Small Area Population Forecasts: A New Integration of Ratio, Hamilton-Perry and Housing-Unit Methods.

If oracles, astrologers, fortune tellers, mediums and other prophets of all kinds could actually predict the future, the work of demographers specializing in projections would be, at the very least, perfectly useless. The demographer, therefore, does not claim to read crystal balls. However, equipped with demographic projection tools and rigorous assumptions, they can work to unveil possible futures. Local administrations, public and private decision-makers, planners and other officials responsible for planning, financing and territorial development must be able to reveal these possible futures. Elementary schools, water treatment infrastructure and public transportation are just a few examples of projects that require anticipating, at a minimum, the age and spatial distribution of potential users of these services.

The future location of people, along with their demographic characteristics, is essential to inform the thinking of needs analysts, planners and decision-makers. This observation is not merely practical; it is firmly rooted in the theoretical frameworks that support the explanation of demographic change at small geographic scales. Individuals and households go through different transitions that mark their life course, such as entering university, getting a first job or changing careers, forming a couple, the arrival of a child, separation or retirement. These transitions can be accompanied by housing-related dissatisfactions: housing that is too small, a location that no longer corresponds to social status, or the need to get closer to work or place of study (Myers, 1990; Rossi, 1955). The choice of new housing, a source of residential mobility and the main driver of demographic change at the local scale, is primarily constrained and directed by present and future housing supply (Léger, 2018; Wilson et al., 2021).

Housing characteristics such as size, type and location align with the characteristics of the household that will occupy it, and vice versa. For example, the construction of a large seniors' residence will necessarily influence the population characteristics of the neighborhood where it is located. In the context of small-area demographic projections, it is therefore the anticipation of housing supply that takes on central importance. The demographic discipline has historically focused on forecasting housing demand (Bourieau et al., 2019; Sauvy, 1946), leaving to other sciences such as economics and urban studies the much more complex task of studying real estate development projections. Such exercises remain extremely rare.

The expected spatial supply of new housing alone cannot drive a demographic projection model. Demographic change is based on the aging of cohorts, reduced by mortality, displaced by migration and renewed by fertility. It would therefore be tempting to build a fine-scale projection model on this method. Even though some (Hansen, 2010) argue that it should be used from the outset whenever data are available, this certainty deserves to be questioned. It thus becomes relevant to explore other demographic methods that can be combined with a housing-based method.

This research project aims to develop and validate a hybrid small-area demographic projection model that accounts for both demographic parameters and real estate development. The few models designed and documented in this way, notably those of Hansen (2010), Kanaroglou et al. (2009) and Portland State University (2015), suffer from significant shortcomings. First, they have not been subjected to statistical validation. Second, they are inconsistent with larger-scale regional projections, meaning that the sum of small-area projections does not match the more accurate projections performed at larger geographic scales. Third, they rely on the cohort-component method. This method, while being the conceptual foundation of demographic science (Le Bras, 2013), is not adapted to small populations. The finer the geographic scale, the smaller the populations, and the more problems related to rare events—in this case births, deaths and migrations—emerge. Inter-regional migration rate matrices at small areas become filled with zeros, and stochastic methods become a necessity at this scale. Finally, the methods underlying the Hansen and Portland State University models are not sufficiently explicit to be replicated.

Methods

While accuracy is the most important criterion for academics, simplicity and transparency are often most valued by practitioners and planners (Yokuma & Armstrong, 1995). With that in mind, we avoided complex stochastic methods and built the model using ratio methods (Schmitt & Crosetti, 1951) and a cohort method (Hamilton & Perry, 1962). The former are expressed through the continuation over time of a proportional relationship between the population of a territory and that of its constituent zones. The latter is a simplified version of the component method, which relies only on the aging of cohorts between two consecutive censuses. These methods have the advantage of being less data-intensive and best suited for small populations.

The model works in three steps. First, the population is forecasted using the Hamilton-Perry method. Next, the population is converted to households and compared to the number of housing units per area. Considering a maximal occupancy rate, excess households are redistributed proportionally to available housing-unit in the same region. Next, the population, by age-group and sex, is raked to a large-scale projection using a novel share-of-housing method.

To assess the accuracy of the model, we produced population projections for 2016 and 2021 using the 2006 and 2011 censuses, and 2021 projections using the 2011 and 2016 censuses. The projections were then compared to the census using the Mean Absolute Percent Error (MAPE) by 5-year age group and sex. Despite its known limitations, MAPE remains the most widely used accuracy measure, allowing for comparisons with other studies.

Housing-unit forecasts

A hybrid approach is used to forecast the new housing units. In the short term (5-years), an aggregation of data from cities, boroughs, developers' websites and other sources is used. Then, a logistic growth model (Verhulst, 1838) is applied to the number of past and short term forecasted housing unit, following Baker's (2008) approach.

Data

The model is built and validated on Canadian census data from 2006, 2011, 2016 and 2021, disaggregated by sex and 5-years age groups, up to 90+. These data are spatialized in 1040 small area units --similar to census tracts-- with populations varying from 140 to 50 000 inhabitants (median = 7300).

We also use historical housing-unit forecasts from the Ministère des Transports et de la Mobilité Durable du Québec (MTMD). These forecasts span the 2006 to 2021 period for the Quebec City metropolitan region. Administrative data on housing-units built between 2006 and 2021 are used to test the performance under "perfect knowledge" conditions. The maximum number of constructible housing units by area, also provided by the MTMD, is used to parameterize the logistic curve.

Preliminary results

The model correctly responds to housing availability, with more people populating developing areas, while areas with no new construction show stable or declining population, partly due to shrinking household sizes, itself a consequence of population aging. In some regions, housing forecasts overshoot population projections, suggesting that some projected real estate projects might be delayed or canceled because of insufficient demand. An in-depth accuracy assessment is currently underway.

Conclusion

Small-area population projection models must consider housing development because the spatialization of new real estate depends on developers' whims and city planning. We propose a new share-of-housing redistribution method to bridge the demographic and housing-led methods in our projection model. Several improvements are envisioned. While the core model will remain user-friendly, optional modules could enhance accuracy. For example, the share-of-housing step could redistribute the population across available dwellings using a housing and households typologies. Another improvement would be to assign priority or probability levels to forecasted developments. When forecasts of new housing exceed the number of projected households, less probable constructions could be excluded first—yielding a more robust small-area spatialization of future households.

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