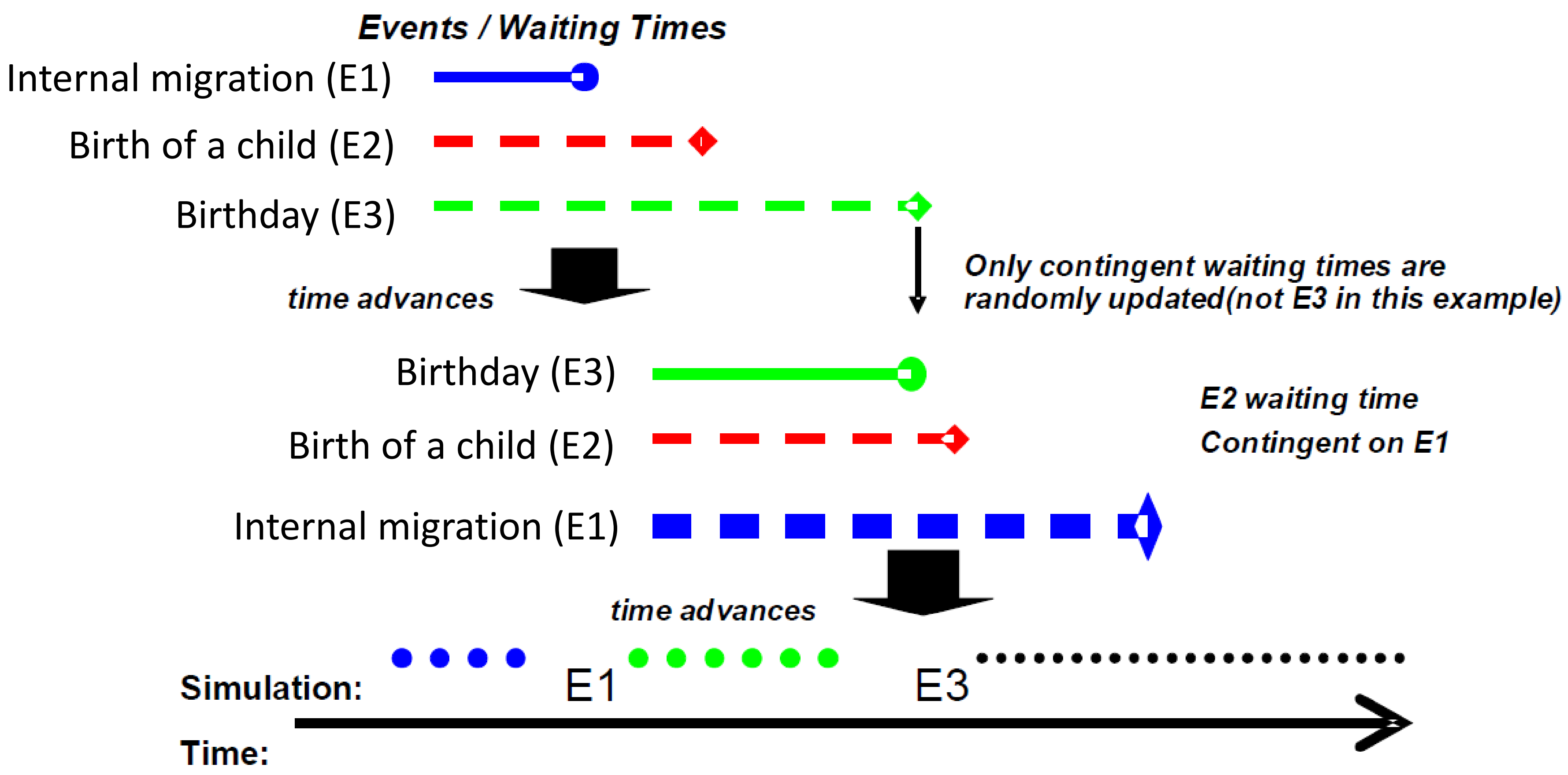
Simulating demographic events

- The cohort-component method uses **event rates** to determine the projected paths of fertility, mortality and migration (e.g. mortality rates by age, sex, domestic/foreign-born)

- In our microsimulation model, these rates are converted into **waiting times** using the inversion method (inverse transform sampling)

→ Each person is assigned waiting times based on their individual characteristics
→ The event with the shortest waiting time is realised
→ As soon as an event occurs, one of the characteristics of the simulated person changes
→ Based on the new characteristics, new waiting times are assigned for all events

Evolution of a simulated life course



Implementation

- Start by replicating CCM results using microsimulation, then gradually develop and extend individual model elements

- Dynamic, case-based model, continuous time

- We use administrative (register) data for the entire Austrian population
  → model could also be applied to a large, representative sample or a synthetic population

- Our model is implemented using Modgen[1], a microsimulation programming language developed at Statistics Canada, and coded in Visual Studio (Microsoft)

[1] https://www.statcan.gc.ca/en/microsimulation/modgen/modgen

First model extension: International emigration

- In place of emigration rates, estimate piecewise constant **hazards for emigration** by sex and country of birth (clustered into 17 groups)

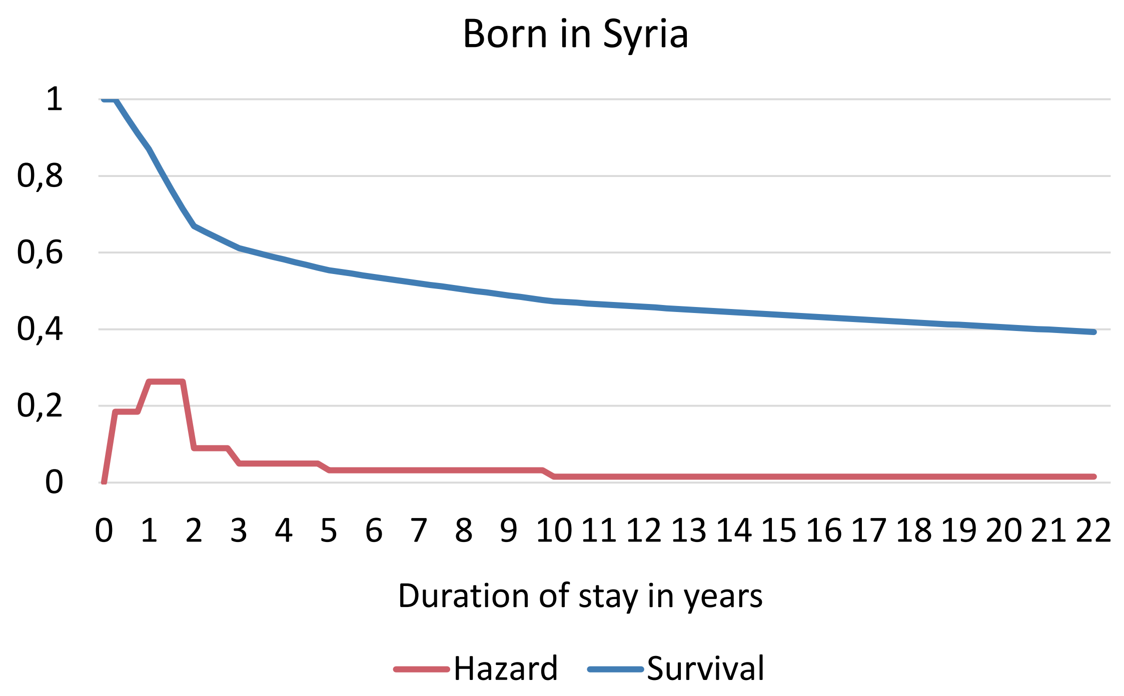
- Input variables: age, federal province of residence, duration of stay

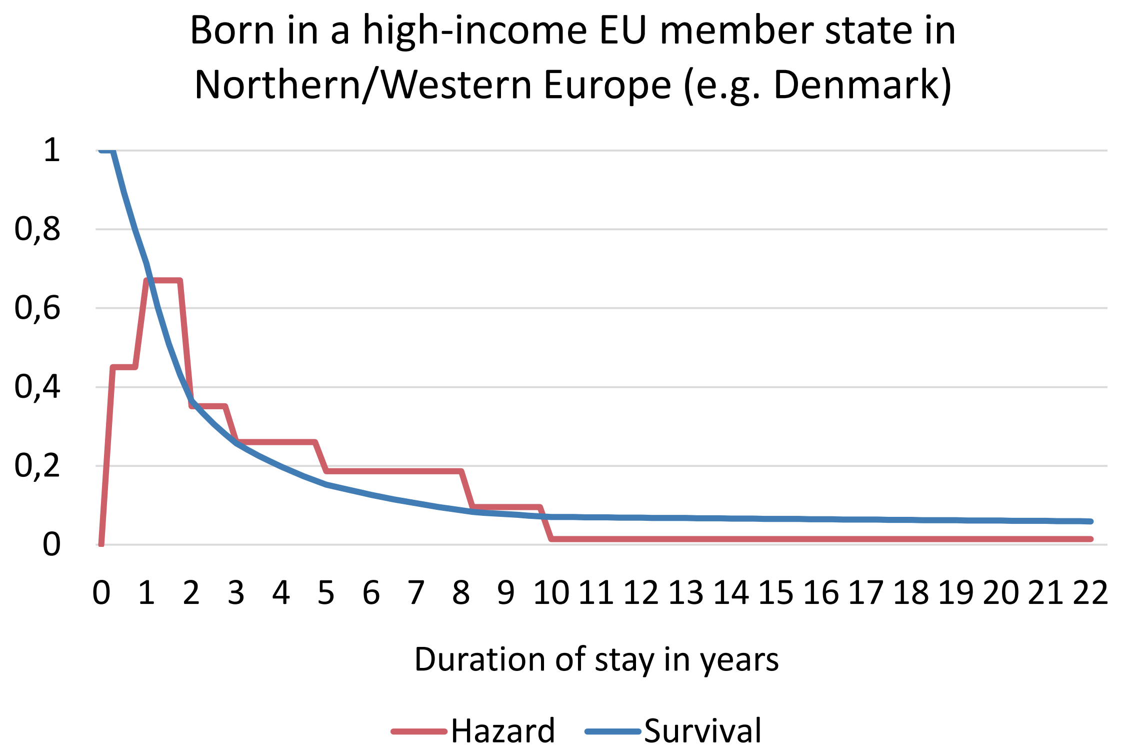
→ Easy to implement, does not require much additional data

→ Relevant because emigration patterns differ based on individual characteristics

Differences in emigration behaviour by country of birth and duration of stay

Example: 18 year old male immigrates to Austria and lives in Vienna



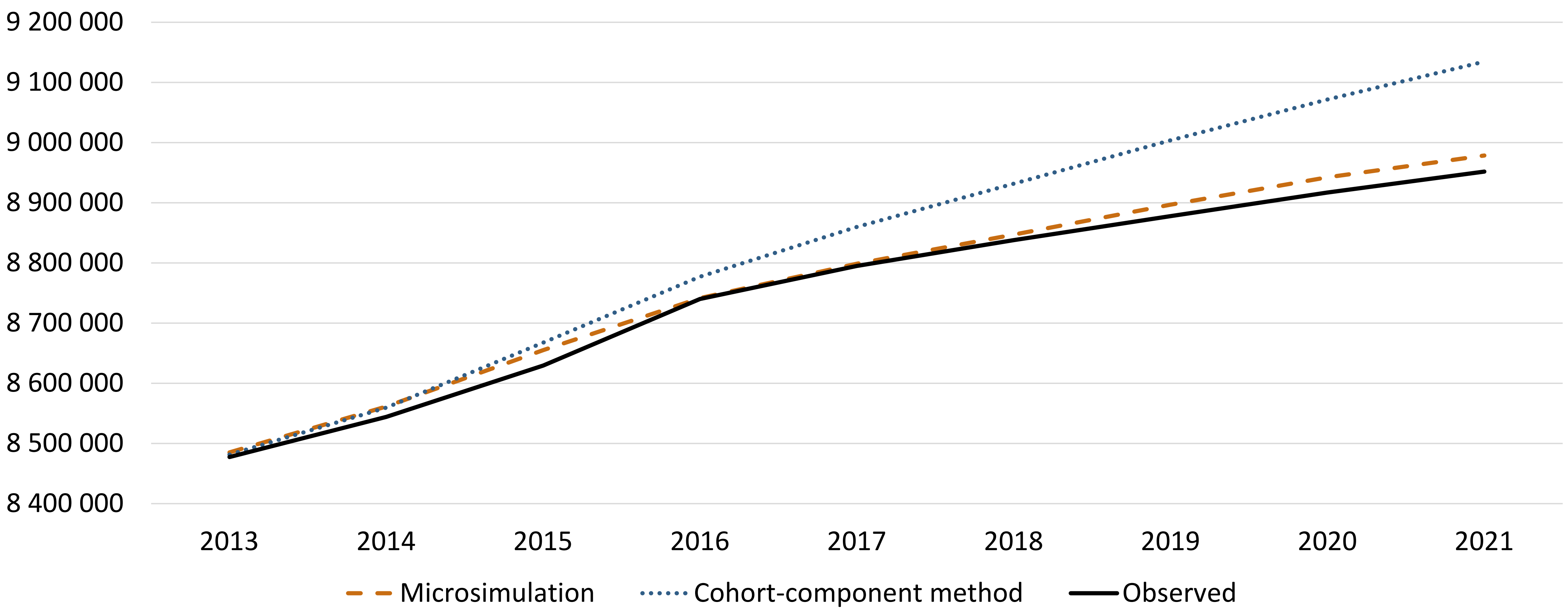


Hazard: Rate at which a person emigrates in a given time interval.
Survival: Proportion of individuals who do not emigrate until a given point in time.

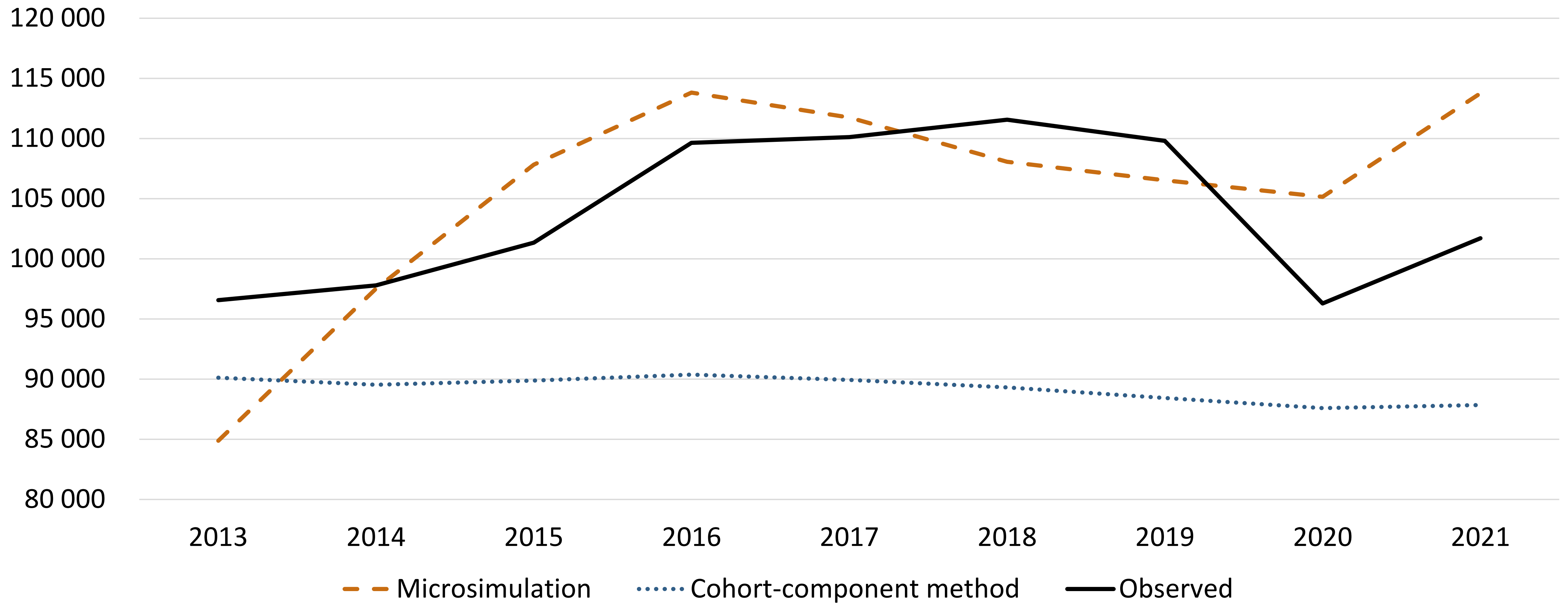
Model validation

Comparing the cohort-component method with the microsimulation model in an ex-post validation

Projected and observed population of Austria 2013-2021, based on the cohort-component method vs. the microsimulation model



Projected and observed emigration from Austria 2013-2021, based on the cohort-component method vs. the microsimulation model



Model extensions

Modules for education and employment

- Model demographic processes dependent on individual-level education and employment characteristics; e.g. modelling women's fertility dependent on their education level and employment status
- Produce projections for educational attainment/enrollment and employment status
- Include additional (register) data
- More interactions between individuals; e.g. passing the information of mother's education level/place of birth to the child

Special case: Modelling the impact of the war in Ukarine

- Three phases:
  1. phase of increased immigration and reduced emigration

  2. phase of increased return migration and family reunification

  3. phase of immigration and emigration as before the war

- Microsimulation allows us to model more complex processes, e.g. family reunification
  → In the 2022 projection, we were able to include assumptions on future immigration of male partners of female Ukrainian refugees in Austria based on survey data (UkrAiA survey; Kohlenberger et al., 2022)

Drawbacks and conclusion

Drawbacks

- Fundamental methodological change, requiring:
  - a deeper understanding of model building
  - advanced statistical programming and data analysis skills
  - more resources and computation capacities.
- Model extensions require additional (administrative/register) data
- New modules require more assumptions for future developments, e.g. which school type will be popular in the future
- Issues related to small-scale regional projections

Concluding remarks

- Using microsimulation for population projections allows for the modelling of more complex and dynamic (demographic) processes
- Unlike the standard cohort-component method, microsimulation can produce results for a variety of individual-level characteristics. Hence, it can be more useful for policy and planning than CCM
- Flexibility to implement new modules as well as more complex scenarios

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