Evaluating Population Projections: Insights from a Review made at Statistics Canada

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Preliminary version

Abstract

The Demography Division of Statistics Canada recently initiated a review of its methodology for population projections. In the process, many important questions emerged as to what should be considered when evaluating the quality of population projections. The goal of this paper is to share some of the insights gained in this review and to provide an overview of the population projections program at Statistics Canada, including its orientation, its strengths and challenges. We begin with an overview of the context in which Statistics Canada makes population projections. This discussion will raise some conceptual issues, which must inevitably be solved before initiating a review of the quality of population projections. We then follow with a brief evaluation of the past projections. Finally, we examine several considerations that, in our opinion, should be at the center of any evaluation of population projections, including two crucial components: the plausibility of the assumptions and the validity of the methodology.

[1] The views and opinions expressed in this paper do not necessarily reflect those of Statistics Canada. The author wishes to thank Nora Bohnert for her precious comments and suggestions.

1. Introduction

The Demography Division of Statistics Canada recently initiated a review of its methodology for population projections. The review covers the assumption building process and the various methodologies used to build the parameters behind the projections. In the process, many important questions emerged as to what should be considered when evaluating the quality of population projections. The goal of this paper is two-fold: to share some of the insights gained in this review, and, to provide an overview of the population projections program at Statistics Canada, including its orientation, its strengths and challenges.

Prior to any evaluation, one must first determine the criteria against which a projection is to be deemed successful or of high quality. The criteria may appear to be straightforward: Did we in fact succeed in predicting the future population growth? As we shall see, however, focusing solely on the accuracy of population projections may be overly simplistic; there are several other important factors that should also be taken into consideration when evaluating a population projection.

In this paper, we aim to identify the various elements that should comprise an evaluation of a population projection. We initiate the discussion with a reflection on what characterizes a population projection, and how this in turn defines what we should expect from it. We then proceed to a brief evaluation of past projections in Statistics Canada. In the fourth section, we identify other elements that, apart from accuracy, should also be considered essential parts of an evaluation. In the last section, we discuss the analytical credibility of population projections, which is, in our view, a critical element of quality.

2. The context of population projections at Statistics Canada: Epistemological considerations

A well-known division in the field of population projections is that between a "forecast" and a "projection". While similar concepts, there is an important distinction between the two: While a forecast will attempt to predict what will occur in the future, a projection seeks to show the outcome of a set of assumptions, if those happened to be realized (Keyfitz and Caswell, 2005). Hence, a forecast could eventually be evaluated in light of future events, but a projection will be proven wrong only if an error in the underlying calculation is found (George and al. 2004). Behind each of these approaches stands a theory of our knowledge of the future, an epistemological posture (Romaniuc, 2010). Depending on the philosophical stance, the answers to some important questions may vary, for example:

> What can the past tell us about the future?
> Can we build confidence intervals, or probabilities based on the trends of the past?
> Can we say one scenario is more likely or the most likely to occur?
> Can we attach a level of certainty to a projection scenario?
> How to interpret the results?

At Statistics Canada, the publication of population projections must conform to certain standards and policies, including those established in the agency's own internal *Policy on Estimates with Future Reference Dates*. This policy states, among other things, that there should be several estimates for any given future reference date, each being the product of different and clearly stated assumptions, or the product of alternative specifications of the model. The policy also states that no single set of estimates

should be labeled as "most probable". In this context, it is clear that Statistics Canada publishes projections, and not forecasts.

However, as clear as the distinction between forecast and projection appears to be, the two may not be so easily distinguishable in reality. This is because the reader most often considers the projection as a forecast (Henry, 1972). Moreover, even though more than one projection scenario exists, users almost invariably turn to the middle-variant to interpret it as a forecast (Keyfitz, 1981). Nathan Keyfitz (1972) questions what criteria should define a projection versus a forecast: Is it the demographer's intention or the reader's use? He also (1981) argues that if demographers cannot judge which variant level of mortality or fertility is likely to be realized, then no one can, and in practice, users have depended on demographers for such judgment. De Beer (2000) notes that "To let users make their own choice does not seem an optimal use of expertise."

Why not then produce a forecasts, rather than projections that will likely be used as forecasts? The point is that demographers are in the best position to evaluate whether or not they effectively have the tools to effectively predict the future, and if, indeed, they can reasonably contend to predict the future population. Demographers who use the label 'projection' rather than 'forecast' adopt a prudent position, a perspective that underlines the high level of uncertainty inherent to projection exercises. They will also, traditionally, offer a variety of alternative outcomes in order to reflect this uncertainty, and avoid to associate probabilities with the estimates.

3. Past projections at Statistics Canada: A brief evaluation of 'accuracy'

If, as stated earlier, populations projections would be proven wrong only if an error in the underlying calculation is found, and not in lights of future events, is the evaluation of accuracy totally irrelevant? In fact, demographers in the process of building assumptions find themselves wondering what outcomes are the most likely to occur. If this kind of process did not exist, there would be no special value given to a projection, and one projection would be as good as any other (Keyfitz, 1972). This also calls into question the value of such projections. So the idea of predicting the future is not totally removed from population projections, but instead it is rather subtly embedded in the assumption building process.

There are, in our opinion, at least three other reasons why accuracy plays an important role in population projections. First, projections are informative of the period in which they were built; the examination of the past projections' 'errors' reveals both the continuity and the changes in demographic trends that occurred since their release.[2] Next, as Wilson and Rees (2005) wrote, "Reflection on past errors is a great help in improving methods and assumptions for the future". Finally, the repeated comparisons of projected estimates with historical data inform us about the limitations of demographic projections and what we can reasonably expect from them.

3.1 Population projections before 2000

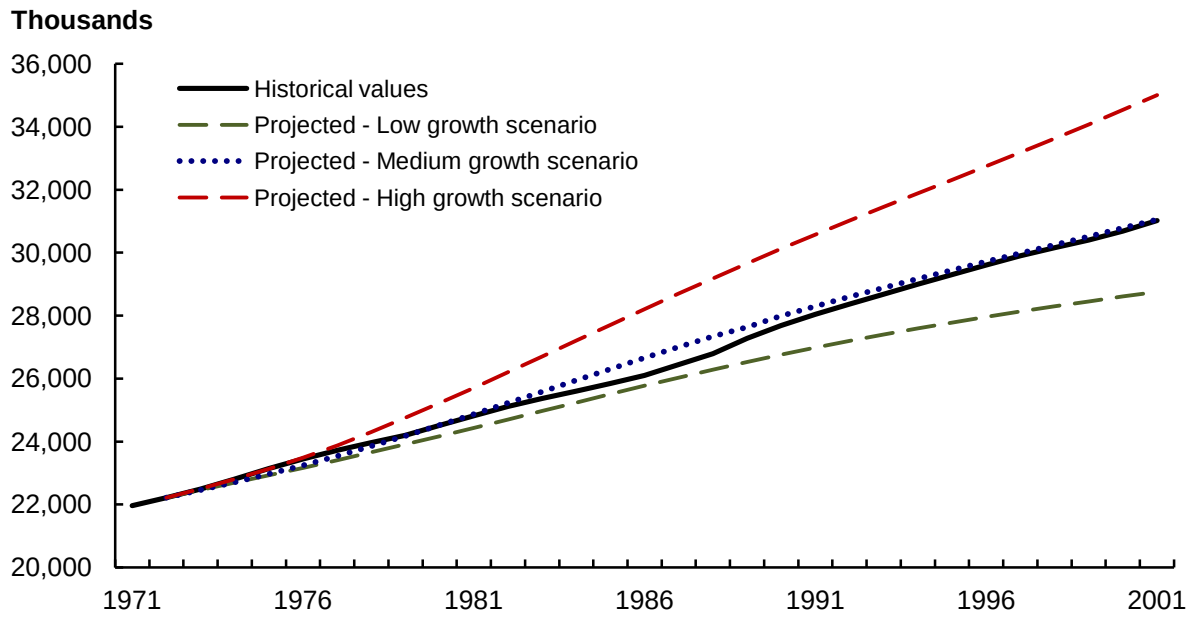
It was not before the 1970s that population projections became a regular activity in Statistics Canada. Before the 1970s, some ad hoc projections had been prepared by the agency, but as George (2001) explains: "[...] the stand of the Bureau during this period was rather mixed or not favourable for

[2] Projections results may themselves be a factor of change (for instance, by highlighting a possible decline in the working age population, which could trigger a rise in the immigration levels).

developing projections." The agency generally maintained a low profile, and these projections were not given general distribution. Beaujot (2000) notes that these projections had limited success in estimating the demographic growth of the country, failing to anticipate the major changes associated with the baby-boom and the increase in international migration.

Since the 1970s, Statistics Canada has published eight widely and publicly released editions of population projections. The time horizon of these projections varied from 20 to 30 years, at the level of the provinces and the territories, and reached 50 years at the national level in recent editions. In a demographic context that turned out to be much more stable than in the early post-war period (Beaujot, 2000), these editions generally succeeded in projecting the demographic growth and the population ageing that would follow.

FIGURE 1
Population observed and projected according to three scenarios of the 1972-2001 edition, Canada



Note: The projected values had, as a base point, a population non-adjusted for the net undercoverage. In this graphic, they have been adjusted in order to be at the same level than the observed values.

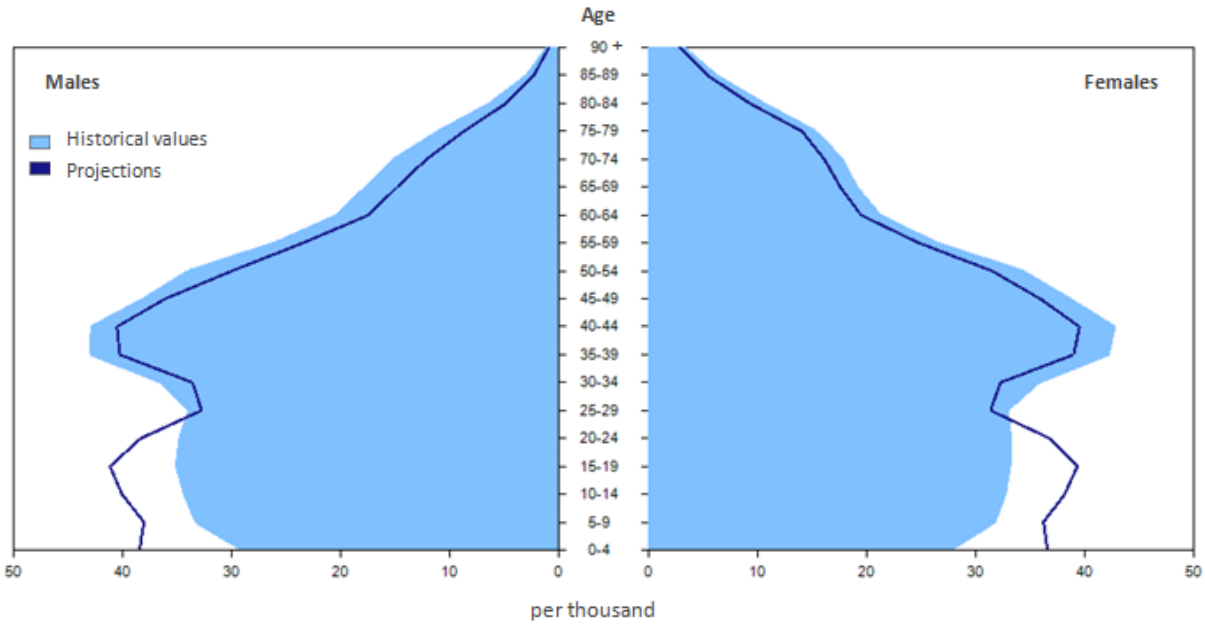
With its time span now past, it is very instructive to evaluate how well the 1972-2001 edition did in terms of estimating the future population of Canada. Indeed, this edition did fantastically well at first glance: The medium growth scenario suggested that the Canadian population would reach 31 050 000 in 2001, a number which ultimately overestimated reality by only 30,000 or less than 0.1% (Figure 1).[3] However, a closer look suggests that we should not attribute this 'success' to sound assumptions. In fact, this scenario suggested that a total fertility rate (TFR) of 2.2 children per woman would be reached in 1985 along with 120,000 annual immigrants, whereas in 2001, the TFR was 1.54 children per woman and the number of

[3] The figures were adjusted to take into account revisions made to the population estimates after the release of the projections. Basically, these revisions consisted of adding net undercoverage and components that were not estimated previously such as non permanent residents and returning emigrants.

immigrants was more than double that of the assumption. These divergences had important consequences: The age structure of the Canadian population in 2001 greatly differed from that which was projected for that year, with a much older population composition occurring in reality (Figure 2).

FIGURE 2

Age and sex pyramids (in relative value) of the Canadian population on July 1st 2001 according to the population projections of the 1972-2001 edition (medium growth scenario) and the population estimates

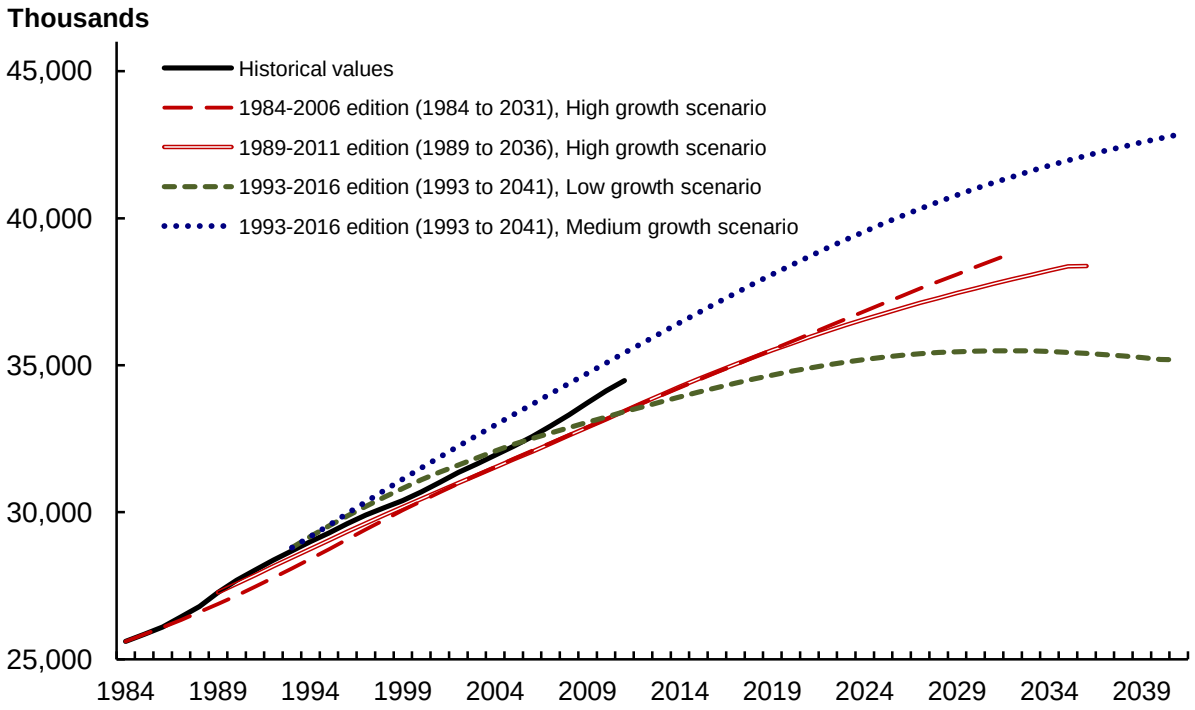


In subsequent projections editions, the growth of the Canadian population more closely followed the high growth scenarios. However, if the range suggested by the 1976-2001 edition enclosed the observed population in 2001 by a very small margin, this was not the case for the 1984-2006 or the 1989-2011 editions (Figure 3). The unanticipated but considerable rise in the immigration levels that occurred in the 1990s explains to a great extent why these projections ended up underestimating the growth. For mainly the same reason, these editions also underestimated the dependency ratio of seniors.[4] In 2006, this ratio was 20.3. In comparison, the 1984-2006 edition projected a senior dependency ratio between 24.1 and 25.2 while the 1989-2011 edition projected it to be between 22.1 and 24.7.

Published after a period in which fertility and immigration had risen considerably, the 1993-2016 edition suggested a TFR of 1.7 children per woman and 250,000 immigrants per year which, interestingly, is very similar to the assumptions utilised in the medium growth scenario of the latest population projections (2009-2036 edition). In the short term, fertility and immigration did not remain at the elevated levels, and so these projections ended up overestimating the population growth while suggesting a younger age structure than what actually occurred. Still, the population range provided by the low growth and the high growth scenario enclosed the observed population number beginning in 2004.

[4] Similarly to what had been done in those years, the old age dependency ratios were calculated by dividing the population aged 65 or over by the population aged 18 to 64. In the remaining of the paper, it is calculated using the population aged 15 to 64 as the denominator.

FIGURE 3
Population observed (1984 to 2011) and projected according to some scenarios taken from previous editions (1984-2006, 1989-2011 and 1993-2016), Canada



Notes :

Starting from the 1984-2006 edition, the horizon span of the projections was generally 20 years at the level of the provinces and the territories, and double that (40 years) at the national level. The official name of the edition continued to reflect the horizon span at the level of the provinces and territories.

The projected values in the 1984-2006 and 1989-2011 editions had, as a base point, a population unadjusted for the net undercoverage. To facilitate comparisons, in this figure, they have been adjusted to start at the same level as the observed values, which are adjusted for net undercoverage.

3.2 Recent editions of population projections

A comparison of recent editions of population projections with historical estimates requires some precautions since it requires pre-judging the accuracy of a long-term projection through its accuracy in the short-term. Nevertheless, it remains a useful exercise as it highlights recent demographic changes.

The 2000-2026 edition underestimated population growth, as it projected that the population would reach 34.0 million in 2011 in the high growth scenario, slightly less than the observed figure of 34.5 million. This scenario has underestimated the number of births to date as well as the number of non permanent residents, while it has overestimated the number of deaths. The match in terms of the age structure of the population also suffered from this phenomenon: the youngest median age projected, suggested by the high-growth scenario, was 40.1 years, compared to an observed median age of 39.9 years in 2011. If the old age dependency ratio (20.8) matches the value projected in 2011 by the medium and high-growth

scenarios, the young dependency ratio (23.7) falls outside the bracket, the closest value being 23.4 in the high-growth scenario.

The 2005-2031 edition has also underestimated the growth to date, the high growth scenario projecting 34.2 million in 2011 (compared to 34.5). The very small intervals between the various scenarios in the early years of the projection may explain partially why this happens. Still, a combination of recent changes in Canadian demographics also contributed to this divergence, all of them entailing higher than expected growth: A rise in fertility, an increase in the number of immigrants and non permanent residents and a slight decrease in the emigration levels.

3.3 Accuracies at smaller geographical scales

Just as accuracy at the total population level may hide significant discrepancies within the age structure of the population, comparisons at the national level may conceal substantial variations at smaller geographic levels. In general, projections show more accurate results in larger places than in smaller places (George et al. 2004; Tayman and Swanson, 1996). At the scale of the provinces and territories, growth depends on an additional component, interprovincial migration, which in a few provinces and territories is sometimes the most important component of growth (Dion and Coulombe, 2008). Internal migration is often recognized as the most difficult component to project, because of its high volatility overtime (Smith, 1986).

In sum, the projection of interprovincial migration has both a relatively high impact and a non-negligible probability of failure. For these reasons, Statistics Canada creates four distinct scenarios in which only the interprovincial migration assumptions vary; the goal being to reflect the higher uncertainty inherent to this component.[5] Thus, when measuring the accuracy of past projections at the level of the provinces and territories, it is important to take into consideration the various interprovincial migration scenarios.

Table 1 shows the accuracy of the medium-growth projections of the 2005 to 2031 edition in projecting the annual growth in each of the provinces and territories, six years after their release. It can be seen that while at the national level the medium-growth scenario underestimated growth by an average of 0.30% annually, the inaccuracy was generally higher at the scale of the provinces and territories. Interprovincial migration is an important factor explaining this phenomenon, as the wide range of outcomes from one scenario to the other may denote, but not the only one. Inaccuracies in the projected number of immigrants and emigrants will contribute divergence at the national level, but their distribution in the country is an additional potential source of inaccuracy at the level of provinces and territories. Notably, differences in opposite signs at the levels of the provinces and territories will cancel out, leaving the national level picture unaffected.

[5] The various interprovincial assumptions are created by selecting distinct reference periods from which the migration rates are calculated, each reflecting various migration patterns that benefited to some regions in particular. For instance, in the 2005-2031 edition, the selected reference periods were 2000 to 2003 (recent trends), 1988 to 1996 (west coast), 1996 to 2000 (central-west) and an average of the 2000 to 2003 and 1988 to 1996 periods (medium assumption).

TABLE 1

Mean annual percent error of the annual growth over the 2005/2006 to 2010/2011 period, by province and territory, for the medium-growth scenarios in the 2005 to 2031 edition of population projections

	Scenario			
Province / Territory	Medium	Recent trends	West coast	Central-West
	%	%	%	%
Newfoundland and Labrador	-0.01	0.20	-0.17	0.65
Prince Edward Island	0.56	0.64	0.52	0.72
Nova Scotia	-0.06	0.07	-0.16	0.01
New Brunswick	0.05	0.18	-0.08	0.17
Quebec	0.33	0.32	0.35	0.43
Ontario	0.01	-0.07	0.10	-0.08
Manitoba	0.48	0.42	0.55	0.42
Saskatchewan	1.25	1.29	1.23	0.90
Alberta	1.11	0.81	1.41	0.65
British Columbia	0.33	0.77	-0.15	0.75
Yukon	1.11	1.58	0.50	2.36
Northwest Territories	-1.21	-1.06	-1.36	0.44
Nunavut	1.00	0.47	1.43	0.90
CANADA	0.30	0.30	0.30	0.30

Notes: The mean percentage error is the average of the annual differences between the historical value and the projected figure divided by the historical population at the beginning of the year. Since the differences are not taken in absolute values, negative and positive differences for different years will cancel out in the calculation of the average. The averages are calculated over the period 2005/2006 to 2010/2011.

Still, interprovincial migration remains the principal source of inaccuracy for the provinces and territories among all of the components of growth, at least in the 2005 to 2031 edition. Table 2 shows the mean annual absolute percentage errors measured for each component of growth in each province and territory. Allowing for variation in the interprovincial migration component, the scenario that best matches the historical data was selected in each province and territory, independently of all others. In spite of this procedure, interprovincial migration appears to be the component that exhibits the worst performance in 8 of the 13 provinces and territories. For instance, in Newfoundland and Labrador, in the most accurate of the four medium-growth scenarios developed, the recent trends scenario, interprovincial migration exhibited an annual percentage of error in absolute terms of 0.39%, which is much higher than the second worst projected component, births (0.09%). In the four other provinces, significant and sometimes unparalleled changes, such as the variation in the number of new immigrants in Prince Edward Island and Ontario, the rise in the number of births in Québec and the increase in the number of non-permanent residents in British Columbia contributed to high levels of inaccuracy in components other than interprovincial migration.

TABLE 2

Mean annual absolute percent error measured for each component of growth over the 2005/2006 to 2010/2011 period, by province and territory, for the scenario showing the best match in the 2005 to 2031 edition of population projections

Province / Territory	Scenario	Births	Deaths	Immigration	Total emigration	Net change in non-permanent residents	Net inter-prov. migration	Interprovincial	
								In-migration rate	Out-migration rate
					%				
N.L.	Recent trends	0.09	0.03	0.03	0.02	0.05	**0.39**	0.12	0.31
P.E.I.	Central-West	0.07	0.03	**0.81**	0.02	0.13	0.33	0.19	0.46
N.S.	Recent trends	0.07	0.02	0.08	0.01	0.10	**0.22**	0.09	0.18
N.B.	Recent trends	0.07	0.02	0.14	0.02	0.05	**0.14**	0.08	0.15
Que.	West coast	**0.14**	0.07	0.07	0.01	0.08	0.04	0.08	0.07
Ont.	West coast	0.06	0.03	**0.11**	0.01	0.07	0.04	0.10	0.12
Man.	Central-West	0.08	0.02	**0.35**	0.04	0.05	0.11	0.21	0.17
Sask.	Central-West	0.14	0.03	0.31	0.04	0.09	**0.45**	0.22	0.30
Alta	Recent trends	0.22	0.02	0.22	0.05	0.31	**0.34**	0.45	0.30
B.C.	Medium	0.05	0.03	0.09	0.03	**0.21**	0.10	0.22	0.17
Y.T.	West coast	0.02	0.08	0.28	0.03	0.20	**0.53**	2.54	2.55
N.W.T.	Central-West	0.18	0.05	0.05	0.03	0.06	**0.51**	1.06	1.36
Nvt	Recent trends	0.07	0.04	0.04	0.04	0.05	**0.40**	0.26	0.49

Notes : The values shown for a specific province or territory come from the scenario showing the best fit between historical and projected estimates, among the four various medium-growth scenarios (each displaying a different interprovincial migration assumption) of the 2005-2031 edition of population projection. The mean absolute percentage error is the average of the annual differences between the historical value and the projected figure in absolute value, divided by the historical population at the beginning of the year. The averages are calculated over the period 2005/2006 to 2010/2011. The values in bold indicate the component where the highest values are found for a specific province or territory, thus indicating the component of growth where the highest average differences were found.

Before ending this section, it should be noted that the time horizon for which the comparisons of projected estimates and historical values are made may greatly influence the results. One could think that in comparison to other components, the internal migration component would show better accuracy in the short-term, especially in the "recent trends" scenario, but this is not necessarily the case. Because migration tends to vary from one year to the next, the uncertainty associated with this component may be substantial in the short term.[6] In contrast, other components, especially mortality and fertility, could be more accurate in the short term since they tend to change much more slowly. A more comprehensive evaluation would require the analysis of more than one edition of population projections, for various time horizons, and using multiple indicators of accuracy.

3.4 Accuracy and assumptions

The previous analysis shows that for the most part, past projections had pointed towards the demographic growth and the key changes in the age structure of population such as the population ageing that occurred

[6] In the long term these annual variations may cancel each other so that the global uncertainty related to internal migration would not increase very much in time.

since the 1970s (though the degree of population ageing was underestimated). But it also showed that some components of the growth displayed more discrepancies with historical values than others. This can be explained in part by the particular demographic context in which some components may be more volatile than others, and the relative difficulties to build plausible assumptions in such contexts.[7,8]

At the national level, frequent underestimation of the future levels of immigration explained why past projections most often suggested a deceleration of population growth that never materialized in the long-term. This is not surprising: immigration is consistently reported as the common source of inaccuracy in population projections at the national level (e.g. Statistics New Zealand, 2008; Mulder, 2002). In fact, compared to births or deaths, the demographic science is not much of a help for the projection of immigration (U.S Census Bureau, 2000). The most important factor in future levels of immigration turns out to be the immigration policies. However, using levels prescribed by these policies appears to be satisfactory in a near future, but less so in the longer term (U.S. Census Bureau, 2000). Another difficulty is that contrary to other components, in the case of immigration, the at-risk population is, by definition, living in another country, and therefore is not projected. As Preston et al. (2001) state, "[...] immigration policies are not fully exogenous factors and their changes often reflect changing demographic conditions".

Past projections from Statistics Canada have used either predetermined number of immigrants, or numbers evolving in proportion of the total population. The latter method was used in the two most recent editions, and implies that the needs for immigration would evolve in the future along with population growth. This may not be unreasonable given the context in which baby-boomers are slowly reaching the ages of retirement, leaving a smaller labour-force aged native population in its wake. On the other hand, some unanticipated phenomenon could easily prove wrong these assumptions as well, if, for instance, the number of admissions remained constant or decreased due to a deterioration of the economic conditions in the country or because the capacity to integrate and support high levels of immigration is questioned. These considerations show how difficult it is to formulate sound assumptions on immigration, and how many factors come into play.

At the levels of the provinces and territories, we found the highest levels of inaccuracy in the internal migration component, a highly volatile component, as stated earlier. In general, we know that migration patterns between the provinces and territories are greatly influenced by fluctuating economic factors such as employment and wages (see e.g. Bernard et al., 2008, Coulombe, 2006); however, these factors are not easily predicted.

In contrast to immigration or internal migration, past projections have shown more accuracy in regards to fertility and, in particular, mortality. In the case of the latter, the long-term steady trend of gains in life expectancies that we are currently observing makes the formulation of assumptions less controversial. Demographers do not agree, however, as to whether a continuation of this trend can be expected in the

[7] In line with what was said earlier, in the perspective of population projections (and not population "forecasts"), a plausible assumption is not one that will necessary materialize, but one that at the time of its conception, suggested a reasonable and realistic evolution given the existing knowledge.

[8] Another aspect known for having an impact on accuracy and documented in the context of this short review is the time horizon. In general, accuracy tends to decrease with the time elapsed since the publication (George et al. 2004).

more distant future. For instance, continuous scientific progress could lead to further gains in life expectancy, but new threats to health, such as obesity, pandemics or antibiotic resistance could result in a stagnation or degradation of life expectancy (Bloom and Canning, 2006).

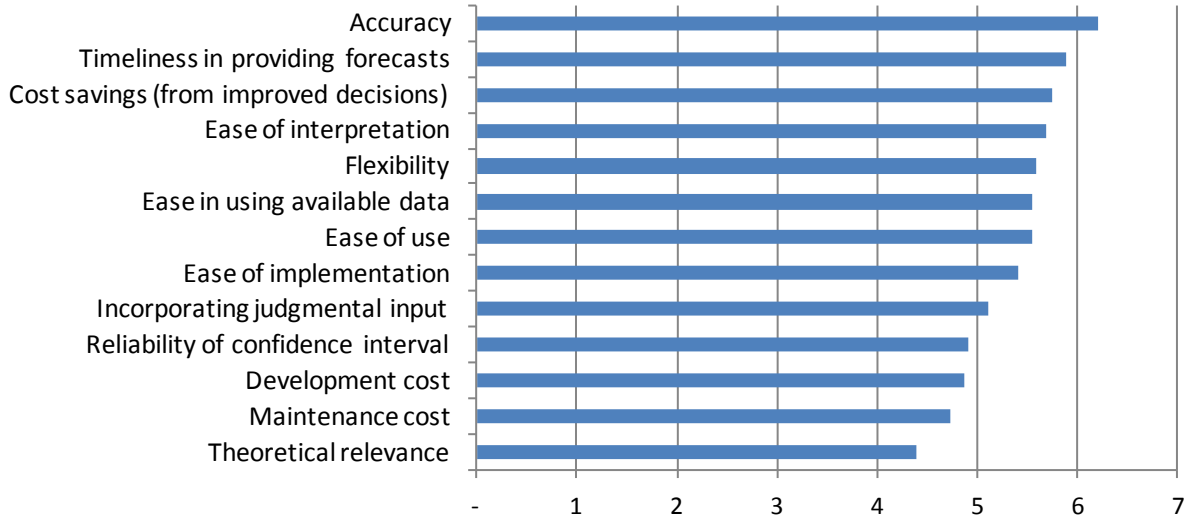
Fertility also exhibited trends that were less volatile than what has been observed for the migration components in the recent past, though to a lesser extent. But changes in fertility remain hard to anticipate and may have a deep impact on the growth and the age structure of the population, like the analysis of the 1972-2001 edition showed. Booth (2006) notes that in regards to fertility forecasting, successes are not common, and that the major difficulty stems from"[...] structural change, seen in the trajectory of the total fertility (quantum), changing age patterns (tempo) and the complex association between the two."

4. The usefulness of population projections

In the end, whether a forecast or a projection, a crucial component of the evaluation is the finality of the exercise or as Romaniuc (2010) puts it, "its usefulness as perceived by its producers and its users". It therefore seems reasonable to ask users which criteria they would use to judge of the quality of projection estimates and their contribution to any decision-making process.

FIGURE 4

Importance of criteria in selecting a forecasting technique



Note: Scale: 1 "unimportant" to 7 "important".
Source: Yokum and Armstrong (1995).

Yokum and Armstrong (1995) surveyed experts in order to assess which criteria were the most important in selecting among forecasting techniques. The respondents were asked to assert the importance of a series of criteria on a scale from one to seven, seven being the most important. Although the survey[9] was not exclusively about demographic forecasts, it provides some interesting insights that can be summarized as follows (see Figure 4):

[9] Questionnaires were sent to 738 experts from 30 countries, among whom 322 replied.

- ‘Accuracy’ is the most important criterion when selecting a forecasting technique, with an average score of 6.2.
- Many other aspects of the forecast were identified as being relatively important, with 8 other criteria recording scores higher than 5.0.
- ‘Timeliness in providing forecasts’ was the second most important criterion, attaining a score of 5.9.
- Other important criteria were ‘Cost savings resulting from improved decisions’, ‘Ease of interpretation’, ‘Flexibility’, ‘Ease in using available data’ and ‘Ease of use’.
- The background of the survey respondent did not dramatically impact the results. One exception is that educators and decision makers gave higher scores to the ‘Ease of use’ than practitioners or researchers.

It is clear from these results that accuracy is an important aspect of quality, but should not be the only criterion. Although not exhaustive by any means, the results suggest many other criteria that should be part of an evaluation of a method, or even a program of projection. Particularly, the adoption of methodologies based on its accuracy power should be weighed against other aspects such as its ease of interpretation, ease of use, and the cost in terms of timeliness.

5. Analytical credibility of the projections

Most people interested in population projections are looking at those in terms of a tool for planning. Their usefulness is not situated in the future, but in the very present. The analytical credibility acknowledged to the estimates at the time of the release is therefore critical (Romaniuc, 2003, 2010). We believe that this analytical credibility depends of essentially two factors: the plausibility of the assumptions and the validity of the methodology.

5.1 Plausibility of assumptions

As per Romaniuc (2003), it is the plausibility of the assumptions, more than the outcomes that should be evaluated. Results from a recent survey show that most statistical agencies see room for improvement in the assumption building process. In the context of the *MicMac* project funded by the European Union, a questionnaire designed by the International Institute for applied Systems Analysis (IIASA) was sent by Eurostat to 25 statistical agencies in order to collect information on the process followed during the projection of the most recent population projections (Prommer and Wilson, 2006). The results are very interesting:

- Every agency that replied to the questionnaire agreed that there is need for improvement in the methods used for assumption building;
- The most widely chosen improvement options were related to increased interactions among agencies and with experts;
- 11 of 21 offices discussed assumptions internally before reviewing them with experts and 5 proposed a baseline forecast that was then discussed within the office;
- In total, 76% of the national offices involved experts to some degree, with 16 agencies involving more than 10 experts;

- Divergence between historical values and past official projections was analysed by 19 of 21 agencies;

For Lutz (2009), the results of the questionnaire indicate very clearly what to do in order to improve the assumption building process. He summarizes it this way: “Have a more systematic review of the substantive arguments behind the assumptions in the form of a structured interaction with the demographic research community which also facilitates the involvement of more experts.”

Statistics Canada, like most statistical agencies, builds assumptions based on a thorough analysis of recent demographic trends, comparing them in balance with longer-term historical trends. We initiate, before each release, a consultation process in which many experts are invited to evaluate and comment the assumptions, including statistical representatives of the provinces and territories, members from the external advisory committee on demography and experts from other federal departments (Office the chief Actuary of Canada, Citizenship and Immigration Canada).

Compared to Statistics Canada, many agencies follow a more structured methodology in order to consult with experts. For instance, the INSEE in France (e.g. see Blanpain et Chardon, 2010) and the ONS in United Kingdom (e.g. see Shaw, 2008) sent questionnaires to a small group of experts, asking them to report on various aspects of the growth components of the population and to provide their own estimates for the future levels of these components. A noteworthy initiative is the questionnaire designed by Wolfgang Lutz and his colleagues at IIASA and implemented by the Office for National Statistics (ONS) in United Kingdom in a pilot study in 2007 (Shaw, 2008). The questionnaire asks the expert to assess the importance and validity of a series of alternative arguments in regards to the various components of population growth. Lutz (2009) called this method an "argument-based approach to defining assumptions".

Keyfitz (1982) argued that user confidence in forecasts comes in part from the fact that it is expected that the demographer who carried them out are knowledgeable and abreast of the population literature. He wrote that even though the knowledge in the field of demography is not directly usable in forecasting, “we trust their results because at the many points where judgment enters, the demographer’s intuition has been sharpened by exposure to the literature.” If this is true, consulting with experts in the field is certainly one optimal way to increase knowledge and exposure to the literature.

Following the initiatives taken by the ONS, Statistics Canada intends to expand the consultation leading to its assumption building process in its next population projections edition by involving a higher number of experts and using a questionnaire. This initiative was well received by the members of the Advisory Committee on Demographic Statistics and Studies when consulted on this possibility in 2011. At this point, it is still under investigation what type of questionnaire will be used and how many experts will be involved. We feel that a more formal consultation with experts will enhance the neutrality of the assumption building process while adding greater insights. It will also influence how we ‘frame’ our scenarios. For instance, rather than merely reflecting the most recent demographic trends, a medium

growth scenario could be seen as the one reflecting the majority of opinions within the community of experts consulted.[10]

5.2 Validity of the methodology

It is clear that the adopted methodology has an important impact on the results and their credibility. Keyfitz (1972) suggests judging the projection results by comparing them with more naive sources of prediction. Mulder (2002) for instance, compares projection estimates with observed data a posteriori but also with results projected simply by extrapolating growth rates recorded in the base year of the projection, or the crude rates of the various components of the growth.

Statistics Canada's official national population projections are produced using a cohort-component model which is the most widely used in the world. Its main advantage is that each component of the population growth is projected separately, allowing for the elaboration of specific assumptions that are consistent with the knowledge we have for each of them (O'Neill et al. 2001). The model used by Statistics Canada was recently improved by allowing interactions between each component.

The validity of the cohort-component model is well recognized. However, the issue of validity also applies to the several methodologies used in order to build the parameters fed into the cohort component model, that is, once the assumptions are selected. As part of the review process of the population projections at Statistics Canada, we have recently initiated reviews of the methodologies used for projecting fertility and internal migration. Although it is often difficult to reconcile the many refinements and advancements recently proposed in the literature with the operational requirements of producing population projections, including considerations provided in the previous section such as timeliness, ease of interpretation and flexibility, this work is essential to ensure that we question our current methodologies, make sure they are adapted to the task at hand, integrate the latest developments and, in a more general way, sustain the credibility of the model.

6. Conclusion

The goal of this paper was to share some of the findings of a review of the population projections program at Statistics Canada. It also intended to act as a guide to users of projections of the Canadian population, documenting how Statistics Canada approaches the challenge of projecting the population, describing what the most important challenges are in doing so, and outlining very briefly how accurate past projection exercises were.

Reviewing the accuracy of past population projection is valuable because it clarifies what reasonable expectations should be in regards to their uncertainty. But such an evaluation requires some important caution remarks. Success in projecting the future with accuracy is not only a matter of technique and assumptions; it is also largely a function of how stable the components of population change have been and will be in the years to follow. This review found that past projections tend not to foresee changes, echoing a finding by the U.S Census Bureau (see Mulder, 2002). As Le Bras (2008) wrote: "Unavoidably, the projection assumptions reflect the spirit of the era in which they are framed. To them are transmitted

[10] It should be noted that expert surveys have some downsides as well, such as the difficulty to achieve consensus, possible bias from strong opinions, and the fact that most demographers are not experts in all facets of population growth but rather specialize in a single area, just to name a few.

its hopes and its fears." Failure to anticipate the continuous decline in fertility in the 1980s and the rise in the immigration levels that occurred in the 1990s are examples of this. We could, at the present time, miss the sociological context in which past projections were made, but it does not mean that these projections were not perfectly plausible propositions at that time, nor useful. Besides, population projections, unlike population forecast, were never meant to predict the future population growth and its composition, but rather to serve as planning or policy making tools. Used as such, population projections may trigger changes that were unexpected, and therefore become the cause of their "inaccuracy".

It is hopefully clear at this point, however, that accuracy must not be the only factor to consider in the evaluation of population projections. In the end, as Isserman (1992) stated: "Projections are a success if they stimulate thought and action oriented toward creating a more desirable future". In other words, the utility of population projection is not in the future, it is in the present, as a tool to raise questions about the future. We could add that this will happen only in a context in which considerable credibility is given to the projections. In order for this to happen, we need to make ourselves constantly open to reviewing our past successes and errors, our methodologies and to increasing our knowledge of the demographic processes.

Bibliography

BEAUJOT, R. (2000) "Canada's Demographic Future: Some Reflections on Projection Assumptions", Office of the Chief Actuary, Canada Pension Plan, Seminar on Demographic and Economic Perspectives of Canada: Years 2000 to 2050, Ottawa.

BERNARD, A., R. FINNIE AND B.SAINT-JEAN. (2008) "Mobilité interprovinciale et gains", *L'emploi et le revenu en perspective*, vol. 9, no 10, catalogue no. 75-001, pp. 16-28.

BLANPAIN N. AND O. CHARDON, (2010) "Projections de population 2007-2060 pour la France métropolitaine", Document de Travail, n° F1008, Insee. Available at: http://insee.fr/fr/publications-et-services/docs_doc_travail/docf1008.pdf.

BLOOM D.E. AND D.CANNING (2006) "Global Demography: Fact, Force and Future", RBA Annual Conference Volume, in: Christopher Kent, Anna Park & Daniel Rees (ed.), Demography and Financial Markets Reserve Bank of Australia. Available at : http://www.hsph.harvard.edu/pgda/WorkingPapers/2006/PGDA_WP_14.pdf.

BOOTH, H. (2006) "Demographic Forecasting: 1980 to 2005 in Review", *International Journal of Forecasting*, 22, pp. 547-581.

COULOMBE, S. (2006) "Internal Migration, Asymmetric Shocks, and Interprovincial Economic Adjustments in Canada", *International Regional Science Review*, vol. 29, no 2, pp. 199-223.

DE BEER, J. (2000) "Dealing with Uncertainty in Population Forecasting", Department of population, Statistics Netherlands, 40 p. Available at: http://www.cbs.nl/nr/rdonlyres/7dc466f9-fe4c-48dc-be90-30216b697548/0/dealingwithuncertainty.pdf.

DION, P., ET S. COULOMBE. (2008) "Portrait de la mobilité des Canadiens en 2006 : trajectoires et caractéristiques des migrants", *Rapport sur l'état de la population du Canada, 2005 et 2006*, Ottawa, Statistique Canada, catalogue no. 91-209.

GEORGE, M. V. (2001) "Population Forecasting in Canada: Conceptual and Methodological Developments", *Canadian Studies in Population*, Vol. 28(1), pp. 111-154.

GEORGE, M.V., S. K. SMITH, D. A. SWANSON AND J. TAYMAN. (2004) "Population Projections", in *The Methods and Materials of Demography*, Second Edition, Elsevier Science, pp. 561-601.

HENRY, L. (1972) "Passé, présent et avenir en démographie", *Population* (French Edition), 27e Année, No. 3, pp. 383-396.

ISSERMAN, A. (1992) "The Right People, the Right Rates: Making Population Estimates and Forecasts with an Interregional Cohort-Component Model", *Research Paper 9216*, West Virginia University. Available at: http://www.rri.wvu.edu/pdffiles/wp9216.pdf.

KEYFITZ, N. (1972) "On Future Population", *Journal of the American Statistical Association*, Vol. 67, No. 338, pp. 347-363.

KEYFITZ, N. (1981) "The Limits of Population Forecasting", *Population and Development Review*, Vol. 7, No. 4, pp. 579-593.

KEYFITZ, N. (1982) "Can Knowledge Improve Forecasts?", *Population and Development Review*, Vol. 8, No. 44, pp. 729-751.

KEYFITZ, N. AND H. CASWELL (2005) Applied Mathematical Demography, Third Edition, Springer.

LE BRAS, H. (2008) The Nature of Demography, Princeton University Press, New Jersey, 362 p.

LUTZ, W. (2009) "Toward a Systematic, Argument-Based Approach to Defining Assumptions for Population Projections", *Interim Report IR-09-037*, International Institute for Applied Systems Analysis, 28 p.

MULDER, T. J., (2002) "Accuracy of the U.S. Census Bureau National Population Projections and Their respective Components of Change", *Population Division Working Paper Series*, No. 50.

O'NEILL, B., D. BALK, M. BRICKMAN AND M. EZRA (2001) "A guide to Global Population Projections", *Demographic research*, Volume 4, Max Planck Institute, pp. 203-288.

PRESTON, S. H., P. HEUVELINE AND M. GUILLOT (2001) Demography, Measuring and Modeling Population Processes, Oxford: Blackwell.

PROMMER, I. AND C. WILSON. (2006) "An Analytical Summary of the Current Practices of Definition of Assumption Making in Population Projections". Deliverable D14. Report prepared for the European Commission 6th Framework Project "Bridging the Micro-Macro Gap in Population Forecasting" (MicMac), Laxenburg, Austria: International Institute for Applied Systems Analysis. Available at: http://www.nidi.nl/Content/NIDI/output/micmac/micmac-d14.pdf

ROMANIUC, A. (2003) "Reflection on Population Forecasting: From Predictions to Prospective Analysis", *Canadian Studies in Population*, Vol. 30(1), pp. 35-50.

ROMANIUC, A. (2010) "Population forecasting: epistemological considerations", *Genus*, 66:1.

SHAW, C. (2008) "The National Population Projections Expert Advisory Group: Results from a Questionnaire about Future Trends in Fertility, Mortality and Migration", *Population Trends 134*, Office for National Statistics.

SMITH, S. K. (1986) "Accounting for Migration in Cohort-Component Projections of State and Local Populations", *Demography*, 23:1, pp. 127-135.

STATISTICS CANADA, (2005) "Population Projections for Canada, Provinces and Territories 2005-2031", catalogue no. 91-520-X, Ottawa.

STATISTICS CANADA, (2001) "Population Projections for Canada, Provinces and Territories 2000-2026", catalogue no. 91-520-X, Ottawa.

STATISTICS CANADA, (1994) "Population Projections for Canada, Provinces and Territories 1993-2016", catalogue no. 91-520-X, Ottawa.

STATISTICS CANADA, (1990) "Population Projections for Canada, Provinces and Territories 1989-2011", catalogue no. 91-520-X, Ottawa.

STATISTICS CANADA, (1985) "Population Projections for Canada, Provinces and Territories 1984-2006", catalogue no. 91-520-X, Ottawa.

STATISTICS CANADA, (1974) "Population Projections for Canada and the Provinces, 1972-2001", Catalogue 91-514 Occasional, Ottawa.

STATISTICS NEW ZEALAND (2008) "How Accurate are Population Projections? An Evaluation of Statistics New Zealand Population Projections, 1991–2006". Wellington: Statistics New Zealand.

TAYMAN, J. AND D.A. SWANSON (1996) "On the Utility of Population Projections", *Demography*, 33:4, pp. 523-528.

U.S. CENSUS BUREAU. (Hollmann, F.W., T.J. Mulder and J.E. Kallan). (2000) "Methodology and Assumptions for the Population Projections of the United States: 1999 to 2100", *Population Division Working Paper no. 38*, Washington D.C.

WILSON, T. AND P. REES. (2005) "Recent Developments in Population Projection Methodology: A Review", *Population, Space and Place*, 11, pp. 337-360.

YOKUM, J. THOMAS, AND J. S. ARMSTRONG, (1995) "Beyond Accuracy: Comparison of Criteria Used to Select Forecasting Methods", *International Journal of Forecasting*, 11, 591-597.