How Many and How Do We Know: Assessing Population Projection Methods in Ontario, Canada

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Résumé
Les projections démographiques sont essentielles à presque tous les aspects de la planification. Comme les projections démographiques informent des différents types de décisions à l'échelle locale, régionale, provinciale et nationale, il s'ensuit que les divers niveaux de gouvernance auraient des méthodes différentes. De même, compte tenu de la variabilité de la taille de la population, et les ressources budgétaires et monétaires entre les municipalités, les différentes villes ont besoin d'utiliser des méthodes de projection démographique qui diffèrent considérablement. Cette analyse des différences méthodologiques dans les approches adoptées par les divers niveaux de gouvernement conclut que des modèles plus complexes et coûteux sont utilisés aux niveaux plus élevés de la gouvernance et dans les grandes villes, et que ces modèles fournissent des résultats plus exacts et plus précis. Les villes qui sont plus petites et périphériques ont tendance à utiliser des méthodes plus simples, qui prennent moins de temps et moins de ressources. Un cadre d'évaluation de neuf critères a conclu que la méthode part de capture est la meilleure possibilité méthodologique pour la projection de la population à l'échelle locale.

Mots clés: projection démographiques, migration, Ontario

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Abstract
Population projections are vital to almost every facet of planning. As population projections inform different types of decisions at the local, regional, provincial and national scale, it follows that different levels of governance would have differing emphases and methods. Similarly, considering the variability of population size, and fiscal and monetary resources between municipalities, different cities implement significantly different population projection methods. This review of methodological differences reflected in the approaches taken by various levels of government concludes that more complex, time consuming and expensive models are used at higher levels of governance and in larger cities and are more likely to provide more accurate and precise results. Smaller and peripheral cities tend to use simpler, less time- and resource-intensive methods. An assessment framework of nine criteria concluded that the share capture method is the best methodological alternative for local scale population projection.

Keywords: population projection methods, migration, share capture, Ontario

1. Introduction

Population statistics are considered by urban planning analysts to be vital to practically all facets of planning (Myers 2001). Planners look to institute changes that will beneficially affect the public in the future. As such, future population statistics, at all governmental levels, are needed to appropriately inform decisions (Wilson and Rees 2005). Population projections are employed for a myriad of planning and budget-related functions and are the basis for many investments and decisions (Smith and Tayman 2003). They are used to inform planners, politicians and other decision makers of potential future needs for education, housing provision, road construction, health, transport, water and sewerage services and more (Wilson and Rowe 2011).

Many researchers feel that the metropolitan focus of North American planners and decision makers is leaving smaller and peripheral communities more exposed to challenges such as socio-economic inequality, selective out-migration of young and educated citizens, and economic instability (Großmann et al. 2008; Pallagst 2010; Rieniets 2006). As a critical starting point, accurate and detailed population and economic projections must be made in order to assess the vulnerability of smaller and peripheral communities. These projections are not only essential for public policy and planning agendas, but also for private developers and special projects.

Many of these smaller and peripheral communities have experienced an economic downturn as the manufacturing industry has declined and resource-based industries have depleted reserves or have cut jobs due to technological advances (Leadbeater 2009). However, in stark contrast, other peripheral Canadian communities deeply engrained in the oil and natural gas industry are witnessing immense population and economic growth (Schatz et al. 2013). Considering these contrasting trends, the demand for practical population information is still very much present. It can be argued that adequate population projections are especially vital to these communities as their fiscal and human resource options are, in some cases, very limited. In turn, their planning and development mistakes can be amplified, as the resources to fix or adapt plans are not present.

In Canada, population projections are produced and published regularly at the federal, provincial and territorial level by Statistics Canada and at the census division level by many provincial ministries of finance. Municipalities themselves are left to their own devices to produce these calculations, which can be a strain for smaller cities with limited fiscal and human resources. Oftentimes municipal population projections are developer driven, as they are integral in identifying development needs and opportunities. However, as private sector municipal population projections often utilize freely available source data (e.g. Statistics Canada or Ministry of Finance), it is beneficial for municipalities to produce their own projections to control the inherent bias (Klosterman 2013). As population projections inform different types of decisions at the local, regional, provincial and national scale, this study asks: how are these differences reflected in the methodological approaches taken by various levels of government? And considering the resource constraints of smaller, peripheral communities, what is the best methodological alternative for local scale population projection?

These questions are explored through a case study assessment of population projection methodologies, with the intention of informing planners, academics and decision makers. Cases at the national, provincial, regional and municipal levels are evaluated using a hybrid framework built upon Rayer's (2008) summative comparative analysis of population projections methods based on the work of Smith, Tayman and Swanson (2001).

2. Literature

2.1 Planners and population projections

Research on population projections can be found in a wide range of disciplines (Wilson and Rees 2005), often with a focus on evaluating or increasing accuracy. Yet Myers (2001) states that planners underutilize the demographic approach of population projections. It is suggested that although population projections are crucial to planning, the dearth of research is due to other constraints placed upon the planners, such as cost of production, timeliness, and difficulty of explanation (Rayer and Smith 2010; Smith, Tayman, and Swanson 2001; Wilson 2014). Political acceptability is another potentially constraining factor, as controversy and criticism often appear when projected population change does not comply with development plans (Wilson and Rowe 2011). The high degree of precision of projections can provide false assurance to readers (Swanson and Tayman 1995). Therefore, when using population projections to inform planning decisions, it is important to stress utility, rather than accuracy or precision. Population projections are not meant to be considered specific predictions, but rather to provide indicators of likely future impacts (Myers 2001). This is especially true for long-term projections and forecasts, as studies have shown that accuracy is greater for short-term durations and also for areas of large population (Goldstein and Stecklov 2002; Keilman 2008; Wilson and Rowe 2011).

Unfortunately, many planning decisions do have long-term impacts and municipalities with small populations do need to make decisions based on population projections. Demographic estimates and projections can express a range of statistics such as school enrolment, violent crimes and traffic fatalities to facilitate regional and temporal comparisons. These projections and statistics are used to inform many decisions, including those regarding school and hospital capacity, protection services, utilities, public transportation, recreational facilities, future housing and commercial development. Underestimated projections may result in overstretched public facilities and infrastructure, and the ensuing costly expansion programs and overtime (Davis 1995). Conversely, overestimated projections may lead to a misallocation of resources due to excess capacity, underused infrastructure, and overstaffing (ibid).

2.2 Demographic and population projections in practice

Some mismatch between projections and reality is expected in planning practice, at all levels of government, and thus evaluation and adjustments to projection-based decisions are crucial. For example, the estimated population in the Region of Waterloo has fallen 3,600 residents shy of its projected total—a projected growth error of 20% (Outhit 2014). Underperforming population has been a cause for concern as expenditure on transit, water and sewer infrastructure must remain in line with the official forecast. Concerns regarding projections are not simply due to accuracy, but also to the demographic detail and the ability to adjust long-term investments.

In Canada, the education system has been historically shortsighted concerning demographic change. Nationally, between 1971 and 1991, the education workforce grew by 20%, whereas in the same time period the school-age population dropped from 5.9 million to 4.9 million (Foot 1998). The change in student-to-workforce ratio resulted in a $7.4 billion cost differential.

The demographic structure of a community plays a key role in the planning of educational systems. In the late 1980s and throughout the 1990s, the baby boom echo escalated school enrollment (ibid). In response, portable classrooms appeared across the country and in many communities, new elementary schools were approved and built to accommodate the increased number of students (ibid). Elementary enrolment peaked in 1999 and in the next 5 years over 250 schools closed in the province of Ontario (People for Education 2004). Between 2009-2012, 172 elementary and secondary schools closed or were recommended to close and another 163 were under review (People for Education 2009). This was partially due to aging infrastructure, but in most cases was due to declining enrolment (ibid). This example demonstrates the importance of demographic analysis, thorough understanding and the need for access to the best information possible—especially when decisions involve long-term cost of infrastructure.

2.3 Population projection methodological overview

This section provides an overview of several common population projection techniques. Table 1 details the basic equations, variables and additional notes.

Table 1: Summary of population projection methodologies

Method	Equations	Variables	Notes
Linear Extrapolation	$P_t = a + bt$	P_t = projected population a = population at time 0 b = coefficient of linear curve t = time	
Parabolic Extrapolation	$P_t = a + b_1t + b_2t^2$	P_t = projected population a = population at time 0 b_1, b_2 = coefficients of parabolic curve t = time	
Housing Unit	$P_t = H^{/}O_N + HO_E$	P_t = projected population $H^{/}$ = new housing H = existing housing O_N = average occupancy rate of new housing O_E = average occupancy rate of existing housing	Calculated for each household type
Share Capture	$P_t = kP^{/}_t$	P_t = projected population k = population ratio $P^{/}_t$ = projected population of surrounding area	
Cohort	$P_t = P_s + B - D \pm M$	P_t = projected population P_s = survived population at time 0 B = births D = deaths M = net migration	Calculated based on sex and age cohorts

Linear extrapolation is the most simple of the methods presented. This method assumes a linear relationship of constant incremental growth or decline based on historic population estimates. By plotting a line of best fit for the limited historic estimates, as seen in Figure 1, the method projects that the same relationship will hold true into the future. Although linear extrapolation is rarely appropriate for demographic and economic phenomena, it can be the best alternative when data limitations prohibit the use of all other methods (Klosterman 1990).

Linear extrapolation is one example of a polynomial curve. Further examples that share the same general mathematical form of equation include parabolic (second-degree), cubic (third-degree), and so on. In the case of a parabolic extrapolation, there is generally one arc with a constantly changing slope (as seen in Figure 2). The parabolic curve has an incrementally changing relationship, which increases or decreases as the x variable (time in this case) increases. This relationship may be representative for rapidly increasing or decreasing populations, however, longer projections will become increasingly large (or small), and as a result, extreme caution should be used when applying parabolic extrapolation for population projections (Klosterman 1990).

Figure 1: Linear extrapolation example

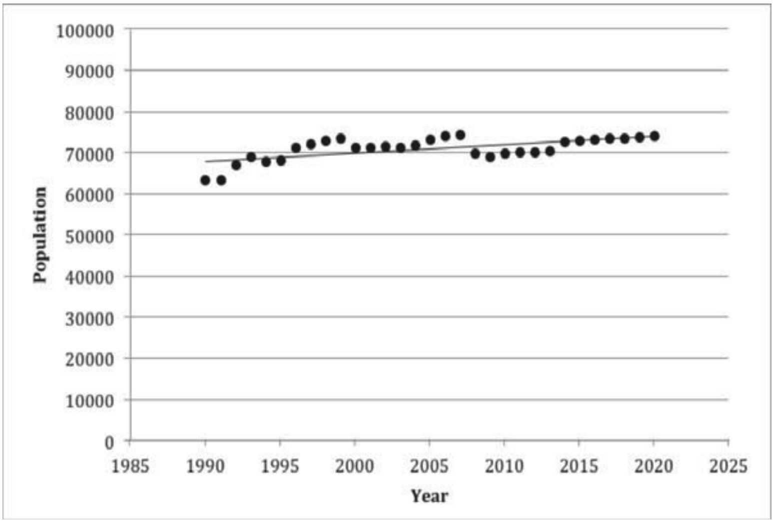
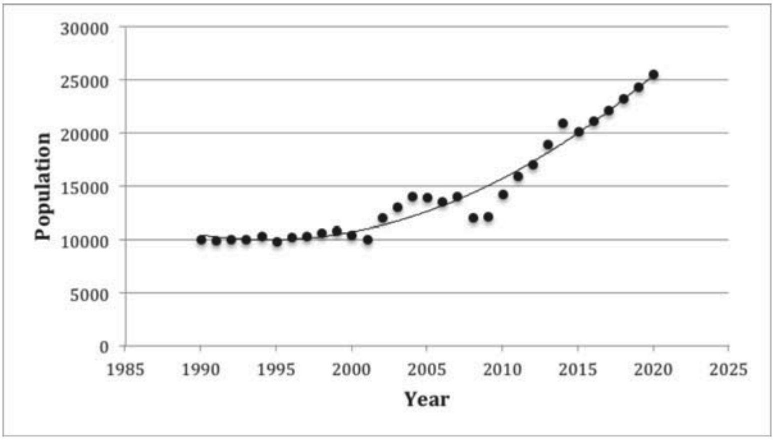


Figure 2: Parabolic extrapolation example



The extrapolation methods project the population as an isolated, unique geographic entity, however, if it can be assumed that the municipality's growth or decline is very closely related to a surrounding region, a share capture model can be applied. This method relies on independent projections for the surrounding region, which are presumably calculated with human and monetary resources not available at the local level (Davis 1995). A constant share capture model assumes that the local municipal share of the surrounding region's population will remain consistently proportional into the future. Therefore if the region's current population grows by 10%, the model will project the local current population to do the same.

The share capture model assumes that all local demographic subsets are proportional to the surrounding region. However, this is rarely the case. If, for example, 40% of the local population and 20% of the regional population are over 65 years of age, their populations will change very differently. To account for this disparity, a shift share approach can be adopted. This technique adjusts the share capture projection method by introducing a shift term to account for differences between local and regional rates of population change (Klosterman 1990). This method is also frequently used in economic projections to account for differences in local and regional industries.

The cohort component model projects not only the population, but also the composition of the population. The share capture and extrapolation methods are also able to project disaggregated age and sex cohorts, however, both rely on static relationships based on the current estimates. The cohort component model uses fertility, mortality and migratory trends to capture dynamic processes within age and sex cohorts. Births, deaths and migration are predominantly independent processes that together determine the overall rates of population change as a population is only altered when a person is born, dies or moves into or out of the city (Klosterman 1990). By working separately with the three components of population change, superior projections can be obtained (ibid).

Certain methods are not based exclusively on population trends at all. In the case of a housing unit method, the focus is on the supply and demand factors of historical and future housing construction (Watson & Associates 2009). The population projection is based on assumed future change in housing stock, and assumptions regarding household size, units and occupancy (Swanson and Tayman 2012). The housing unit method is widely used for subnational population estimates, as it is applicable at any level of geography (ibid). However, this method generally presents aggregate population forecasts, which limits its usefulness to planners.

2.4 Accuracy

There is an abundance of literature concerning the accuracy of population projections for large scale geographical areas, however, relatively little academic discourse has been dedicated to smaller scale areas such as individual cities or towns (Rayer and Smith 2010; Wilson 2014). This is partially due to the fact that projection error, regardless of method, is probable to remain quite substantial at the local scale (Wilson and Rowe 2011).

There is little guidance from the academic literature and a lack of consensus on best methodological practices for projections for smaller population areas (Wilson 2014). As expected, complex models are advantageous as they provide more detail, however, these models are time-consuming, expensive and difficult to calculate. In contrast, simpler models are easily applied but lack the depth of analysis. Often a significant difference between the simpler and more complex methods is the inclusion (or lack) of an internal migration component. Many researchers have concluded that at the local scale, due to the high projection error, complex models are no more accurate than simpler alternatives (Chi 2009; Rayer and Smith 2010; Rayer 2008; Smith and

Tayman 2003; Wilson and Rees 2005).

A small number of studies have examined, retrospectively, the accuracy of different models in smaller areas. Applying 66 different population projection models in Dutch municipalities, Openshaw and van der Knapp (1983) determined the ratio correction model (a form of share capture) to be one of the best. Similarly, in an examination of census tracts in the United States, Smith and Shahidullah (1995) concluded that of four models, the lowest errors were generated by a share capture model. Rayer's (2008) analysis at the county level across the United States found that of the five models he examined, linear extrapolation performed best. The same result was concluded again in Rayer and Smith's (2010) study of sub county areas in Florida, although share capture models also performed very well. Wilson (2014) assessed 10 models using datasets from Australia, New Zealand and England & Wales concluding that, once again, share capture models outperformed the other alternatives.

Both Rayer (2008) and Rayer and Smith (2010) applied assessment frameworks that built directly upon the work of Smith, Tayman and Swanson (2001). The twelve criteria of Smith, Tayman and Swanson when evaluating different population projections methods were: (1) geographic detail, (2) demographic detail, (3) temporal detail, (4) face validity, (5) plausibility, (6) cost of production, (7) timeliness, (8) ease of application, (9) ease of explanation, (10) usefulness as a analytical tool, (11) political acceptability, and (12) forecast accuracy. Rayer (2008) followed a very similar assessment framework, only changing "usefulness as an analytical tool" to "usefulness for scenarios."

Although select academic discourse has evaluated the differing population projection methods for small areas, no such research has been done in the Canadian context. And as there is no standardization of population projection methods at any sub-national level in Canada, this paper fills a necessary gap by comparing and contrasting the different methods being applied in Canada. Furthermore, this paper presents the comparison and evaluation of different levels of governmental population projections.

3. Methodology

In order to evaluate a variety of population projection methods being used in the Canadian context, the population projections of every municipality and region in Ontario, as well as the province itself and of Canada as a whole, were examined. From this preliminary evaluation, targeted sampling was used to select regional and municipal cases that represented a diverse array of population projection methods. All Canadian provinces, regions and cities would be of interest to this study, however for the sake of feasibility, the scope has been limited to cities within Ontario.

This study evaluates Statistics Canada's national population projections, and both Statistics Canada and the Ontario Ministry of Finance's projections at the provincial level. Waterloo was selected as the case study at the regional tier of governance, and three municipal cases, Belleville, North Bay and London, were considered at the local level. All data is secondary and was collected online from a multitude of sources including Statistics Canada, Ontario Ministry of Finance, and individual municipalities. Regional and municipal community profiles, based on data from the 2011 census, are presented in Table 2.

Table 2: Community profiles of case studies (Statistics Canada 2013a; Statistics Canada 2012)

Location	Waterloo	Belleville	North Bay	London
Size (km^2)	1,368.94	247.21	319.05	420.57
Population	507,096	49,454	53,651	366,151
Population density per km^2	370.4	200	168.2	870.6
Median employment income	$49,788	$42,955	$47,396	$47,805
Median age	37.7	43.5	42.1	39.3
% Population 65+	12.5	19.2	17.3	14.7
% Population change between 2006-2011	5.7	1.3	-0.6	3.9
% Foreign born or immigrant	23.1	7.5	5.7	21.2

Following the population projection method comparison criteria of Smith, Tayman and Swanson (2001) and the subsequent additions of Rayer (2008) and Rayer and Smith (2010), a hybrid assessment framework is developed to compare the methods and results of different levels of Canadian governmental population projections. The criteria consists of: (1) forecast accuracy, (2) cost of production, (3) timeliness, (4) ease of application, (5) ease of explanation, (6) geographic detail, (7) demographic detail, (8) temporal detail and (9) usefulness for scenarios. The methodologies used in different cases are qualitatively evaluated based on their strengths and weaknesses identified in the technical reports and the academic literature. Forecast accuracy is judged by comparing past projections with actual population estimates through the calculation of mean absolute percentage error (MAPE). The remaining criteria have been qualitatively assessed, by projection method, by Rayer (2008) based on the strengths and weaknesses identified by Smith, Tayman and Swanson (2001). Keeping consistent with Rayer (2008), for each criterion, a rating of "good", "average" or "poor" will be applied, based on his summative evaluations of the different population projection methods, to the case studies examined in this paper. When multiple scenarios are provided, the reference or medium scenario is evaluated.

4. Results

The national, provincial and regional cases all employed cohort component methods, which project population changes based on age and gender explicit fertility, mortality and migration rates, to calculate their respective population projections (Statistics Canada 2010; Ontario Ministry of Finance 2012). For the national and provincial cases, the cost of production, timeliness and ease of application were given a poor ranking as the cohort component method is data intensive, monetarily and temporally expensive and relatively difficult to apply. The Statistics Canada national and provincial projections also received a poor ranking for geographic detail, as they do not provide further detail at local levels. The Ministry of Finance simply aggregate their census division level projections to calculate their provincial level projections and therefore contain additional geographic detail and thus received an average ranking. All cases applying the cohort-component methodology scored good for demographic and temporal detail as they are projected by gender and age at regular time intervals.

The City of Belleville applies both linear and polynomial extrapolation methods, which rely solely on past population estimates and do not project by age or gender (City of Belleville 2010). The linear growth rates follow low (0.85%) and high (1.19%) growth rates provided by Statistics Canada's Population Projections for Canada, Provinces and Territories (2010). Polynomial projections are calculated using a parabolic trend line based on historical population values from 1979 through to 2006. These methods allow for economical, fast, and easy to explain results. Although these results do contain adequate temporal detail, they unfortunately are not useful for demographic detail or scenarios.

Produced by the Altus Group (2012), the population projections for the City of London are calculated using a share capture model. This essentially assumes the City of London will maintain a consistent population ratio, by age and sex, with that of its surrounding area, Middlesex County. The model projects future populations based on historical population trends in the City of London and future share capture assumptions relative to Middlesex County. The projections for Middlesex County were calculated by the Altus Group using Statistics Canada data. Similar to the City of Belleville's method, it is inexpensive, quick, easy to explain, maintains geographic and temporal detail, but the City of London's share capture model also provides demographic detail and is more useful for scenarios.

Lastly, Watson & Associates (2009) used a housing unit method for North Bay's population projections. This method assumed that population will grow in sync with housing, and thus, by projecting housing developments based on historical trends, population projection estimates can also be calculated. This approach provides good temporal and geographic detail and, once the housing projection is made, can be done in a timely and cost-efficient manner. However, it does not provide demographic detail and is poor in terms of usefulness for scenarios.

Forecast accuracy was evaluated based on MAPE calculations. A sample calculation of the MAPE for Statistics Canada's national population projections is detailed in Table 3 and Equation 1. The MAPE results of all cases can be seen in Table 4. As many of the population projection reports were recently published, it was primarily short-term projections that were evaluated for forecast accuracy—which are much more likely to report high accuracy values. The federal and provincial projections proved to be very accurate, while the local scale projections were deemed average.

All cases that employed demographic detail ranked average for usefulness for scenarios. More complex methods such as multivariate time series models, which include more input components, are more useful and flexible for scenario analysis. Table 5 depicts the results for evaluation criteria of the cases. As the methodologies for the Statistics Canada national and provincial population projections are identical, the results for the Statistics Canada provincial case study have been omitted from Table 5.

Table 3: MAPE calculation for national population projections based on data from Statistics Canada (Statistics Canada 2013b; Statistics Canada 2010)

Year	Projected Population [1000s]	Actual Estimated Population [1000s]	Difference: (Actual – Projected) [1000s]	Absolute Percent Error (Difference/ Actual)
2010	34,138.1	34,005.3	-132.8	-0.0039
2011	34,532.2	34,342.9	-189.4	-0.0055
2012	34,921.9	34,754.3	-167.6	-0.0048

MAPE = (1)

Table 4: MAPE calculations for each case study based on data from Statistics Canada (2013b, 2010), Ontario Ministry of Finance (2012), Hemson Consulting (2012), City of Belleville (2010), Watson & Associates (2009) and the Altus Group (2012)

Name	Level	Author	Method	MAPE
Canada	National	Statistics Canada	Cohort-component	-0.47%
Ontario	Provincial	Statistics Canada	Cohort-component	-0.43%
Ontario	Provincial	Ministry of Finance	Cohort-component	1.45%
Waterloo	Regional	Hemson	Cohort-component	-5.44%
Belleville	Municipal	City of Belleville	Extrapolation	-3.89%
North Bay	Municipal	Watson & Associates	Housing unit	-3.77%
London	Municipal	Altus Group	Share capture	N/A

Table 5: Evaluation Criteria Results

Level	National	Provincial	Regional	Municipal	Municipal	Municipal
Name	Canada	Ontario	Waterloo	Belleville	North Bay	London
Source	Statistics Canada	Ministry of Finance	Hemson Consulting	City of Belleville	Watson & Associates	Altus Group
Method	Cohort Component	Cohort Component	Cohort Component	Extrapolation	Housing Unit	Share Capture
Forecast Accuracy	+++	+++	++	++	++	-
Cost	+	+	++	+++	++	+++
Time	+	+	++	+++	+++	+++
Ease of Application	+	+	++	+++	++	+++
Ease of Explanation	++	++	++	+++	++	+++
Geographic Detail	+	++	++	+++	+++	+++
Demographic Detail	+++	+++	+++	+	+	+++
TemporalDetail	+++	+++	+++	+++	+++	+++
Use for Scenarios	++	++	++	+	+	++

+++ good, ++ average, + poor, - not applicable

Migration is the key difference between projecting population at the national and local scale. At the local scale population projections are often simply derived from projections from larger geographical jurisdictions. Municipalities not relying on projections from encompassing regions often choose to omit the complex and volatile calculation of internal migration for their official projection figures. However, many municipalities rely heavily on historic trends identified from the census population counts, which essentially contain immigration, emigration, interprovincial, intraprovincial, interregional, and intraregional migration.

Age- and gender-specific migration analysis is important, as different sects of the population have different migratory tendencies. For example, the baby boomer generation may shift away from major city centers as they enter retirement. This has different implications for the housing market than an influx of young families would, as baby boomers are considered to be more mobile and more likely to re-locate again. Decisions regarding housing stock and developments need to be informed of such issues so that adequate preparations can be made to optimize spending and to help stabilize housing markets.

If population projections and demographic forecasts are so essential to planning decisions, why do planners not demand more rigor and accuracy? Again, this question demonstrates the differentiation between large and small cities. In large cities, thorough and detailed population projections are expected and human and monetary resources can be used to address the need. Conversely, in smaller, peripheral cities there can be little to no human resources allocated exclusively to planning, let alone demographics, as planning officials often hold a myriad of titles, which restrict them in their duties, and the scope of their needs.

5. Conclusion

At the national and provincial scale, cohort component methods are generally used. These methods tend to be more expensive, time consuming, difficult to apply and explain and are lacking in specific geographic detail. However, they do provide very detailed and dynamic projections. Although technological advances and inexpensive software have diminished barriers to producing more complex projections, human power and knowledge constraints still limit the use of these methods in smaller communities. Hence, cohort component projections are generally produced by federal or provincial organizations (e.g. Statistics Canada, Ontario Ministry of Finance) where resource constraints are much less stringent.

At the local level, simpler methods for producing population projections are often applied. Linear extrapolation or share capture models are practical, as results from higher-level governmental projections (provincial or census division rates calculated by Ministry of Finance or Statistics Canada) are often used as a basis for the local level community projections. These methods do not rely on raw data and, as such, are inexpensive, timely and easy to explain. Depending on the method and source data, structural demographic information vital to future city plans can be retained in the local level projection, however, this is not always the case and can limit the usefulness of projections to planning decisions. Larger metropolitan areas are more likely to use complex cohort component models, as they are not as fiscally restrained.

Many researchers have concluded that complex models are no more accurate at the local scale than their simple alternatives (Chi 2009; Rayer and Smith 2010; Rayer 2008; Smith and Tayman 2003; Wilson and Rees 2005), therefore it follows that the best method for population projection at the local scale would be a simple method that still produces age and gender specific projections. The specific method would depend on data availability at the regional or census division level, but of the methods presented, the share capture method would be preferred for smaller communities as they lack the human and monetary resources to produce more complex population projections.

It is clear from the literature that more research is needed regarding population projections at the sub-regional level. Best practice literature regarding methods and accuracy does exist, but is often outside the scope of feasibility for practical use in smaller areas. Planning literature tends to concentrate on local scale, but does not often explicitly discuss the methodologies of population projections. In the demography literature, much of the focus is on larger areas, such as population projections at the national or provincial level. In these cases, the migratory movements are well documented and models can be very complex, but are difficult to apply or are not applicable at the local level.

National, provincial and to some extent regional population projections are able to capture migratory components within their forecasts. As globalization, deindustrialization and general urbanization continue to reshape Canada's cities and urban centers, migratory rates are of growing importance to future planning decisions. As immigration is accounting for an increasing amount of the nation's population growth, city officials need to be aware of the demographic structure that is both moving into and out of their cities. Unfortunately, migration is volatile at the local level, although that does not mean that they should be overlooked. As was discussed in Section 2.1, utility, rather than accuracy, is the primary motivation for local population projections. Research to establish best practice guidelines for smaller, fiscally constrained communities would be of significant value as populations continue to age and migrate towards large metropolitan areas.

References

Altus Group. 2012. Employment, Population, Housing and Non-Residential Construction Projections, City of London, Ontario.

Chi, G. 2009. Can Knowledge Improve Population Forecasts at Subcounty Levels? *Demography* 46 (2): 405–27.

City of Belleville. 2010. Population and Household Statistics Population Projections 1.0 - Census Population Trends. Belleville.

Davis, H.C. 1995. *Demographic Projection Techniques for Regions and Smaller Areas*. Vancouver: UBC Press.

Foot, D.K. 1998. *Boom, Bust & Echo 2000*. 2nd ed. Toronto: Macfarlane Walter & Ross.

Goldstein, J. R., and G. Stecklov. 2002. Long-Range Population Projections Made Simple. *Population and Development Review* 28 (1): 121–141.

Großmann, Katrin, Annegret Haase, Dieter Rink, and Annett Steinfuhrer. 2008. Urban Shrinkage in East Central Europe? Benefits and Limits of a Cross-National Transfer of Research Approaches. In *Declining Cities/Developing Cities: Polish and German Perspectives*, ed. M. Nowak and M. Nowosielski, 77–99. Poznań, Poland: Institute for Western Affairs.

Keilman, N. 2008. European Demographic Forecasts Have Not Become More Accurate Over the Past 25 Years. *Population and Development Review* 34 (March): 137–153.

Klosterman, R.E. 1990. *Community Analysis and Planning Techniques*. Savage, Maryland: Rowman & Littlefield Publishers.

———. 2013. Lessons Learned About Planning. *Journal of the American Planning Association* 79 (2): 161–169.

Leadbeater, D. 2009. Single-Industry Resource Communities, 'Shrinking' and the New Crisis of Hinterland Economic Development. In *The Future of Shrinking Cities: Problems, Patterns and Strategies of Urban Transformation in a Global Context*, 89–100. Berkeley, California: Center for Global Metropolitan Studies, Institute of Urban and Regional Development, and the Shrinking Cities International Research Network.

Myers, D. 2001. Demographic Futures as a Guide to Planning. *Journal of the American Planning Association* 67 (4): 383–397.

Ontario Ministry of Finance. 2012. Ontario Population Projections Update.

Openshaw, S., and G.A. van der Knapp. 1983. Small Area Population Forecasting: Some Experience with British Models. *Tijdschrift Voor Economische En Sociale Geografie* 74 (4): 291–304.

Outhit, J. 2014. Population Growth Fails Expectations, Again, in Waterloo Region. *The Record*, April 4.

Pallagst, K. 2010. Viewpoint: The Planning Research Agenda: Shrinking Cities – a Challenge for Planning Cultures. *Town Planning Review* 81 (5): i–vi.

People for Education. 2004. Ontario School Closing Report. Toronto.

———. 2009. School Closings and Declining Enrolment in Ontario. Toronto.

Rayer, S. 2008. Population Forecast Errors: A Primer for Planners. *Journal of Planning Education and Research* 27 (4): 417–430.

Rayer, S., and S.K. Smith. 2010. Factors Affecting the Accuracy of Subcounty Population Forecasts. *Journal of Planning Education and Research* 30 (2): 147–161.

Rieniets, T. 2006. Shrinking Cities - Growing Domain for Urban Planning? *Cahiers Thématiques* 6.

Schatz, Laura, David Leadbeater, Cristina Martinez-Fernandez, and Tamara Weyman. 2013. From 'Up North' to 'Down Under': Dynamics of Shrinkage in Mining Communities in Canada and Australia. In *Shrinking Cities: International Perspectives and Policy Implications*, ed. K. Pallagst, T. Wiechmann, and C. Martinez-Fernandez, 205–223. New York: Routledge.

Smith, S.K., and M. Shahidullah. 1995. An Evaluation of Population Projection Errors for Census Tracts. *Journal of the American Statistical Association* 90 (429): 64–71.

Smith, S.K., and J. Tayman. 2003. An Evaluation of Population Projections by Age. *Demography* 40 (4): 741–57.

Smith, S.K., J. Tayman, and D.A. Swanson. 2001. *State and Local Population Projections: Methodology and Analysis.* New York: Kluwer Academic/Plenum Publishers.

Statistics Canada. 2010. Population Projections for Canada, Provinces and Territories: 2009 to 2036. *Statistics Canada Catalogue No. 91-520-X*. Ottawa.

———. 2012. Focus on Geography, 2011 Census. *Statistics Canada Catalogue No. 98-310-XWF2011004, Analytical Products, 2011 Census. Focus on Geography Series*, 2011 Census: Ottawa, ON.

———. 2013a. NHS Focus on Geography Series. *Statistics Canada Catalogue No. 99-010-X2011005*.

———. 2013b. Population by Year, by Province and Territory. *CANSIM Table 051-0001*.

Swanson, D.A., and J. Tayman. 1995. Between a Rock and a Hard Place: The Evaluation of Demographic Forecasts. *Population Research and Policy Review* 14 (2): 233–249.

Swanson, D.A., and J. Tayman. 2012. Housing Unit Method. In *Subnational Population Estimates*, 137-163. Dordrecht: Springer.

Watson & Associates. 2009. City of North Bay Population, Housing and Employment Forecast Update, 2006-2031. North Bay, Ontario.

Wilson, T. 2014. New Evaluations of Simple Models for Small Area Population Forecasts. *Population, Space and Place*

Wilson, T., and P. Rees. 2005. Recent Developments in Population Projection Methodology: A Review. *Population, Space and Place* 11 (5): 337–360.

Wilson, T., and F. Rowe. 2011. The Forecast Accuracy of Local Government Area Population Projections: A Case Study of Queensland. *Australasian Journal of Regional Studies* 17 (2): 204.