

Representing Value Orientation in System Dynamics Models of Fertility Decline

Mārtiņš Bataitis, Saeed P. Langarudi and Ali Akhlaqi

Dept. of Geography, University of Bergen, Bergen, NORWAY

Abstract

Persistently low fertility rates are contributing to population aging across many developed societies, placing increasing pressure on labour markets, public finances, and long-term economic sustainability. While fertility has been extensively modelled using socioeconomic variables, comparatively little attention has been given to representing changing social values within system dynamics models. This paper presents a dynamic structure that incorporates value orientation into fertility decision making through two interacting population groups with differing responses to perceived childrearing costs. The model combines demographic processes with ideological change to illustrate how gradual shifts in values can influence long term fertility behaviour. Historical behavioural testing demonstrates that the proposed structure can reproduce characteristic fertility decline patterns while remaining sufficiently simple for integration into broader socioeconomic models. The work provides a foundation for incorporating social value change into demographic policy analysis.

1. Introduction

Population aging has become one of the defining demographic challenges of the twenty first century (United Nations, 2024). Declining fertility has increased dependency ratios and created growing pressures on healthcare systems, labour supply, pension systems, and economic growth (Mason & Lee, 2022; Khan et al., 2024). Although demographic forecasting models commonly represent fertility through economic conditions, education, or policy interventions, cultural and ideological change is often represented only indirectly (Lee, 2024).

The second demographic transition proposes that increasing individualism and postmaterialistic values influence reproductive behaviour by altering preferences surrounding family formation, education, and personal fulfilment (Van de Kaa, 1987; Van de Kaa, 2001). Inglehart's theory of postmaterialism similarly argues that increasing economic security encourages a societal shift towards self expression values that influence life choices beyond material survival (Inglehart, 2009). Incorporating these changing value orientations into quantitative system dynamics models may offer an opportunity to better represent long term demographic behaviour.

This paper proposes a system dynamics structure that explicitly models value orientation as an evolving characteristic of a population and examines its influence on fertility behaviour. Rather than focusing on a particular national case, the objective is to

demonstrate a general modelling approach that can be adapted to different demographic contexts.

2. Methodology

The proposed model divides the population into two interacting value orientations representing materialist and postmaterialist perspectives. Individuals transition gradually between these orientations as education levels, socioeconomic development, and generational replacement alter societal values over time, consistent with theories of value change (Inglehart, 2009; Tormos, 2019).

Each value group evaluates childrearing differently. Materialist populations exhibit comparatively lower sensitivity to perceived childcare costs, whereas postmaterialist populations place greater emphasis on opportunity costs associated with education, career development, and individual aspirations, as suggested by the second demographic transition literature (Van de Kaa, 2001). These differing behavioural responses influence aggregate fertility through changes in total fertility rate.

The resulting stock and flow structure creates reinforcing feedback between demographic change and societal value evolution. Lower fertility contributes to aging populations while continuing socioeconomic development increases childrearing costs, which discourages larger families for those with postmaterialist values, producing additional downward pressure on fertility. Balancing feedback arises through demographic replacement and changes in population composition.

The structure was implemented using established system dynamics methodology and developed with inspiration from the Millennium Institute's iSDG modelling environment (Millennium Institute, 2021), allowing potential integration into broader socioeconomic simulation frameworks.

3. Results

Behavioural testing indicates that the proposed structure reproduces the gradual long term fertility decline commonly observed across developed societies (United Nations, 2024). Rather than representing fertility as a purely economic response, the model captures how changing social values modify the perceived costs and benefits associated with parenthood, reflecting the behavioural mechanisms proposed by the second demographic transition (Van de Kaa, 1987). Fertility policy effects are also captured, showing the effects of time specific adjustments to parental leave and subsidy changes.

Simulation results show smooth transitions in population value orientation accompanied by corresponding reductions in fertility rates. The model reproduces demographic behaviour without requiring excessive structural complexity, suggesting that value orientation can be represented as a behavioural subsystem within integrated demographic models.

Although calibration was performed using historical demographic data, the emphasis of this work is the structural formulation rather than country specific forecasting accuracy.

4. Discussion

The proposed structure illustrates how cultural change may be incorporated into demographic system dynamics models using relatively simple stock and flow structures. Representing value orientation explicitly provides a mechanism for analysing long term interactions between social development and fertility behaviour that are often omitted from conventional demographic models. However, an approach based on the theory of the second demographic transition may only be applicable to European and Nordic countries and largely ignoring cultural differences (Zaidi & Morgan, 2017).

The model necessarily simplifies several demographic processes, including migration, cohort specific fertility, and heterogeneous household behaviour. Future work should extend the framework by incorporating additional behavioural mechanisms and testing its applicability across multiple demographic settings.

Because value orientation influences personal decisions regarding family formation, any policy applications should recognise the ethical implications of attempting to influence individual preferences. Consequently, the framework is intended primarily as an analytical tool for understanding demographic dynamics rather than prescribing interventions.

5. Conclusions

This paper presents a system dynamics representation of value orientation within fertility modelling. By explicitly linking evolving societal values with reproductive decisionmaking, the model provides a mechanism for representing demographic transitions driven by ideological change. The proposed structure demonstrates that relatively simple behavioural formulations can reproduce characteristic fertility decline while remaining suitable for integration into broader socioeconomic simulation models.

Future research should evaluate the framework using multiple demographic settings and investigate its usefulness for prospective policy analysis.

References

- United Nations (2024). World Population Prospects 2024: Summary of Results. UN DESA/POP/2024/TR/NO. 9. New York: United Nations.
- Mason, A., & Lee, R. (2022). Six ways population change will affect the global economy. *Population and Development Review*, 48(1), 51–73. <https://doi.org/10.1111/padr.12469>
- Khan, H. T. A., Addo, K. M., & Findlay, H. (2024). Public health challenges and responses to the growing ageing populations. *Public Health Challenges*, 3(3). <https://doi.org/10.1002/puh2.213>
- Lee, R. (2024). Forecasting population in an uncertain world: approaches, new uses, and troubling limitations. *Population and Development Review*. <https://doi.org/10.1111/padr.12674>
- Van de Kaa, D. J. (2001). Postmodern Fertility Preferences: From Changing Value Orientation to New Behavior. *Population and Development Review*, 27, 290–331. <http://www.jstor.org/stable/3115262>
- Van de Kaa D. J. (1987). Europe's second demographic transition. *Population bulletin*, 42(1), 1–59.
- Inglehart, R. (2009). Postmaterialist Values and the Shift from Survival to Self-Expression Values. In Oxford University Press eBooks (pp. 223–239). <https://doi.org/10.1093/oxfordhb/9780199270125.003.0012>
- Tormos, R. (2019). The Rhythm of Modernization: How Values Change over Time. <https://doi.org/10.1163/9789004411913>
- Millennium Institute. (2021, May 6). iSDG documentation. Retrieved December 12, 2024, from https://isdgdoc.millennium-institute.org/en/_static/isdg-documentation-en.pdf
- Zaidi, B., & Morgan, S. P. (2017). The second Demographic Transition Theory: A review and appraisal. *Annual Review of Sociology*, 43(1), 473–492. <https://doi.org/10.1146/annurev-soc-060116-053442>