Measuring and Modelling Migrant Fertility: Using Hazard Models and Dynamic Microsimulation to Simultaneously Account for Multiple Clocks

Karel NEELS & Leen MARYNISSEN, University of Antwerp

Abstract

The share of individuals with a migration background in European societies is increasing, both directly because of migration and indirectly because migrants' descendants give rise to an increasing second and third generation, raising questions on the potential impact of unfolding diversity by migration background on fertility trends in Europe. Life course research has identified a large number of mechanisms and clocks that shape patterns of family formation in migrant populations, but the translation of such micro-level (inter)actions into macro-level population outcomes remains a key challenge. Using population-wide longitudinal microdata from Belgian registers, we use a multistate discrete-time hazard model of entry into parenthood and parity progression that simultaneously considers conventional determinants of family formation (e.g. age, education, parity, time since index birth), migration-specific factors (origin group, migrant generation, age and parity at migration, duration of residence), while additionally incorporating unobserved heterogeneity that shapes transitions over the life course. We subsequently feed parameter estimates and variance estimates into a dynamic microsimulation model that allows to quantify the sensitivity of macro-level demographic trends in timing and quantum of order-specific fertility to unfolding diversity by migration background and contrasting migration scenarios.

Extended abstract

The share of individuals with a migration background in European societies is increasing, both directly because of migration and indirectly because migrants' descendants give rise to an increasing second and third generation, raising questions on the potential impact of unfolding diversity by migration background on fertility trends in Europe. Life course research has identified a large number of mechanisms and clocks that shape patterns of family formation in migrant populations (see Kulu et al. (2019) for an overview). Among first generation migrants the timing of family formation after migration is closely related to migration motives, leading to an initiation of family formation shortly after migration among family migrants (cf. interrelated events), or deferral of family formation when the aim of migration is to pursue education or enter the labour market (cf. migration as a disruptive factor), while the effects of socialization in the origin country, selective migration and opportunities in the destination country (e.g. with respect to education and employment) will determine inter alia whether patterns of family formation in first generation migrants remain distinct or rapidly converge to the patterns found in the majority population. Also for descendants of migrants the migration history of (grand)parents continues to play depending on whether subcultures persist that affect family formation, or whether acculturation has taken place with patterns of family formation converging to those of the majority population (Portes & Zhou, 1993). Similar to first generation migrants, the opportunity structure available to descendants of migrants in the host country has been shown to impact the pace of acculturation in tempo and quantum of order-specific fertility (cf. minority status hypothesis) (Maes et al., 2021).

Despite the wealth of insights that life course research has generated on patterns of family formation in migrant populations, the translation of such micro-level (inter)actions into macro-level population outcomes remains a key challenge (Billari, 2015). Conventional aggregate level fertility measures such as the period TFR have repeatedly been shown to function poorly for populations with a migration background, often leading to severely biased estimates (Kulu et al., 2019; Robards & Berrington, 2016;

Toulemon & Mazuy, 2004), as these indicators are typically unidimensional (e.g. only controlling for age) and therefore fail to consider in a consistent way the multitude of factors and clocks that affect family formation in migrant populations. Using population-wide longitudinal microdata from Belgian registers, this paper introduces an alternative approach to bridge the gap between micro-level life course research and macro-level outcomes at the population level. We use an extended version of the ReNAISSANCE-microsimulation model that was recently developed to inform the fertility scenario of the population prospects generated by the Belgian Federal Planning Bureau and Statistics Belgium (Kondi et al., 2025; Vandresse, 2024). The ReNAISSANCE-model is a multistate discrete-time hazard model of entry into parenthood and parity progression that can simultaneously consider conventional determinants of family formation (cf. age, education, parity, time since index birth, etc.), migration-specific factors (cf. origin group, migrant generation, age and parity at migration, duration of residence), while additionally incorporating individual-level unobserved heterogeneity that shapes transitions over the life course (Figure 1):

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\begin{cases}
\text{P0:} \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P0}_{xi}.\text{CA}_{xi}^{1}}.e^{\hat{\beta}.\text{P0}_{xi}.\text{CA}_{xi}^{2}}.e^{\hat{\beta}.\text{P0}_{xi}.\text{CA}_{xi}^{3}}.e^{\hat{\beta}.\text{P0}_{xi}.\text{CA}_{xi}^{4}}.e^{\hat{\beta}.\text{P0}_{xi}\text{CA}_{xi}^{5}}.e^{\hat{\beta}.\text{P0}_{xi}.\text{CA}_{xi}^{6}}.e^{\hat{\beta}.\text{P0}_{xi}.\text{CA}_{xi}^{7}}.e^{\hat{\beta}.\text{P0}_{xi}\text{CA}_{xi}^{8}}.e^{u_i} \\
\text{P1:} \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P1}_{xi}}.e^{\sum\hat{\beta}.\text{P1}_{xi}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P1}_{xi}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P1}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P1}_{xi}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P1}_{xi}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P1}_{xi}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i} \\
\text{P2:} \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P2}_{xi}}.e^{\sum\hat{\beta}.\text{P2}_{xi}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P2}_{xi}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P2}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P2}_{xi}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P2}_{xi}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P2}_{xi}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i} \\
\text{P3:} \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P3}_{xi}}.e^{\sum\hat{\beta}.\text{P3}_{xi}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P3}_{xi}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P3}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P3}_{xi}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P3}_{xi}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P3}_{xi}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i} \\
\text{P4:} \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P4}_{xi}}.e^{\sum\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i} \\
P5: \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P5}_{xi}}.e^{\sum\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i} \\
P6: \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.\text{P6}_{xi}}.e^{\sum\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i} \\
P7^{+}: \quad [-ln(1-q_{xi})] = \int_{x-0.5}^{x+0.5} h(a)da = e^{\hat{\alpha}}.e^{\hat{\beta}.P7_{xi}^{+}}.e^{\sum\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{AI}_{i}^{2}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{1}}.e^{\hat{\beta}.\text{P4}_{xi}^{+}.\text{DI}_{xi}.\text{AI}_{i}^{2}}.e^{u_i}
\end{cases}
$$

where P0, P1, P2, P3, P4, P5, P6, P4+ and P7+ are dummy variables for having parity 0, 1, 2, 3, 4, 5, 6 and 4+ or 7+ respectively; CA is centred age (at age 14); DI is the duration in years since index birth; AI is the age of the mother when having the index birth and u is an individual-level frailty that is shared across parities. The model is compartmental in nature where conditional age-parity-duration-specific probabilities q_{xi} are estimated independently for modelling the (synthetic) parity progression ratio to a first child (SPPR1), second child (SPPR2), third child (SPPR3) and fourth child (SPPR4), while the estimation of the baseline hazard as a joint function of duration since index birth and age at index birth is pooled for fifth and higher-order births, although intercepts remain parity-specific up to parity seven. From parity seven onwards the parameter estimates remain constant, but the submodel will nevertheless continue to generate differentiated conditional age-parity-duration-specific probabilities from parity seven onwards as the age at index birth which is an important input in the function typically continues to increase for these higher-order births. The hazard model is parametrized independently by origin group (distinguishing natives from the major migrant groups living the country) and migrant generation (1.5G versus 2G), allowing a late entry for migrant women (G1) for whom additional indicators on their migration trajectory are taken into account (e.g. age and parity at migration, as well as duration of residence in the country). We subsequently feed parameter estimates and variance estimates into a dynamic microsimulation model of family formation (Figure 1) that allows to quantify the sensitivity of macro-level demographic trends in timing and quantum of order-specific fertility to unfolding diversity by migration background and contrasting migration scenarios.

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Figure 1. Multistate representation of entry into parenthood and parity progression in the ReNAISSANCE-microsimulation model allowing separate parametrization for native women and descendants of migrants (1.5G and 2.0G) as well as late entry and additional time clocks for migrant women (1G).