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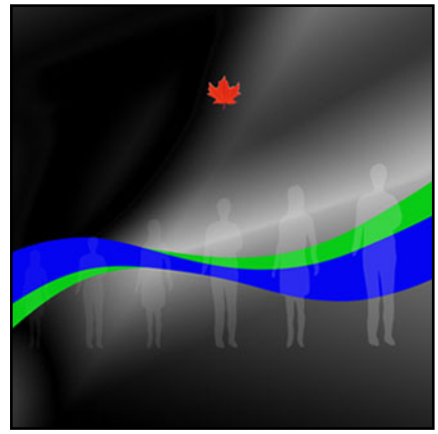
Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038): Technical Report on Methodology and Assumptions



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. not available for any reference period
.. not available for a specific reference period
... not applicable
0 true zero or a value rounded to zero
0^s value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p} preliminary
^{r} revised
x suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E} use with caution
F too unreliable to be published
* significantly different from reference category ($p < 0.05$)

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Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038)

Technical Report on Methodology and Assumptions

Report written by

Nora Bohnert, Jonathan Chagnon, Simon Coulombe, Patrice Dion and Laurent Martel

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Preface

The methods used to project the population are constantly evolving. Following the publication of the 2009 to 2036 edition, the Demographic Analysis and Cohort-Component Projections Section of Statistics Canada's Demography Division conducted a review of its methods while considering the most recent developments in the field of population projections. The review led to a number of changes in methods and the introduction of many innovations. Hence, it was a good time to publish a separate, more detailed report describing the methods used to calculate the projection parameters and develop the assumptions.

Introduction

This report describes the methodology used to calculate the projection parameters and develop the various projection assumptions for the Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038). Previously combined with the analysis and data tables in a single publication (Statistics Canada Catalogue no. 91-520-X), the description of the methods and assumptions is presented here in a separate, more detailed document.

This change is especially opportune, since this edition of the population projections contains many innovations, including the following:

- a more extensive consultation with demography experts;
- a new method of projecting fertility;
- distinct fertility parameters for non-permanent residents;
- a new method of projecting interprovincial migration;
- an enhanced method of projecting mortality;
- strategies for taking account of the residual deviation component present in intercensal estimates.

The report contains eight chapters, which provide a detailed description of the methods and various analyses of the components of population growth and the factors likely to affect their evolution in the years ahead. Chapter 1 describes Statistics Canada's cohort-component projection model. Chapter 2 outlines a new initiative: the *Opinion Survey on Future Demographic Trends*. This survey is part of a broader consultation process designed to incorporate more expert opinion into the assumption development process. The following six chapters cover the various components of population growth, one by one, in the following order: fertility, mortality, immigration, emigration, non-permanent residents and interprovincial migration. The main report, containing the projection results (Statistics Canada Catalogue no. 91-520-X), includes a summary of the projection assumptions and scenarios.

Chapter 1: Statistics Canada's cohort-component population projection model

By Patrice Dion

Introduction

This chapter describes Statistics Canada's cohort-component projection model in its entirety. The first section outlines the general premises behind the model and presents a brief overview of its history. The second section describes the model used by Statistics Canada and its specificities, including the relationship between the population estimates and population projections programs, and how the latter can be seen as an extension of the former. The final section contains a more detailed analysis of the algorithm used to transform the parameters into projections.

The cohort-component model

Genesis of the model

The idea of creating population projections became popular in the 18th century, in a context where Europe was experiencing some serious social and epidemiological crises. The first population projections consisted of extrapolations of the total population. At that time, the main focus was on discovering a universal law of population growth, a 'universal multiplier' that obeyed certain laws of nature. For example, at the end of the 18th century, Malthus suggested that populations grow exponentially, resulting in an imbalance with available resources, which exhibit linear growth.

Up until the beginning of the 20th century, mortality and fertility, though recognized as having an impact on population growth, were not taken into account in population projection calculations. It was only later, and gradually, that the cohort-component method was developed, and the first of these projections were published early in the 20th century. It was an important step for demography, providing a greater understanding of population dynamics and bringing together several fields of knowledge to form classical demography as it is known today (Le Bras 2008).

The first component-based projections included mortality rates that varied by age, but the number of births was set in advance, regardless of the population. An important development took place in 1924, with the publication of Alfred Lotka's Elements of Physical Biology. By adding women's probabilities of giving birth to the life table, Lotka introduced the idea that women could have fertility rates that were a function of their age. He thus demonstrated the possibility of producing projections using variable mortality and fertility rates that could be applied to cohorts.[1]

The way in which migration was handled in the first cohort-component projection models remained problematic, however. Those models usually employed a uniregional perspective, in which each region was projected independently of the others. When considered, migration was incorporated using predetermined net migration counts or rates. Hence, the advantages of using age-specific fertility and mortality rates, applied directly to the populations at risk, were absent for migration. It was not until the mid-1960s, when a new paradigm in demography, known as multiregional demography, began to emerge, that projection models began to treat regions as a system composed of a number

1. For more details on the genesis of the cohort-component projection model, see Le Bras (2008). The information in this paragraph is largely based on that source.

of interdependent populations connected by migration flows (Rogers 2006). Through the use of matrix operations, multiregional projection models make it possible to incorporate specific rates of migration from each of the system's regions to every other region.[2, 3]

Cohort-component projection models constitute a considerable advance over models which extrapolate the total population because they associate quantitative measures of mortality and fertility with population growth and its composition, and because they permit the development of specific assumptions for each component which take advantage of what is known about it (O'Neill et al. 2001). Rather than attempting to predict population growth, the goal is to forecast changes in fertility and mortality.

Statistics Canada's cohort-component model

Today, most statistical agencies produce their official projections with the cohort-component model. At Statistics Canada, the model was first used to make 'official projections' in the 1970s, when population projections became an important activity at Statistics Canada.[4] Since the first series was released in 1974, there have been seven other series which have generally followed the cycle of population censuses.[5] The model has evolved over the years. For example, the purely multiregional version of the model did not appear until the 1984/2006 edition.

Statistics Canada's cohort-component model was developed to extend the data series of Statistics Canada's Population Estimates Program (PEP) further in time. Thus, the provincial estimation model and the provincial projection model are accounting models that have the same components:

$$\begin{aligned} \textit{Population}_{t+1} = {} & \textit{Population}_{t} + \textit{Births}_{t,\,t+1} - \textit{Deaths}_{t,\,t+1} + \textit{Immigrants}_{t,\,t+1} - \textit{Emigrants}_{t,\,t+1} \\ & - \textit{Net temporary emigrants}_{t,\,t+1} + \textit{Returning emigrants}_{t,\,t+1} \\ & + \textit{Net non-permanent residents}_{t,\,t+1} + \textit{Net interprovincial migration}_{t,\,t+1} \end{aligned}$$

In the context of the projections, each scenario makes assumptions about the future evolution of each of these components,[6] separately for each province and territory. In fact, Statistics Canada uses a 'hybrid bottom-up' approach: 'bottom-up' because the projected values for Canada are the sum of the individual projections for the provinces and territories, with no projection produced at the Canada level, and 'hybrid' because the assumptions are often developed initially at the national level. In other words, the assumptions for each province and territory are derived from assumptions first developed at the national level.

2. For more details on the genesis of the multiregional model, see Rogers (2006). The information in this paragraph is largely based on that source.
3. However, unrestricted use of the multiregional model results in certain difficulties. This is discussed in the chapter on interprovincial migration of this report, and a solution is proposed.
4. The Dominion Bureau of Statistics produced projections before this, however, they were not intended for official publication (George 2001).
5. Note that the cohort-component projections are not the only projections produced by Statistics Canada. Since 2005, Statistics Canada has published a series of projections for particular populations using a microsimulation projection model. This additional projection tool currently enables Statistics Canada to meet the varied needs of population projection users, especially for the production of highly detailed projections. Microsimulation is better suited to coherent projections for a large number of characteristics of the population. It produces results that cannot be achieved with the component model. Microsimulation projections are usually requested and funded by other federal government departments. For analyses based on microsimulation models, see Statistics Canada (2010; 2012b).
6. For a description of these components in the Population Estimates Program (PEP), see Statistics Canada (2012a).

Relationship between the Population Estimates Program and the projections

As noted above, the PEP data are the reference universe and the primary source of population projections in the context of the cohort-component model. A brief description of the various series produced by the PEP is necessary in order to understand the nature of the relationship between Statistics Canada's population estimates and population projections.

Data sources for the projections

To meet data timeliness and accuracy requirements, the PEP produces more than one series of population estimates for the same reference date, though it does so at different times. Postcensal estimates are produced using data from the most recent census adjusted for census net undercoverage (CNU), including an adjustment for incompletely enumerated Indian reserves. There are three series of postcensal estimates. Preliminary postcensal estimates are available shortly after the reference date, but they are derived in part through certain assumptions because there are no data for several components. Updated postcensal estimates and final postcensal estimates are produced one year and two years, respectively, after the preliminary postcensal estimates. Though not as timely, these series include data that were unavailable when the preliminary estimates were produced, and therefore they are usually more accurate. In general, however, the accuracy of postcensal data tends to diminish as they get further away from the date of the last census.

The accuracy of postcensal estimates can be estimated with data from each new census as well as the results of coverage studies conducted following the census. The difference between the postcensal population estimates on Census Day and the population enumerated in that census (after adjustment for CNU (including incompletely enumerated Indian reserves)) is referred to as the error of closure. It stems from errors in the components of population growth during the period between two censuses and from precision errors in measuring census coverage, mainly sampling errors. When a new base population is calculated following a census, an additional series of estimates is produced, the intercensal estimates, which revise the final postcensal estimates to take the error of closure into account.[7] This revision consists of adding a component known as the residual deviation, which includes the error of closure, while the other components of population growth remain the same as in the final postcensal estimates.

Thus, each series of estimates involves a degree of compromise between data timeliness and accuracy. The starting point for the population projections in this edition is the population of Canada on July 1, 2013, according to the preliminary postcensal estimates. It is preferable to use data that are as timely as possible—rather than data that are more 'exact' but less up to date—in order to take account of the latest demographic trends.

Nevertheless, other considerations apply in the calculation of the projection parameters when the latter are based on data from population estimates. First, it makes sense in this context to favour estimates that are considered more accurate. Second, postcensal estimates are historically consistent only over a five-year period, since they start from a new base following each census. For these two reasons, intercensal estimates are the ultimate projection reference series for the development of assumptions about the components of growth. In fact, when postcensal estimate are used, it is only because the intercensal series are not yet available.

However, this does present a conundrum: in intercensal estimates, the demographic equation is balanced only if the residual component is included, but it is both undesirable and very difficult to project that component because of its nature and historical trends. Although the error of closure has only a minor

7. An adjustment is produced to make this error accurate for the reference date of the population estimates and not for the date of the census.

impact on the projections at the national level, the difference can be more significant at the provincial/territorial level.[8] Moreover, unlike the PEP data, a projection series does not have the luxury of revision. For this reason, strategies are introduced in this edition to take account of the residual component in the projections. These strategies consist of analyzing the sources of the residual deviation so that whenever possible, it can be distributed among the other demographic components. The goal of these efforts is to minimize the residual deviation and to increase the accuracy of the other components of population growth. Two different approaches are used, one for the immigration component and the other for the emigration component. They are described in detail in the relevant chapters of this report.

Projection assumptions

The connections between the projections and the PEP data affect not only the cohort-component model's structure but also the way in which the projection assumptions are designed. The assumptions always contain, in one way or another, a function that remains constant. If we take the mortality component as an example, an assumption might be that in the short term, the number of deaths will remain constant in the future. However, an assumption that mortality risks will remain constant is more likely to contain constant mortality rates or death probabilities. Since it is the future of age-sex cohorts that is being projected, those mortality rates or death probabilities should be disaggregated by age and sex, so that both the size and the structure of the populations at risk can be taken into account. With rare exceptions, assumptions are developed in the form of rates rather than probabilities, because population estimates and vital statistics are better suited to the calculation of rates:[9] the measurement of demographic events (i.e., the components) is not associated with a population at risk, which is required for the calculation of probabilities. If we go back to the mortality example, the deaths counted during a year may include persons who were in Canada at the beginning of the year, as well as immigrants who arrived during the year. Thus, the various components of population growth affect the population at risk simultaneously, which makes it impossible to determine an exact number of persons at risk. However, it is possible to find a suitable denominator by estimating the average number of person-years, which combines the number of persons (at a location) and the duration of their presence during a year.[10] For example, a person who was in Canada for six months will theoretically contribute 0.5 person-years to the denominator. The number of person-years is usually estimated by taking the average of the population at the beginning of the period and the population at the end of the period (one year later).

8. At the Canada level, the error of closure as a proportion of the enumerated population adjusted for CNU was 0.16% in 2001, 0.14% in 2006 and 0.50% in 2011. It is generally larger at the provincial/territorial level, in particular because of the higher variability associated with the estimates of interprovincial migration (Statistics Canada 2012a).

9. More specifically, in the demographic components of the PEP, the events associated with age x during a one-year period from t to $t+1$ actually relate to individuals aged x in year t, who will all be aged $x+1$ in year $t+1$. The resulting rates are so-called 'prospective' rates.

10. In this case, we have annualized rates.

Algorithm of the model

In addition to the reasons mentioned above, the use of rates has another advantage: the rates for the various demographic events can be added together (unlike probabilities) to take the interaction between events into account instead of applying each event in a predetermined order. The projection model sums all the rates and combines them to form out-migration rates in what is known as a transition matrix. The transition matrix contains one row and one column for each combination of age, sex and province/territory. More specifically, the (net) out-migration rates are on the diagonal:

$$M_{a,s}(i,i) = D_{r,a,s} - I_{r,a,s} + E_{r,a,s} - RE_{r,a,s} + \sum_{z \neq i} MI_{z,a,s} \quad 1.1$$

A given cell located on the diagonal of transition matrix M applies to a specific region and is therefore composed of all the rates for that region: mortality rate D, immigration rate I, total emigration rate E, return emigration rate RE, and total rate of out-migration from the region to other regions MI. The indexes r, a and s refer to region, age and sex respectively. Note that at this stage, non-permanent residents (NPRs) are excluded from the calculation.[11] The cells that are not on the diagonal are used exclusively for internal migration. The values in these cells are negative, representing rates of interregional migration, from each region to every other region:

$$M_{a,s}(i,j) = -\sum\nolimits_{z \neq i} MI_{j,i,a,s} \quad 1.2$$

The transition rate matrices are then transformed into survival probability matrices using matrix operations:

$$S_{a,s} = \left(I - 0.5M_{a,s}\right)\left(I + 0.5M_{a,s}\right)^{-1} \quad 1.3$$

where S is the survival probability and I is the identity matrix. The projected population for year $t+1$ is derived by multiplying the population of the previous year t, excluding NPRs, by the probabilities in matrix S:

$$P^{t+1}_{a+1,s} = S_{a,s} * \left(P^{t}_{a,s} - NPR^{t}_{a,s}\right) \quad 1.4$$

where $P^{t}_{a,s}$ is the population vector at the beginning of the period, $P^{t+1}_{a+1,s}$ is the population vector at the end of the period, and $NPR^{t}_{a,s}$ is the population vector for non-permanent residents present at the beginning of the period.

However, the model does not rule out the use of parameters in the form of ratios or counts. In the case of ratios, for a given component, they are first transformed into counts:

$$Cnt_{r,a,s} = \left[P^{t}_{r,a,s} - NPR^{t}_{r,a,s}\right] * Q_{r,a,s} \quad 1.5$$

where $Q_{r,a,s}$ is the vector of prospective ratios.

11. In fact, NPRs are not subject to the risks of dying or emigrating, and their number is determined only by the annual net counts. For more details, see Chapter 7.

Whether they are derived from ratios or not, the counts are summed, and the net result is multiplied by the probability of survival over half the period between *t* and *t+1* and added to the population at time *t*, which is calculated as shown above using components whose parameters consist of rates:

$$P_{a+1,s}^{t+1} = S_{a,s} * \left(P_{a,s}^{t} - NPR_{a,s}^{t}\right) + S'_{a,s} Cnt_{a,s}^{net} \qquad 1.6$$

where $Cnt_{a,s}^{net}$ is the net value of the components expressed as counts, and S', the probability of survival over half the period, is calculated as follows:

$$S'_{a,s} = \left(1 + 0.5M_{a,s}\right)^{-1} \qquad 1.7$$

Then the number of non-permanent residents at time *t+1* is added at the end:

$$P_{a+1,s}^{t+1} = S_{a,s} * \left(P_{a,s}^{t} - NPR_{a,s}^{t}\right) + S'_{a,s} Cnt_{a,s}^{net} + NPR_{a+1,s}^{t+1} \qquad 1.8$$

The last step is to include the births for the permanent resident (PR) population and the non-permanent resident population.[12] If they are in the form of counts, the births are simply added.

If they are fertility rates, the rates are multiplied by the estimated average population between *t* and *t+1*. In the case of permanent residents, for a given region, total births are calculated as follows:

$$N^{PR} = \sum_{x=10}^{54} F_x^{PR} * PRavg_{x,fem}^{t} \qquad 1.9$$

where N^{PR} are the total births for the permanent resident population, F_x^{PR} are the age-specific fertility rates for the PRs and $PRavg_{x,fem}^{t}$ is the average PR population at the beginning of the period, estimated as follows:

$$PRavg_{x,fem}^{t} = \left(P_{x,fem}^{t} - NPR_{x,fem}^{t} + P_{x+1,fem}^{t+1} - NPR_{x+1,fem}^{t+1}\right)/2 \qquad 1.10$$

NPR births are estimated in much the same way as PR births:

$$N^{NPR} = \sum_{x=10}^{54} F_x^{NPR} * NPRavg_{x,fem}^{t} \qquad 1.11$$

where $NPRavg_{x,fem}^{t}$ is calculated as follows:

$$NPRavg_{x,fem}^{t} = \left(NPR_{x,fem}^{t} + NPR_{x+1,fem}^{t+1}\right)/2 \qquad 1.12$$

12. The capacity to incorporate distinct fertility rates by residence status is one of the innovations in the present edition. For more details, see Chapter 3.

Lastly, the number of births of each sex is calculated using the sex ratio (or masculinity ratio) specified in advance for the projection.[13] For example, for the PR population in a given region, births of boys and girls will be calculated as follows:

$$N(\text{males}) = N(total) * \frac{mr}{100 + mr} \quad 1.13$$

$$N(\text{females}) = N(total) * \frac{100}{100 + mr} \quad 1.14$$

Conclusion

The cohort-component projection model has numerous advantages. Its relative simplicity and therefore transparency aid the involvement of experts in the consultation processes, the communication of assumptions to users and the reproduction of results. Despite its simplicity, the model is highly effective at producing plausible projections. In this regard, the innovations included in this edition of the projections enhance the quality, transparency and relevance of Statistics Canada's National Projections Program.

The cohort-component projection model is also used to produce customized projections for specific regions and/or based on particular assumptions. The improvements made in the program in recent years increase Statistics Canada's capacity to respond quickly to these requests.

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13. The ratio is 105 males to 100 females in the present edition.

Chapter 2: Opinion Survey on Future Demographic Trends

By Nora Bohnert

Introduction

The *Opinion Survey on Future Demographic Trends* is a new tool developed by Statistics Canada to gather inputs from the community of experts in demography and population studies about their views on future demographic trends. Although Statistics Canada already utilized some mechanisms allowing the assumptions and methods to be externally commented and reviewed, the motivation for the implementation of this tool was the desire for greater input from experts through a more formal process, the results of which could improve the plausibility and credibility of projection assumptions.[1]

There is, in fact, strong evidence of the benefits of combining the views of a large group of informed individuals: across a number of disciplines, it is found that simply averaging the responses of many individuals can reduce error by up to 15% to 20% (Silver 2012).[2] Moreover, consulting with experts in the field is an optimal way to increase exposure to the literature and developments in demography. As Keyfitz (1982) argued, user confidence in forecasts comes in part from the fact that it is expected that the demographers who carried them out are knowledgeable and abreast of the population literature.

Examples from other statistical agencies

The conception of the survey started with an examination of the approaches taken by other agencies in this regard. The design and scope of the surveys utilized by other statistical agencies were found to vary depending on the associated objectives.

The British Office for National Statistics (ONS), for example, has organized an expert advisory panel with which to consult on each update of their population projections since the 2004 edition (Shaw 2008). The panel is small in size, consisting of approximately 10 scholars. Panel members respond to a short questionnaire which asks them to provide future estimates of various demographic indicators, including 67% confidence intervals. Additionally, the ONS meets with the expert panel in order to have an informed discussion about the long-term assumptions, a summary of which is eventually published.[3] The role of the expert panel is strictly advisory and all final decisions on the projection assumptions remain with the ONS. The ONS note that the goal of the panel consultation is not to achieve consensus, but rather to hear the full range of views on the key assumptions. The expert advisory panel is now considered to be an integral part of the Office's assumption-setting process.

France's statistical agency, l'Institut National de la Statistique et des Études Économiques (INSEE), has also conducted an expert survey as part of their most recent population projections (Blanpain and Chardon 2009). INSEE surveyed 22 national and international demography experts. The questionnaire asked respondents to provide estimates for low, central and high hypotheses for each component to a confidence level of 90%, and also to comment on their chosen values, for instance, how quickly they expect those values to be obtained. Respondents were also asked to what degree they agreed with the agency's previous projection assumptions, methodology and communication of results.

1. This desire is shared by many statistical agencies, as indicated by a recent survey of European statistical agencies regarding their population projection programs (Prommer and Wilson 2006).
2. Under the condition that the forecasts are made independently.
3. See also Office for National Statistics (2007; 2009a; 2009b; 2011; 2012).

A final example, quite ambitious in scope, comes from the International Institute for Applied Systems Analysis (IIASA), based out of Austria. IIASA has recently concluded a large-scale expert survey using what the agency refers to as an 'argument-based approach' (Lutz 2009). The objective of the questionnaire is to assess the validity and importance of a series of arguments regarding future demographic trends. It is structured around a set of major 'forces' which could potentially shape future levels of fertility, mortality and migration. Within each force, respondents are asked whether they think a given argument is correct or incorrect (its validity), and, if the argument did prove to be correct, how much of an impact it would have on the demographic variable (its importance), and whether that impact would be positive or negative. Invitations to participate in this exercise were sent to members of major international population associations. Around 550 demography experts from around the world submitted responses. As of the time of writing of this report, IIASA is still in the process of analyzing the results of this exercise. A modified version of this argument-based questionnaire has also been utilized by the ONS in recent years as part of their expert panel advisory process (ONS 2011).

Survey objectives and design

The approaches to expert consultation reviewed above vary in many aspects: the number of experts consulted, the backgrounds of those experts, the intensity of expert involvement as well as the topics on which experts are expected to provide input. It was therefore necessary to elaborate which objectives were most important, in terms of expert consultation, for the purposes of Statistics Canada's National Population Projections Program. The key objectives were determined to be:

- Obtaining a range of views from Canadian demographers regarding future levels of fertility, mortality and immigration at the Canada level:

  Given that the population projections always contain several different projection scenarios (as per the agency's *Policy on Estimates with Future Reference Dates*), it was considered important to obtain a variety of views from a large number of experts. In other words, arriving at a consensus of views was not the objective of this process but rather to survey the range of viewpoints held by professionals working in the field of demography.

  Notably, the core components of fertility, mortality and immigration were the focus of the questionnaire, even though there are other components of varying importance which factor into the population projections, including non-permanent residents, emigration, return emigration and interprovincial migration.[4] In addition to being the major components of population change, they are the components that are the most well-known and studied by external scholars.

- Obtaining both quantitative estimates and qualitative comments from respondents:

  It was considered desirable to obtain not only quantitative estimates of future demographic indicators, but perhaps more importantly, a justification from respondents as to what factors and trends they considered when forming a given estimate. Emphasis was placed on giving respondents the option to elaborate on the trends and factors that they consider most influential, in an open-ended manner and in as much detail as required. With this open-ended comment approach, respondents could also provide feedback on other aspects of the projections not directly addressed in the survey (methods, presentation of findings, other projection components such as emigration, for example) and on the survey itself, opening up the possibility of obtaining useful suggestions to improve future editions of the projections.

4. While interprovincial migration is particularly important in the case of the population growth of certain provinces, formulating a question regarding the future levels of this component would be quite cumbersome, and therefore respondents were instead given the option to comment qualitatively in as much detail as desired on this component.

- Relatively low burden for respondents:

  It was determined that a relatively short questionnaire, followed by a review and discussion of the survey findings with Statistics Canada's External Advisory Committee on Demographic Statistics and Studies,[5] would best meet the timelines and resources dedicated to the project while encouraging the participation of invitees by minimizing respondent burden. Thus, the survey focused on the major components of population change at the national level.

- Anonymity and confidentiality of responses:

  While not an official Statistics Canada survey, in following the policies of the *Statistics Act*, responses to the survey were kept strictly confidential and no information has been released that could identify individual respondents.

Survey design

Following internal testing of a preliminary version of the survey, a revised survey was finalized in March 2013. The introductory section of the survey asked respondents to provide basic information regarding their years of experience in the area of demography/population studies generally as well as self-rated expertise in fertility, mortality and migration. The main part of the survey consisted of three sections regarding fertility, mortality and immigration, respectively. In each section, a series of tables and figures demonstrating historical trends were provided for selected indicators (for example, the total fertility rate in Canada from 1921 to 2010). Respondents were asked to provide estimates of the most probable level of a given indicator 5 years and 25 years into the future (2018 and 2038),[6] representing short and long-term future outlooks. Additionally, respondents were asked to provide the range of the same indicator in both years that would encompass approximately 80% of possible future trends. At the end of each section, an open-ended comment box was provided for respondents to elaborate on the trends or factors considered when deciding upon the given future estimate. At the end of the questionnaire, there were two additional options for respondents to provide comments regarding a) the other projection components (emigration, non-permanent residents and interprovincial migration); and b) the production of population projections generally and the questionnaire itself.

Quantitative future estimates were asked only at the Canada level in the survey in order to keep the questionnaire to a manageable length; however, in each section, respondents were encouraged to provide any additional comments and views regarding the component at the provincial or territorial level.

Method of dissemination

In order to reach as many Canadian demographers as possible, the Demography Division worked with the executive councils of Canada's two demography associations—the Canadian Population Society (CPS) and l'Association des démographes du Québec (ADQ)— to facilitate the dissemination of the survey to association members. In the case of l'ADQ, an invitation to participate in the survey was included in the association's electronic bulletin, while the CPS president sent an email directly to CPS members containing the invitation to participate in the survey.

5. The Advisory Committee consists of a small group (around 10 persons) of established Canadian and international demography experts who provide recommendations on various matters related to the work of the Demography Division. The Advisory Committee typically meets with the Demography Division on a biannual basis, and was consulted during the development of the *Opinion Survey on Future Demographic Trends* in November 2011 as well as in May 2013 in order to discuss the survey results.
6. The exception was a sub-section within fertility concerning cohort fertility rates. Respondents were asked to estimate the future completed fertility rate of women born in 1980 and 1990.

In order to facilitate ease of response for both the quantitative and open-ended qualitative sections of the questionnaire, while also allowing respondents to complete the survey electronically or by hand, the questionnaire was provided in Adobe PDF format. Respondents submitted the completed survey by sending it either through email or regular mail to the population projections team.

The invitation to participate in the survey was sent to association members in mid-March 2013. Respondents were given a period of four weeks during which completed surveys could be submitted.

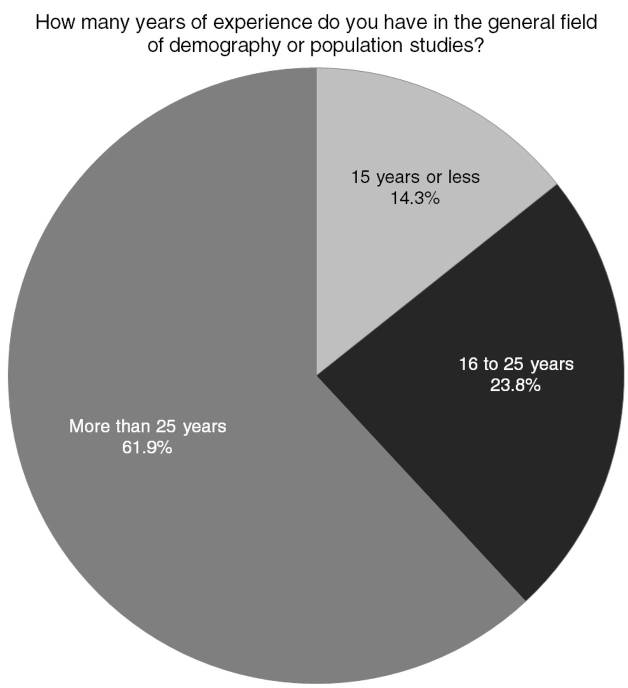
Survey results

In total, 21 persons responded to at least some part of the survey. This relatively small number of respondents, considering the membership sizes of the two associations, likely reflects the fact that population projections is a fairly specialized area of study within the field of demography. Those persons that did participate were most likely those that felt confident that they were able to provide informed future estimates of various demographic indicators. This notion is confirmed by the high years of experience of the majority of respondents (Figure 2.1).

As seen in Figure 2.1, more than half of respondents (62%) had 25 or more years of experience in the field. It also appears that those who participated had high levels of expertise in population projections and in at least one of the sub-components of fertility, mortality and migration (Figure 2.2).

Despite attempts to make the survey as concise as possible and allowing respondents the option of skipping sections they felt less qualified to respond to, response rates generally declined the further one went into each section of the questionnaire, and the further in general into the questionnaire. Furthermore, more respondents provided a 'most probable' estimate than those who provided a corresponding range of low and high estimates. Finally, respondents were slightly more likely to provide estimates for 2018 than for 2038.

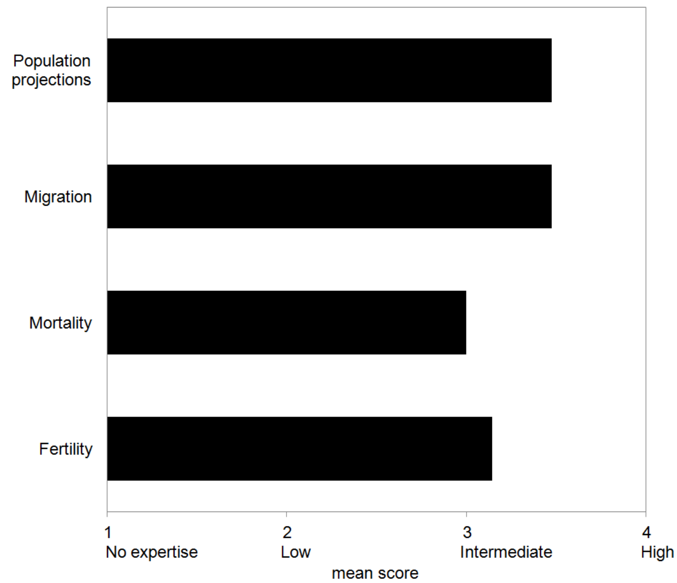
Figure 2.1 Distribution of responses to Question 01 of the 2013 *Opinion Survey on Future Demographic Trends*



Source: Statistics Canada, Demography Division.

A summary of the responses to the survey are reviewed in the respective sections of the technical report, with figures displaying the median values and the overall spread of future estimates of the various demographic indicators.

Figure 2.2 Mean response to Question 02 of the 2013 *Opinion Survey on Future Demographic Trends*



Source: Statistics Canada, Demography Division.

Conclusion

This first venture into a formal surveying of Canadian demographers proved to be a very fruitful exercise for the National Projections Program. The persons that elected to respond to the survey held high levels of experience in the field of demography as well as expertise related to population projections and the major components of population change. The well-balanced quantitative estimates provided by respondents as well as the considerable quality and depth of the comments which accompanied estimates can attest to this fact.

The quantitative estimates received in the survey have proven extremely valuable in the assumption-building process. Equally important were the many arguments, methodologies and other evidence that were introduced to the population projections team via the open-ended comment sections of the survey. In many cases, this new information resulted in a change in approach which has undoubtedly strengthened the projection assumptions.

Feedback received from respondents indicated that the opinion survey was a welcome initiative, and there was considerable interest expressed in seeing the results of the survey. Many respondents provided comments not only related to the survey questions but also general feedback on the National Projections Program (for example, possible ways to improve access and presentation of results) and the survey itself. All of these useful suggestions have been noted and will be assessed for feasibility of implementation for the next edition of population projections.

Owing to the participation of many experts in the Canadian demography community, the survey resulted in much rich information that supports and strengthens the projection assumptions. Given the success of the pilot survey, it is anticipated that a survey of Canadian demographers will continue in some form for future editions of the projections.

Acknowledgements

The Demography Division of Statistics Canada would like to thank each of the respondents who participated in the inaugural *Opinion Survey on Future Demographic Trends*. We would also like to thank the executive council members of Canada's two demography associations, the Canadian Population Society and l'Association des démographes du Québec, for their cooperation and assistance in disseminating the first edition of the *Opinion Survey on Future Demographic Trends*. Finally, we would like to acknowledge and thank the members of Statistics Canada's External Advisory Committee on Demographic Statistics and Studies for their useful comments and input at various stages of the development of the survey.

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Chapter 3: Projection of fertility

By Patrice Dion and Nora Bohnert

Introduction

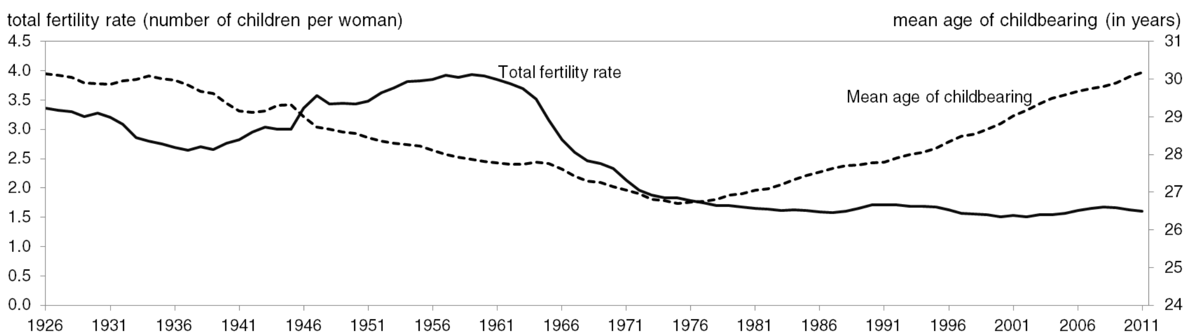
Fertility has a major impact on the size and the age structure of a population. Assumptions are based on an examination of historical and recent trends in fertility at provincial, territorial, national and international levels, results from the *Opinion Survey on Future Demographic Trends* and evidence from the scientific literature. Trends in fertility are examined using many different indicators from the perspectives of age, parity, period and cohort. Three assumptions (low, medium and high) are formulated.

Fertility trends

Following a sharp decline between the baby-boom period (1946 to 1965) and the early 1980s, Canada's period total fertility rate (PTFR) has fluctuated between 1.5 and 1.7 children per woman for more than 30 years. This relative stability has been paired with a continued increase in the ages at which most Canadian women are having their children (Figure 3.1).[1] After experiencing the lowest fertility rate ever recorded in Canada in 2000 and 2002 (1.51 children per woman), the period 2003 to 2008 saw the PTFR increase steadily to reach 1.68 children per woman in 2008. At that time, this was taken as evidence that the postponement of fertility may have been approaching an end and that the PTFR was on its way to returning to levels closer to cohort fertility.[2] However, since 2008, the PTFR has declined each year, reaching 1.61 children per woman in 2011.

Beginning in the 1970s, the age-specific fertility rates (ASFR) of women under the age of 30 began a declining trend which resulted in two milestones in the new millennium: in 2005, for the first time, the fertility rates of women aged 30 to 34 surpassed those of women aged 25 to 29, while in 2011,

Figure 3.1 Total fertility rate and mean age of childbearing, Canada, 1926 to 2011



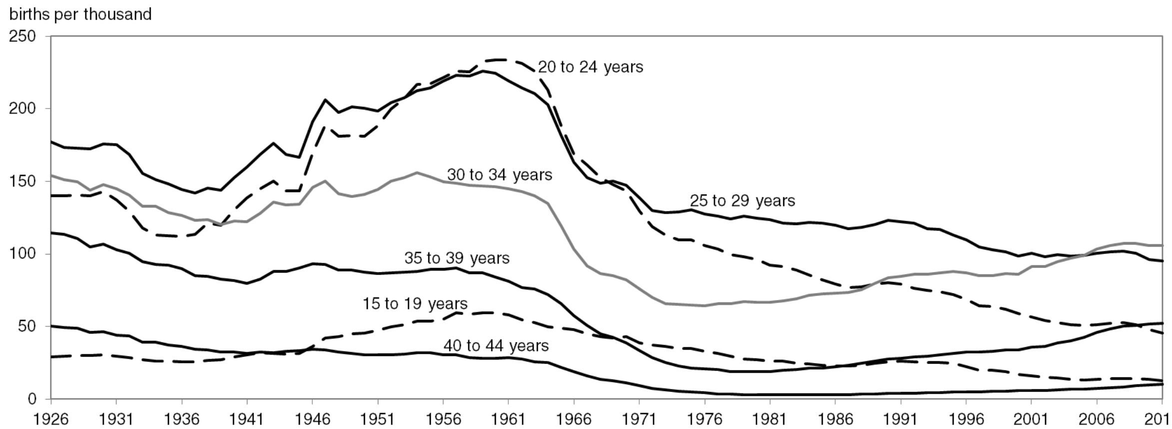
Note: The mean age of childbearing's calculation is based on age-specific rates (and not actual number of births).

Sources: Statistics Canada, Canadian Vital Statistics, Births Database, 1926 to 2011, Survey 3231 and Demography Division, Population Estimates Program.

1. For more information on recent trends in Canadian fertility, see Milan, A. 2013. "Fertility: Overview 2009 to 2011", *Report on the Demographic Situation in Canada*, Statistics Canada Catalogue no. 91-209-X.
2. See the Fertility Assumptions section of *Population Projections for Canada, Provinces and Territories, 2009 to 2036*, Statistics Canada Catalogue no. 91-520-X.

for the first time, the fertility rates of women aged 35 to 39 surpassed those of women aged 20 to 24 (Figure 3.2). Since 2007, the combined fertility rates of women aged 30 to 39 have been higher than those of women aged 20 to 29.

Figure 3.2 Fertility rate by age group, Canada, 1926 to 2011

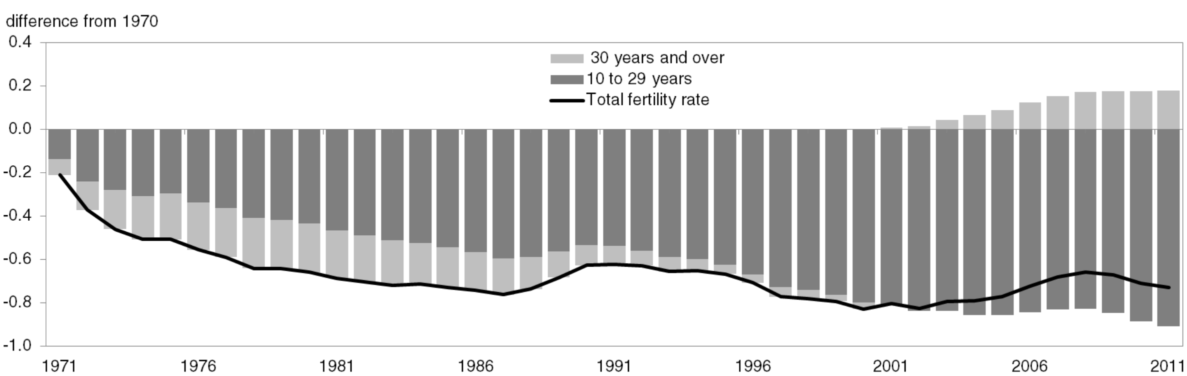


Note: Births to mothers for whom the age is unknown were prorated.

Sources: Statistics Canada, Canadian Vital Statistics, Births Database, 1926 to 2011, Survey 3231 and Demography Division, Population Estimates Program.

As seen in Figure 3.3, the recently observed downturn in the PTFR was due to the fact that over the period 2008 to 2011, younger women's fertility rates steadily diminished while older women's fertility rates were stable. In the preceding period of 2002 to 2007, younger women's fertility rates temporarily halted their diminishing trend while older women's fertility rates steadily increased. Thus, while it appeared during the 2002 to 2007 period that the continued postponement of fertility among young women may have been coming to an end, the more recently observed trends suggest that this is not the case. Instead, the postponement of younger women's fertility is continuing to occur at a stronger level than the 'recuperation' of older women (Frejka 2010).

Figure 3.3 Decomposition of annual changes in fertility rates according to the contribution of mothers at different ages, Canada, 1971 to 2011 compared to 1970



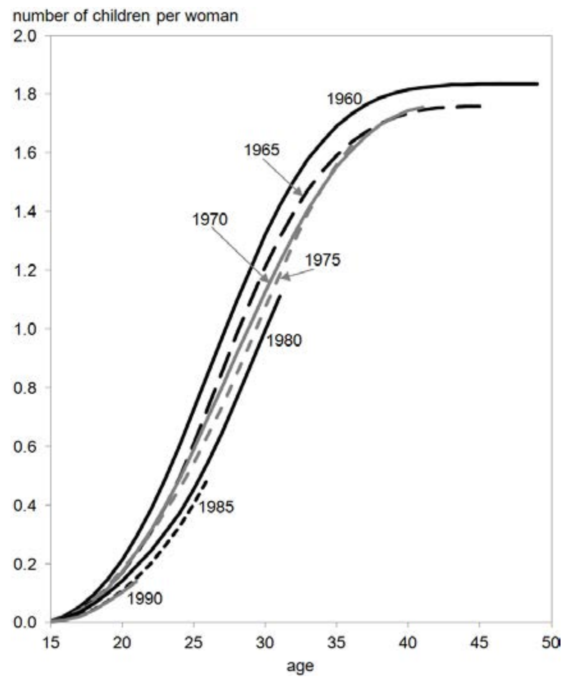
Note: Decomposition method based on Lesthaeghe and Moors (2000) as well as D'Addio and d'Ercole (2005).

Source: Statistics Canada, Demography Division.

The delayment of fertility among younger women can also be observed by examining the cumulated fertility experienced to date by successive cohorts of women, displayed in Figure 3.4. Generally, more recent cohorts of women have experienced lower levels of fertility in their early childbearing years compared to older cohorts. Though the cohorts of the 1970s have shown some signs of 'recovery' (for example, the 1970 cohort has met, and may eventually surpass, the fertility rates of the 1965 cohort), the more recent cohorts of women born in the 1980s have so far demonstrated relatively lower levels of fertility.

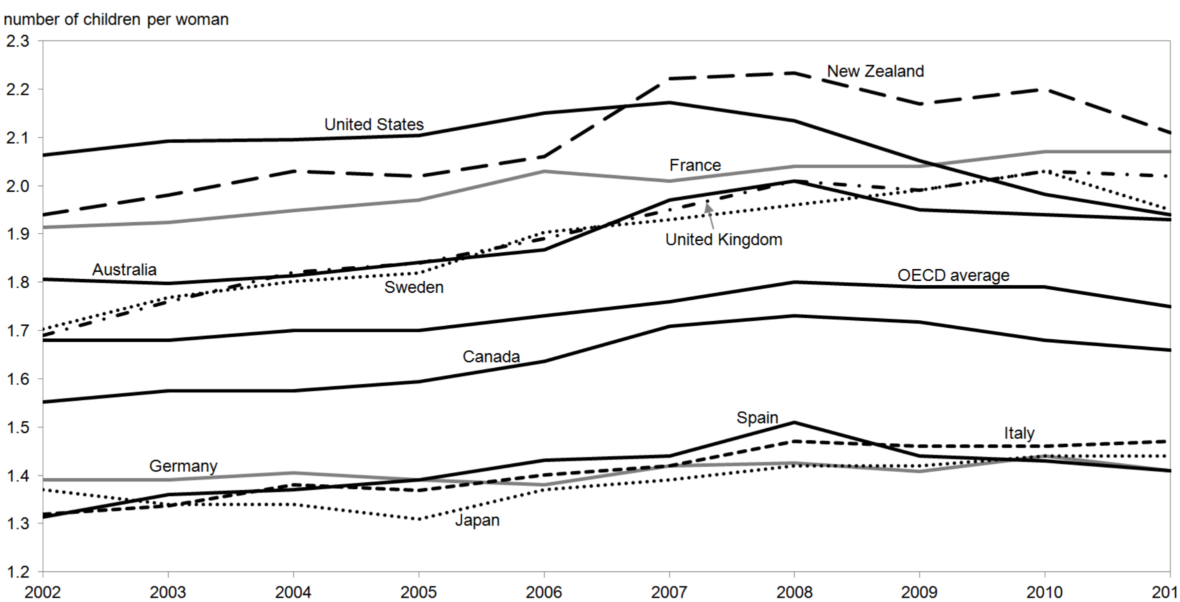
In an international context, Canada's fertility has generally followed the year-to-year trends experienced in other industrialized countries, and yet, Canada is also quite unique in terms of its level of fertility. Among industrialized OECD countries, there are two general groupings in terms of fertility. As seen in Figure 3.5, Anglo-Saxon and Nordic countries such as the United States, the United Kingdom and Sweden have experienced relatively high fertility rates close to or above the theoretical replacement level of 2.1 children per woman.

Figure 3.4 Cumulated fertility rate by age, selected birth cohorts of Canadian women, 2011



Source: Statistics Canada, Demography Division.

Figure 3.5 Period total fertility rate, selected OECD countries and OECD average, 2002 to 2011



Notes: Values for France in 2010 and 2011 and for Italy in 2011 are provisional data. Values for Japan in 2010 and 2011 and for New Zealand in 2011 are projected data.

Sources: OECD. 2013. *Table SF2,1 Fertility rates*, updated June 2013, http://www.oecd.org/social/soc/oecdfamilydatabase.htm, accessed December 18, 2013. For Canada, Statistics Canada, Canadian Vital Statistics, Births Database, 2002 to 2011, Survey 3231 and Demography Division, Population Estimates Program.

In contrast, countries such as Germany, Spain, Italy and Japan have experienced what can be considered low fertility rates over the last decade, all below 1.5 children per woman. Canada's PTFR tends to lie between these two groups, being close to the OECD average.

Between 2005 and 2008, most OECD countries (including Canada) experienced an increasing trend in their fertility rates, a phenomenon that has been attributed by some scholars to more favourable economic conditions and/or to an end in some countries to continued postponement of fertility (see for instance Goldstein et al. (2009), OECD (2011) and Bongaarts and Sobokta (2012)). Since 2008, however, most OECD countries have seen a stabilization or slight decline in their fertility rates. Canada experienced one of the steepest declines in its fertility rate between 2008 and 2010 (-3.0%), following Australia (-3.6%), Spain (-5.5%) and the United States (-7.3%).

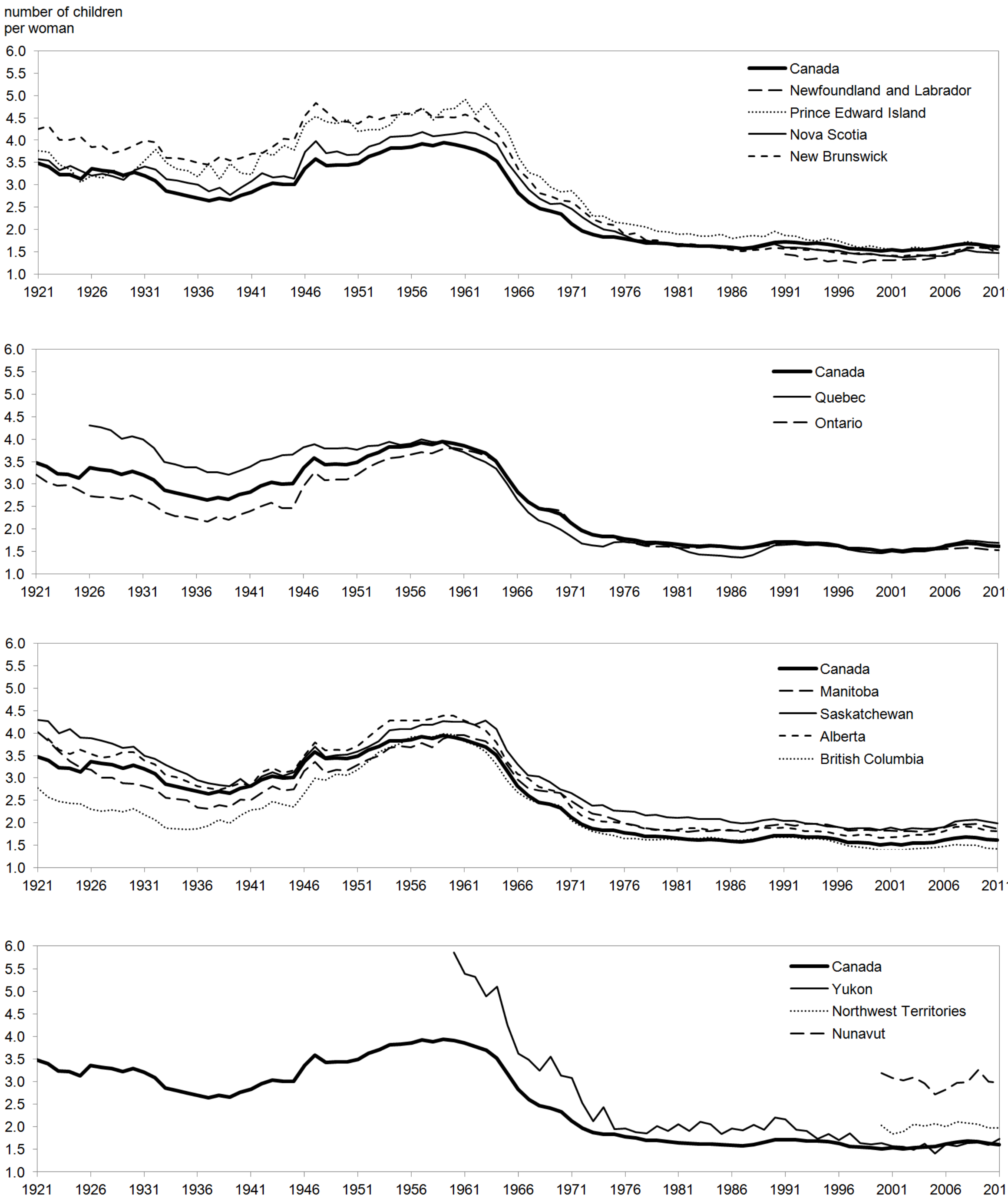
Looking at European countries, Lutz et al. (2006) find evidence of demographic, sociological and economic factors that could work together toward lower birth rates in self-reinforcing processes, constituting what they call the "low-fertility trap". This demographic mechanism is simply the effect of the age structure of the population on the number of births. A sociological mechanism could also be at play in low-fertility countries where young generations, influenced by their environment, develop lower family size ideals. Finally, a third mechanism relates to the relative income hypothesis developed by Richard A. Easterlin (1980), who argued that "Marriage, childbearing and many other aspects of family formation and growth depend crucially on how the 'typical' young couple assesses its 'relative income', that is, the prospects for achieving the economic lifestyle to which they aspire".[3] Historically, children tend to experience higher standards of living than their parents did at the same age, in part due to the fact that they generally share parental wealth with fewer siblings, and thus develop higher aspirations. However, they must also bear with the consequences of social security reforms put in place to mitigate the effects of population aging, which tend to have a negative effect on their income.[4] Thus, an increasing gap between the material aspirations of young adults and their relative income may have a depressing effect on cohort fertility levels as well as the timing of births through postponement of childbearing.[5] Martel and Bélanger (1999) found evidence of this phenomenon in Canada for the period 1975 to 1997, linking the interaction between declines in the relative income of young males and changes in female wages to decreases in the fertility rates of women aged 20 to 29.

A study by Goldstein et al. (2003) finds that indeed ideal family sizes could be on the decline in some German-speaking European countries such as Austria, where the PTFR has fallen well below replacement since the end of the baby boom. The most appealing explanation for the authors is that this change is a consequence of the history of low-fertility; in these countries, young generations have "witnessed below replacement fertility for their entire lives". The authors note that although fertility intentions (in terms of completed family size) rarely actualize in low-fertility countries, this trend could mark a new stage that is indicative of what is to come in other low-fertility countries. However, Edmonston et al. (2010) find no evidence that ideal family size is lowering in Canada to date.[6]

At the subnational level, PTFRs vary considerably between Canada's provinces and territories. In recent decades, the Atlantic provinces have had among the lowest fertility rates in the country, though in 2011, British Columbia registered the lowest rate of 1.42 children per woman (Figure 3.6). Ontario and Quebec had fertility rates closest to the Canadian average (partly a result of their large populations), while the Prairie

3. It should be noted here that Lutz et al. (2006) do not refer to the second part of Easterlin's theory which related to the effect of cohort size.
4. Lutz et al. (2006) find some support for the relative declining well-being of young generations in some European countries.
5. Goldstein et al. (2013) give a further example of these interacting factors, finding evidence that the recent economic crisis (specifically unemployment rates) had a negative impact on fertility in several European countries, particularly the fertility rates of younger women.
6. Examining past trends in fertility intentions in Canada using information available in the General Social Survey (GSS) for years 1990, 1995, 2001 and 2006, they observe that fertility intentions have been relatively stable from 1990 to 2006, ranging from 2.11 to 2.29 children per woman. Moreover, the slight variations could be due to changes in the population composition.

Figure 3.6 Period total fertility rate, Canada, provinces and territories, 1921 to 2011



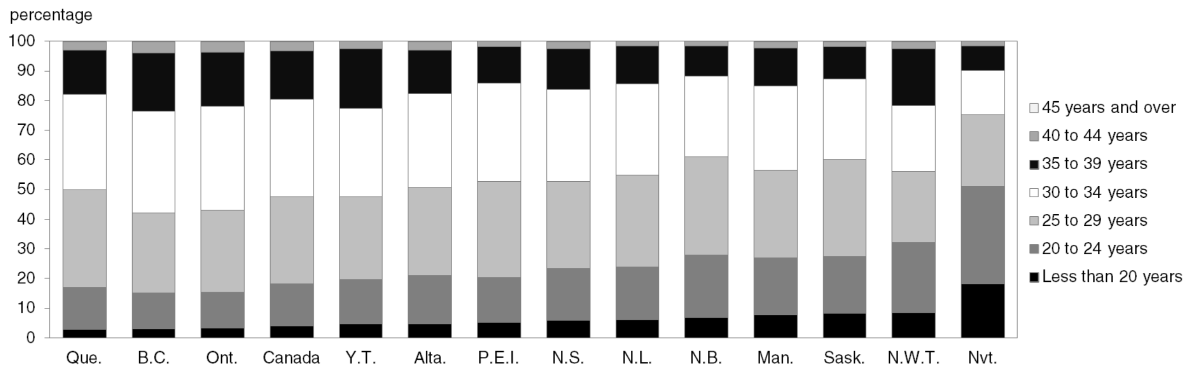
Notes: Data are available for Alberta beginning in 1922, for Quebec beginning in 1926, for Yukon beginning in 1960, for Newfoundland and Labrador beginning in 1991 and for the Northwest Territories and Nunavut beginning in 2000.

Sources: Statistics Canada, Canadian Vital Statistics, Births Database, 1921 to 2011, Survey 3231 and Demography Division, Population Estimates Program.

provinces and the territories were considerably higher than the Canadian average. The highest fertility rate in 2011 and the only to fall above replacement level was that of Nunavut (2.97 children per woman). With the exception of Nunavut, the PTFRs experienced by the provinces and territories have generally been converging over the last 100 years.

There is also evidence of divergence in terms of age-specific fertility patterns among the provinces and territories in recent years. While at the national level, there were more births to women in their 30s than women in their 20s in 2011, this was only the case for three provinces (Ontario, Alberta and British Columbia) and one territory (Yukon) (Figure 3.7). Among the other provinces and territories, the majority of births were to women aged less than 30. The proportion of all births that were to mothers aged less than 30 was highest in Nunavut (75.1%), New Brunswick (60.9%) and Saskatchewan (60.1%) and was lowest in British Columbia (42.0%). The distribution of births by age of mother in Nunavut demonstrates a uniquely high prevalence of younger mothers, with close to one in five births (18.3%) to women aged less than 20 in 2011—more than three times the average proportion among the other provinces and territories (5.6%).

Figure 3.7 Distribution of births by age group of mother at childbearing, Canada, provinces and territories, 2011



Sources: Statistics Canada, Canadian Vital Statistics, Births Database, 2011, Survey 3231 and Demography Division, Population Estimates Program.

In addition to socioeconomic and cultural differences, variations in the PTFR and age-specific rates among the provinces and territories could be in part due to distinctions in public policies that could have an impact on fertility and family size. As with most OECD countries, Canada does not have any explicit policy with regards to fertility, as these issues are generally considered to be part of the private sphere (OECD 2011). However, policies within Canada and other countries have been developed with reference to reducing barriers and costs to having children. Beaujot et al. (2013) note that in Canada, these measures are mostly focused on families with low income. Evaluating the effect that specific policies may have on fertility is often very difficult (Gauthier 2008). Generally, it has been found that while some family benefits may reduce the costs of children, their effects on fertility itself are quite limited, heterogeneous, and often relate more to the timing of births rather than the quantum (OECD 2011; Gauthier 2007; Gauthier 2008; Thévenon and Gauthier 2010). Nonetheless, these timing effects have been found to have an impact on the total fertility rate in some cases.[7]

In the case of Canada, there is some evidence of positive but limited impacts of policies on fertility. For example, Morency and Laplante (2010) find small positive impacts of financial aid and parental leave on the first birth of working couples, though the effects vary by the couple's income and other factors such as job security and homeownership (see also Laplante et al. 2010). The province of Quebec has been the focus of several studies in terms of the impact of various policies on fertility, mainly the

7. See Figure 3.10 of OECD (2011).

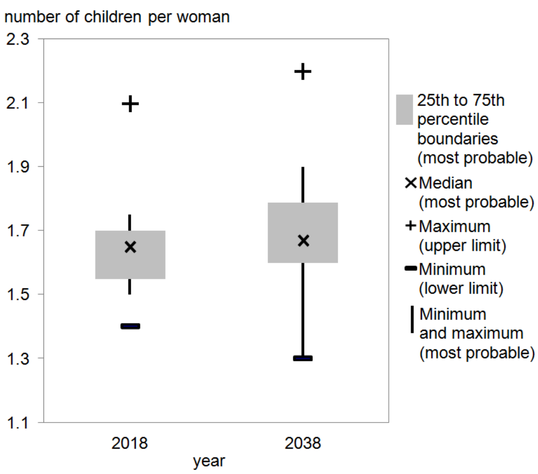
province's introduction of a 'baby bonus' cash transfer in the early 1990s and the subsequent subsidized child care and parental leave programs which are more generous and less restrictive compared to the federal programs (Milligan 2005; Beaujot et al. 2013). While the more recent programs seem to have some positive impacts on the labour force participation of mothers (Lefebvre et al. 2011), it is still too early to evaluate their impact on the completed fertility of mothers (Lapierre-Adamcyk 2010).

Survey results

Respondents to the *Opinion Survey on Future Demographic Trends* gave their views regarding future levels of both period (PTFR) and cohort (CTFR) fertility in Canada. In terms of PTFR, respondents generally anticipated a slight increase. Specifically, the median responses of the most probable estimate of the PTFR were 1.65 children per woman for 2018 and 1.67 children per woman for 2038 (Figure 3.8).

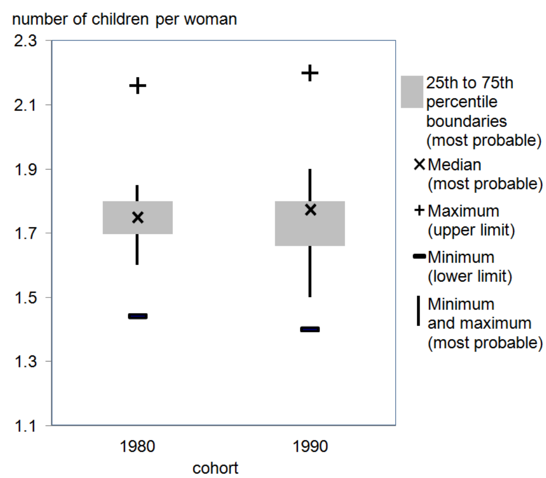
Somewhat in contrast, respondents anticipated a slight decline in cohort fertility rates in the future. Compared to the most recently completed fertility rate of 1.81 children per woman for the 1962 cohort, the median survey responses to the most probable estimate of the completed fertility of the 1980 and 1990 cohorts were 1.75 and 1.78 children per woman, respectively (Figure 3.9).

Figure 3.8 Summary statistics from the 2013 *Opinion Survey on Future Demographic Trends*, estimates of the period total fertility rate in Canada in 2018 and 2038



Source: Statistics Canada, Demography Division.

Figure 3.9 Summary statistics from the 2013 *Opinion Survey on Future Demographic Trends*, estimates of the completed fertility of the 1980 and the 1990 cohorts of women, Canada



Source: Statistics Canada, Demography Division.

In supporting their estimates, survey respondents mentioned trends that could alternatively suggest a small increase or a small decrease in fertility in the future. Many respondents anticipated that sociocultural trends such as delayed union formation, union instability, diversification of family types, and the increasing educational attainment and labour force participation of women will persist and cause further declines in fertility in the future. The trend of increasing mean age of childbearing suggested to some respondents that fertility levels will decline in the future, due simply to the biological limits of fecundity as, if women increasingly delay childbearing, they could increasingly face difficulties in achieving their desired number of children. For others, it was expected that the mean age of childbearing will cease to continue to increase (again, for biological reasons), and eventually, PTFRs will rise as the 'timing effects', which have contributed to lower PTFRs in recent years, lessen. Other arguments supporting an increase in fertility levels in the future included the potential impact of higher fertility among recent immigrants, as well as the fact that as the western provinces grow proportionally in size, their higher fertility levels could have more influence on Canada's overall fertility rate.

Methodology

As Preston et al. (2001) state, the total fertility rate is the "single most important indicator of fertility". They define it as "the average number of children a woman would bear if she survived thorough the end of the reproductive age span and experienced at each age a particular set of age-specific fertility rates" (Ibid, page 95). These age-specific fertility rates can be observed during specific periods in order to obtain the period total fertility rate (PTFR), or, over the course of the reproductive life of a cohort of women, in which case we obtain a cohort total fertility rate (CTFR), also known as cohort completed fertility.

Theoretical and practical considerations

Most agencies frame their projection assumptions in terms of PTFRs, mainly because projection inputs take the form of age-specific fertility rates on a yearly basis, and because the CTFR can be calculated only for cohorts of women who have already reached the end of their reproductive years. However, period measures are affected by changes in the timing (tempo) of fertility of successive cohorts, and thus, they can be misleading indicators of actual cohort fertility (quantum). For instance, if in a given year, delayed fertility leads to a decrease in the PTFR, it does not necessarily imply a decrease in cohort fertility if those women ultimately recuperate those births at older ages. For Sobotka (2003), the postponement observed over recent decades in low-fertility countries has rendered the PTFR an inadequate indicator of the quantum of fertility.

Since its variations reflect solely changes in the number of children that cohorts of women have, the CTFR is, in contrast to period measures, much more stable, and is generally more appropriate for use in projections.[8] As Li and Wu (2003, page 303) state, "Demographers generally agree that cohort fertility measures are better than period measures at reflecting how well a society is replacing itself".

The challenge then, as van Imhoff (2001, page 24) explains, is how "to arrive to statements about family formation processes from a cohort perspective from data that are essentially collected on an annual basis, i.e., from a period perspective". Some adjustment procedures to remove the 'tempo effects' inherent to the PTFR have been proposed in the literature, such as that proposed by Bongaarts and Feeney (1998). However, the evidence of the validity of these tempo-adjusted measures as estimators of cohort fertility are at best mixed (Ní Bhrolcháin 2011). While some have found that the Bongaarts-Feeney adjustment is generally robust (Zeng and Land 2000), and that deviations from main assumptions "will introduce only minor errors in estimates of the quantum and tempo effects components…" (Bongaarts and Feeney 2000, page 563), the capacity of this measure to isolate pure quantum effects has also been much criticized (van Imhoff and Keilman 2000; Kim and Schoen 2000; Kohler and Philipov 2001).[9] These considerations convinced Ní Bhrolcháin (2011) to advocate for an explicit forecast of cohort fertility, as a more transparent and versatile way to estimate the ultimate mean family size of cohorts not having reached the end of their reproductive years.

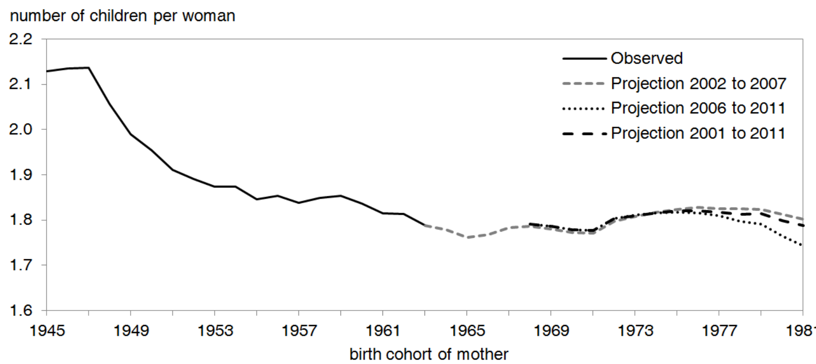
Several projections based on CTFR have been conducted for Canada in the literature (see for instance Li and Wu 2003; Schmertmann et al. 2012; Myrskylä et al. 2013). Recently, Myrskylä et al. (2013) projected CTFRs by extrapolating age-specific fertility rates five years into the future based on trends observed over the past five years using a variation of the Lee-Carter method (Lee and Carter 1992) which is generally

8. Several respondents to the *Opinion Survey on Future Demographic Trends* also recommended using cohort fertility measures to build future fertility assumptions.
9. More robust tempo-adjusted indicators requiring data by parity (including denominator of women at risk by parity, not available from Canadian Vital Statistics) have been proposed by Kohler and Philipov (2001) and Kohler and Ortega (2002) among others.

used to project period mortality.[10] Using birth data for Canada up to 2007, they projected CTFRs of 1.84 children per woman for both cohorts of women born in 1975 and 1979, which implies an eventual end to the long-term declining trend of cohort fertility. They obtain similar results in other countries: in fact, their projections show a leveling off or an increase of cohort fertility in most countries that experienced low period fertility over the last few decades. The authors obtained better results in posteriori comparisons than other methods such as using unlimited linear extrapolation or simple 'freeze rate' methods.

However, as was mentioned earlier, the year 2007 marked the end of a period of fertility increase which began in 2003; in the subsequent years of 2008 to 2011, period fertility decreased. Applying the same model to the most recent data available, considerably different results are obtained. Figure 3.10 shows the result of three projections. In the first two projections, age-specific rates are extrapolated for five years before freezing them, using two different reference periods: firstly, the period 2002 to 2007 is used, similarly to Myrskylä et al. (2013); secondly, the most recent data is used, that is, the 2006 to 2011 period. It can be seen that the results differ substantially depending on the reference period. In the early years of the projection, the results are indistinguishable because the women of these cohorts have already passed through most of their reproductive years; thus, only the later years (where fertility rates are relatively low) are extrapolated. However, the trends for later cohorts differ, and cohort fertility ends up declining further over the longer term when using the most recent reference period. A third projection was made using a 10-year reference period, in which the rates were extrapolated for 10 years before being held constant: the resulting CTFRs also show a declining trend in the long run, but less pronounced than in the projection based on the 2006 to 2011 period.

Figure 3.10 Observed and projected cohort total fertility rate, Canada, Lee-Carter variant using three different reference periods



Source: Statistics Canada, Demography Division.

Description of method

The previous considerations show that in a context of volatility of fertility rates, it is difficult to extrapolate future levels of cohort fertility without making somewhat arbitrary—but heavily significant—choices about the reference period. The problem is made worse when attempting to project the provinces and territories separately: not only do the various regions experience differing trends over the same period in some cases, but in some regions, volatile year-to-year trends can be the result of very small population sizes. That said, the Lee-Carter variant method used by Myrskylä et al. (2013) holds many advantages. It is simple, transparent, and can be adapted to create different assumptions. Moreover, it consistently translates changes in overall levels of fertility to plausible changes in the ASFRs using trends observed in the past. For these reasons, the method was used to calculate the age-specific fertility rates serving as inputs in the projection in conjunction with targets established in terms of PTFR at the Canada level.[11]

10. The authors freeze rates after the first five years of the projection, and they project age-specific fertility rates only for women aged 30 and over.

11. Not all aspects of the method of Myrskylä et al. (2013) are utilized. For instance, the method can also be used to calculate estimates of uncertainty for the calculation of confidence intervals, a feature not used here.

Briefly, the method consists of a variation of the Lee-Carter model:

$$f_{x,t} = a_x + b_x K_t$$

In this equation, $f_{x,t}$ is the age-specific fertility rate at age x and time t; a_x is the age-specific fertility rate of the most recent period (the baseline rate); b_x is a vector of parameters measuring the changes related to each specific age over time, estimated as the average annual change in age-specific fertility rates during the reference period; and K_t is the time component which is projected. For a reference period of 10 years, the K_t parameters are estimated using a regression of $(f_{x,t} - \hat{a}_x)$ on $K_t \hat{b}_x$ for years *t-9* to *t*. For a more detailed description of the method, the reader should refer to Myrskylä et al. (2013).

The method is adapted to match the 'hybrid bottom-up' approach generally employed in the projections, which requires the production of separate projections for the individual provinces and territories while observing a main set of assumptions for Canada. Three separate assumptions are proposed: low, medium and high fertility. In a first step, a specific reference period is chosen for each assumption, reflecting the general desired trend in terms of PTFR and CTFR at the national level. The ASFRs and resulting PTFRs are projected at the Canada level using the selected reference period. The period 2001 to 2011 was selected for the medium assumption because its extrapolation produces a 'moderate' evolution of a slight increase in period fertility and slight decrease in cohort fertility rates at the Canada level, an evolution which was supported by the 'most probable' estimates provided by respondents to the *Opinion Survey on Future Demographic Trends*. The selected reference period for the low assumption is 2008 to 2011, a period during which the PTFR for Canada as a whole declined steadily. In contrast, the reference period for the high assumption is 2002 to 2008, a period of fairly steady increases in the PTFR at the Canada level. In the low and high assumptions, the selected PTFR and CTFR targets at the national level are reached not only through the selection of the reference period but also by adjusting the weight given to the rate of change over the reference period, the K_t (time trend) factor. In all assumptions, the ASFRs are extrapolated from 2012 up to 2021, after which they remain constant. However, the values extrapolated for 2012 are not utilized for the projection of births, which commences in 2013.

The production of a Canada-level extrapolation is only done as an intermediary step in order to build the provincial and territorial rates. Thus, as a second step, the method is repeated for each province and territory, using the same reference periods as the Canada level when possible.[12] PTFR targets for each province and territory are set to match, in proportion, the projected change in the PTFR for Canada in the previous step. For instance, if the Canada-level PTFR was projected to decrease by 12% between 2011 and 2021 under the low-fertility assumption, the desired target of PTFR in 2021 for each province and territory would be 12% lower than its observed level in 2011. This target is reached by obtaining the appropriate time factor, K_t, through iterations. In using PTFR targets, the same variation between the low and high assumptions is obtained in every province and territory, thus providing an acceptable range of projected fertility outcomes. It also ensures that the projection of all provinces and territories will provide the PTFR target assumed at the Canada level.[13] As with the projection at the national

12. If the selected target for Canada implies a decrease in fertility, the reference period for the province or territory must also exhibit a decline; this is necessary not only for the method to work, but also for plausibility of the results—the general idea being that the projected changes in fertility will follow those that occurred in the recent past. Different reference periods were required for certain provinces and territories when the time trend differed substantially from that experienced at the Canada level. The medium assumption was based on the period 2000 to 2010 for Ontario and the period 2005 to 2010 for Nunavut. The high assumption was based on the period 2005 to 2007 for both Yukon and Nunavut. The low assumption was based on the periods 2009 to 2010 for Yukon and 2000 to 2005 for Nunavut. Note that since the PTFR targets are predetermined, the reference period is used only to provide the specific age composition of future changes.

13. In practice however, changes in the demographic weights of the provinces and territories over the course of the projection can introduce variations.

level, ASFRs are extrapolated from 2012 up to 2021,[14] after which they remain constant, with the exception of the province of Quebec. In the case of Quebec, observed ASFRs for 2012 and 2013 became available at the time of assumption-building; thus, the extrapolation for Quebec begins in 2014 from observed 2013 ASFR values.[15]

It should be noted that the method could not be used to achieve specific (pre-defined) CTFR targets. Indeed, for cohorts of women who have already entered their fertile years, the eventual CTFR reached will depend in part on the ASFRs already observed and in part on the projected ASFRs. For instance, the completed CTFR level of the 1980 cohort will be determined in part by ASFRs that have already been observed, that is, when these women were aged 10 to 31, and in part by future rates from 2012 to 2035, as these women move through the ages 32 to 54. Thus, imposing a target CTFR for the 1980 cohort would imply no assumptions about the ASFRs under age 32, although these ASFRs will nevertheless impact the projected number of births, and the projected CTFR of subsequent cohorts of women.

In fact, although the CTFR targets were considered in the selection of reference periods for projection at Canada level in the first step for consistency, clearly, Myrskylä et al.'s methodology, intended principally for the projection of cohort fertility rates, is used here to project targets in terms of period fertility measures. It nonetheless holds many useful features in regards to the projection of cohort fertility rates. Its main strength is its ability to model variations in ASFRs in a sound manner independently for each province and territory. Since past variations in ASFRs observed in the individual provinces and territories are often weakly correlated, it is indeed preferable not to impose a single future path of ASFR evolution common to all of them. Using each province and territory's own past trends to project their future trends should lead to more plausible variations in ASFRs and number of births.[16] As a result, the eventual CTFR levels to be attained in each province and territory are not determined a priori in conjunction with the desired Canada levels; rather, they evolve independently from the national level. More precisely, since each province and territory has a distinct structure of b_x (composition of changes by age) which is applied at different intensities, and given that cohort fertility is affected by b_x structures, the effect on CTFR at the Canada level is unknown prior to the projection. Ultimately, the CTFR reached in a province or a territory is only known for cohorts of women who enter their fertility years in or after 2021; in these cases, the CTFR will equal the PTFR which is held constant as of 2021.

Fertility of non-permanent residents

In past editions, non-permanent residents (NPRs) were always assumed to have fertility behaviours identical to Canadian permanent residents (PRs). However, it is doubtful that this is the case, given that their residence in Canada is temporary. While it is possible to provide distinct fertility parameters for NPRs, since they are projected separately from the PR population,[17] specific information about NPR fertility is not available through Canada's Vital Statistics system, from which births data are used in the calculation of fertility rates.

This edition incorporates, for the first time, a distinct series of fertility parameters for the population of NPRs in Canada. To do so, fertility rates were calculated using the 2011 National Household Survey (NHS) in conjunction with the own-children method. Specifically, the own-children method consists

14. The 2012 fertility assumptions are, however, not directly utilized in the projections of births.
15. ASFRs for the Canada level were projected again, taking this exception into account, so as to obtain a consistent measure at the national level of the assumptions specific to the provinces and territories.
16. Some adjustments were needed for areas where high annual variances of ASFRs were observed due to the small number of births and/or population sizes. One adjustment was to smooth the ASFRs observed in the reference periods to obtain a more polished curve for bx. In these cases, the resulting bx involve less extreme variations at single ages when projected for 10 years than what would have been the case if the reference period ASFRs were unaltered.
17. See Chapter 6 of this report for more details.

of identifiying infants living in families and linking them to the women likely to be their mothers in the NHS, thus allowing for the calculation of an estimation of ASFRs.[18] While holding limitations, this approach is judged to result in a net improvement in capturing the fertility behaviour of NPRs as compared to assuming that this group holds fertility rates that are identical to the PR population.[19]

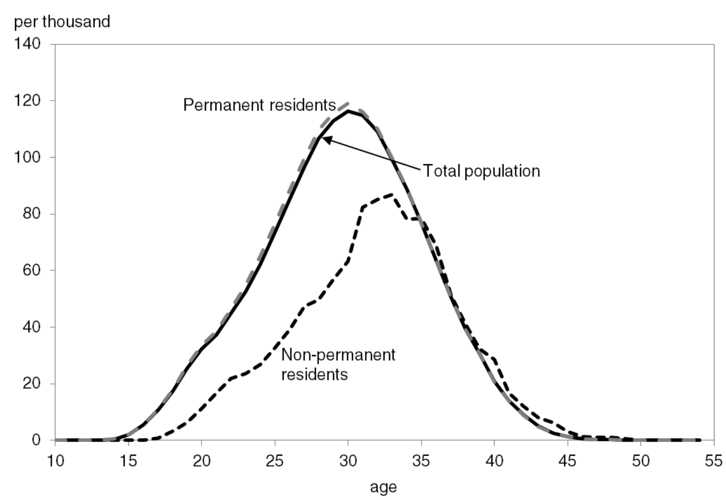
Due to the small numbers involved in some areas (in terms of both births to NPR women and the population of NPR women), it was only viable to calculate a base-year ASFR schedule for NPR women at the Canada level. Specific low, medium and high fertility assumptions for NPR women were created through evolving the base-year NPR ASFRs to follow the main fertility assumptions for the total population in each province and territory.

Since separate fertility assumptions were created for the NPR population, it was then necessary to derive fertility assumptions for the remaining PR population. The PR fertility assumptions were set to equal, at each age and for each province and territory, the balance of fertility which remained after NPR fertility was subtracted from the fertility of the total population (i.e., the fertility of NPRs and PRs combined). Like for the NPR population, the fertility assumptions for PRs evolve with time in proportion with the assumptions determined previously for the whole population.

Figure 3.11 displays the base-year (2011) age-specific fertility rates calculated for NPRs, PRs and the total population of Canada as a whole. Results show that, as expected, NPR females exhibit lower fertility than PR females (experiencing an estimated PTFR of 1.08 and 1.64 children per woman, respectively, in 2011). The NPR population also displayed a distinct age structure of fertility, with an older mean age at childbearing (32.4 years) than PRs (30.1 years). As for the differences between the fertility of the total population and PR fertility, those are minimal because of the small weight of NPRs in the total population. The extrapolated trends described earlier for the total population and the changes in ASFRs that they convey are applied to both the PR and NPR fertility schedules, thus maintaining consistency with the assumptions for the total population in terms of both PTFR and CTFR indicators.

In the following section, assumptions are presented for the total population only; however, fertility inputs into the projection program are separated for PRs and NPRs, which together sum to the total population fertility assumptions.

Figure 3.11 Age-specific fertility rate, total population, non-permanent residents and permanent residents, Canada, 2011



Source: Statistics Canada, Demography Division.

18. For more information on this methodology, see Grabill and Cho (1965), Desplanques (1993) and Bélanger and Gilbert (2002).
19. For example, one limitation comes from the potential biases in the measurement of NPRs in the NHS. The number of NPRs in the NHS and from the Population Estimates Program differs considerably, which reflects in part differences in how they were measured (from a survey sample and from administrative data, respectively). ASFRs measured from the NPR population in the NHS and applied to the NPR population derived from the Population Estimates Program (which is the case in the projections) could create biased fertility levels and schedules if biases in non-response are present in the NHS.

Assumptions

The analysis of trends in regards to past fertility and the results from the *Opinion Survey on Future Demographic Trends* lead to the elaboration of three distinct assumptions of low, medium and high fertility. In all assumptions, age-specific fertility rates are frozen 10 years after the beginning of the projection. This implies that the PTFR from that point will remain the same, and that the CTFR will eventually converge to the PTFR level in the long term. It also implies that changes in the age structure of fertility rates stop, which is consistent with the assumption that further postponement is limited due to biological limits to fecundity and to the fact that women can only reduce time between births to a certain extent.

Under the **medium assumption**, at the Canada level, the period total fertility rate increases slightly from the most recently observed level of 1.61 children per woman in 2011 to 1.67 in 2021, after which it is held constant. Under this assumption, Canada would continue its long-term trend of holding a PTFR below 1.70 children per woman, but levels would be considerably above the lowest observed levels of the early 2000s. Reflecting recent trends, for Canada as a whole, fertility postponement and recuperation would continue to occur at similar levels to one another, resulting in a near-stabilization of the PTFR. Incidentally, a PTFR of 1.67 children per woman matches the median 'most probable' long-term estimate provided by opinion survey respondents.

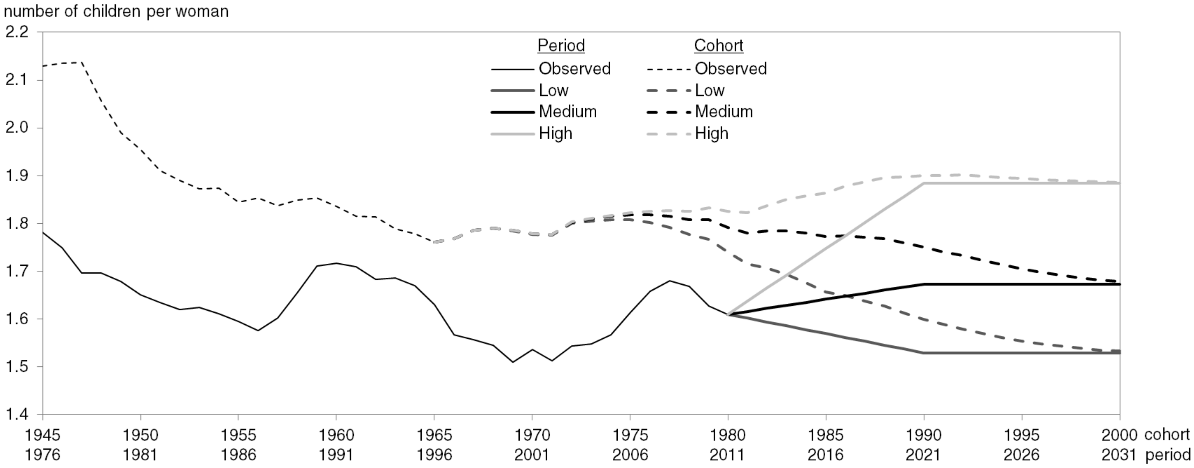
In the **high assumption**, the PTFR increases from 1.61 children per woman in 2011 to 1.88 in 2021, after which it holds constant. A PTFR value of 1.88 children per woman, while recently observed in Australia and the United States, was last observed for Canada as a whole in 1973. An increase in fertility of this magnitude could occur if, for example, age-specific fertility rates among women in their thirties continue their increasing trend or if certain subpopulations with higher fertility grow in share within the Canadian population.

In the **low assumption**, the PTFR decreases from 1.61 children per woman in 2011 to 1.53 from 2021 onward. A PTFR of 1.53 children per woman is slightly above the lowest recorded level for Canada (that being 1.51 children per woman in 2000 and 2002) and still falls above levels recently observed in certain 'low-fertility' industrialized countries such as Italy, Germany and Spain. Such an evolution could occur if, for example, young women increasingly delay the onset of childbearing to an extent that completed fertility is lower simply due to the biological limits of fecundity; or if, as some experts suggest, various sociocultural trends such as delayed union formation and the increasing educational attainment and labour force participation of women evolve in a manner which promotes lower fertility.

Figure 3.12 shows the projected levels of the PTFR for the low, medium and high assumptions at the Canada level,[20] while Table 3.1 summarizes the projected CTFR and PTFR for all assumptions, for Canada, provinces and territories. The results show that the provinces and territories greatly differ in their projected CTFRs, a result of the fact that in projecting each region on the basis of its own past trends, each region preserves its own (heterogeneous) path.

20. In theory, with separate fertility for PRs and NPRs, changes in the demographic weights of these populations will modify the eventual rates reached for the whole population. However, this effect is minimal in practice and very unlikely to alter significantly the assumptions shown in Figure 3.12.

Figure 3.12 Fertility assumptions: Observed and projected values of cohort total fertility rate and period total fertility rate for Canada



Notes: The projection of fertility rates begins in 2012 since 2011 was the last year for which observed fertility rates were available. The 2012 projected fertility rates are, however, not directly utilized in the projections.

Source: Statistics Canada, Demography Division.

The evolution of the mean age at childbearing for each of the low, medium and high assumptions follows the changes observed during the selected reference periods and the intensity at which these changes were applied during the first 10 years of the projection (Table 3.2). As is notable in Figure 3.3 for Canada as a whole, in the low assumption, the reference period (2008 to 2011) was characterized by a diminution of fertility rates at ages 10 to 29 and a general stability at ages 30 and over. In the high assumption, the reference period (2002 to 2008) was characterized by increases of fertility rates at ages 30 and over and a general stability at ages 10 to 29. The medium assumption, based on the period 2001 to 2011, shows a slight diminution of fertility rates at ages 10 to 29 and a more substantial increase of those at ages 30 and over. Thus, all assumptions imply an increase in the mean age at childbearing (this appears to be also true for all individual provinces and territories; see Table 3.2).

Table 3.1 Observed and projected total fertility rates for selected cohorts and selected years

Cohorts[1]

Region	Observed	Projected (assumptions)					
	1965[2]	Low		Medium		High	
		1980	1990	1980	1990	1980	1990
Canada	1.76	1.74	1.60	1.79	1.75	1.83	1.90
Newfoundland and Labrador	..	1.53	1.45	1.53	1.52	1.55	1.65
Prince Edward Island	1.95	1.71	1.60	1.75	1.74	1.79	1.82
Nova Scotia	1.65	1.53	1.43	1.56	1.55	1.60	1.70
New Brunswick	1.63	1.60	1.51	1.61	1.60	1.65	1.73
Quebec	1.64	1.80	1.67	1.74	1.74	1.85	2.00
Ontario	1.76	1.66	1.51	1.71	1.71	1.79	1.84
Manitoba	1.95	1.98	1.85	2.08	2.07	2.08	2.18
Saskatchewan	2.10	2.08	2.01	2.14	2.14	2.15	2.22
Alberta	1.94	1.96	1.79	1.93	1.92	2.05	2.11
British Columbia	1.75	1.57	1.42	1.68	1.65	1.69	1.71
Yukon	1.99	1.90	1.79	2.01	1.96	2.04	2.11
Northwest Territories	..	..	1.93	..	2.19	..	2.36
Nunavut	..	..	2.95	..	3.05	..	3.21

Years[3]

Region	Observed	Projected (assumptions)					
	2011	Low		Medium		High	
		2018	2038	2018	2038	2018	2038
Canada	1.61	1.55	1.53	1.65	1.67	1.80	1.88
Newfoundland and Labrador	1.45	1.40	1.38	1.49	1.51	1.63	1.70
Prince Edward Island	1.62	1.56	1.54	1.67	1.68	1.81	1.90
Nova Scotia	1.47	1.42	1.39	1.51	1.52	1.64	1.72
New Brunswick	1.54	1.48	1.46	1.58	1.60	1.72	1.80
Quebec	1.69	1.62	1.61	1.68	1.70	1.86	1.98
Ontario	1.52	1.47	1.45	1.57	1.58	1.71	1.78
Manitoba	1.86	1.80	1.77	1.91	1.94	2.09	2.18
Saskatchewan	1.99	1.92	1.89	2.04	2.06	2.22	2.32
Alberta	1.81	1.74	1.72	1.86	1.88	2.02	2.11
British Columbia	1.42	1.37	1.35	1.46	1.48	1.59	1.67
Yukon	1.73	1.67	1.64	1.78	1.80	1.94	2.02
Northwest Territories	1.97	1.90	1.87	2.03	2.05	2.21	2.31
Nunavut	2.97	2.87	2.83	3.06	3.09	3.33	3.48

1. The 2013 *Opinion Survey on Future Demographic Trends* asked for targets for birth cohorts 1980 and 1990, which explains the choices of the cohorts in this table.
2. Latest cohort for which fertility rates are observed for the totality of the reproductive age span.
3. The 2013 *Opinion Survey on Future Demographic Trends* asked for targets for years 2018 and 2038, which explains the choices of the years in this table.

Source: Statistics Canada, Demography Division.

Table 3.2 Observed and projected mean age at childbearing[1] for selected cohorts and selected years

Cohorts[2]

Region	Observed	Projected (assumptions)					
	1965[3]	Low		Medium		High	
		1980	1990	1980	1990	1980	1990
Canada	28.4	29.7	30.3	30.0	30.7	30.1	30.8
Newfoundland and Labrador	..	29.1	29.4	29.0	29.3	29.1	29.6
Prince Edward Island	27.4	28.7	29.4	29.0	30.0	29.1	30.0
Nova Scotia	27.5	29.0	29.4	29.3	29.9	29.3	30.1
New Brunswick	27.1	28.2	28.5	28.3	28.7	28.4	29.0
Quebec	28.5	29.9	30.3	29.9	30.4	30.1	30.8
Ontario	28.9	30.2	30.9	30.6	31.5	30.7	31.6
Manitoba	27.7	28.4	28.8	28.9	29.6	28.9	29.5
Saskatchewan	26.9	28.2	28.6	28.4	28.9	28.4	29.0
Alberta	27.9	29.3	29.8	29.4	30.0	29.6	30.3
British Columbia	28.5	30.3	31.0	30.9	31.9	30.9	31.8
Yukon	26.8	29.2	29.7	29.5	30.2	29.7	30.6
Northwest Territories	..	..	28.9	..	29.9	..	30.1
Nunavut	..	..	25.7	..	25.9	..	26.4

Years[4]

Region	Observed	Projected (assumptions)					
	2011	Low		Medium		High	
		2018	2038	2018	2038	2018	2038
Canada	30.2	30.5	30.6	30.8	31.1	30.8	31.0
Newfoundland and Labrador	29.1	29.5	29.7	29.3	29.3	29.3	29.4
Prince Edward Island	29.4	29.5	29.6	29.9	30.2	29.6	29.7
Nova Scotia	29.4	29.5	29.6	29.8	30.0	29.8	30.0
New Brunswick	28.4	28.5	28.6	28.6	28.7	28.7	28.7
Quebec	30.1	30.5	30.7	30.5	30.6	30.8	31.0
Ontario	30.7	31.1	31.2	31.8	32.3	31.6	32.0
Manitoba	28.8	29.0	29.1	29.8	30.2	29.4	29.6
Saskatchewan	28.5	28.9	29.0	29.0	29.2	28.6	28.7
Alberta	29.7	30.0	30.1	30.1	30.3	30.2	30.4
British Columbia	30.9	31.3	31.4	32.4	33.1	31.7	32.0
Yukon	30.3	30.5	30.5	30.9	31.1	30.7	30.9
Northwest Territories	28.9	29.0	29.1	30.1	30.5	30.1	30.5
Nunavut	25.8	25.9	26.0	25.9	25.9	26.0	26.0

1. The mean age of childbearing's calculation is based on age-specific rates (and not actual number of births).
2. The 2013 *Opinion Survey on Future Demographic Trends* asked for targets for birth cohorts 1980 and 1990, which explains the choices of the cohorts in this table.
3. Latest cohort for which fertility rates are observed for the totality of the reproductive age span.
4. The 2013 *Opinion Survey on Future Demographic Trends* asked for targets for years 2018 and 2038, which explains the choices of the years in this table.

Source: Statistics Canada, Demography Division.

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Chapter 4: Projection of mortality

By Patrice Dion, Nora Bohnert, Simon Coulombe and Laurent Martel

Introduction

Mortality trends have been evolving slowly and in a generally linear fashion for almost a century. This consistent pattern facilitates projections of future death rates. Yet, in most countries, mortality projections have underestimated the rise in life expectancy (Lee and Miller 2001; Keilman 2007).

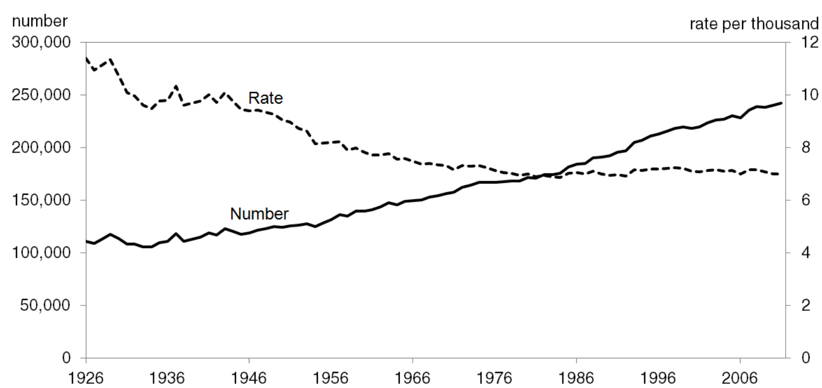
Expert opinion has also tended to provide fairly pessimistic views regarding future improvements in life expectancy (Booth and Tickle 2008; Lee and Miller 2001). These days, concerns about specific health issues such as obesity and diabetes lead some demographers to think that life expectancy at birth could stop its increasing trend (Olshansky et al. 2005). Still, others highlight the fact that past increases in life expectancy occurred in spite of some health issues such as widespread cigarette smoking (Shkolnikov et al. 2011).

Among the various components of population change used to formulate the population projections—that is, mortality, fertility and migration—mortality does not have the largest impact in terms of the total population. Unlike fertility or immigration, mortality generally has no compound effect on the future number of births. On the other hand, it does have a large impact on projections of the oldest ages of the population. While the main driver of the current population aging trend was fertility (Hyndman and Booth 2008), declining mortality trends at older ages in particular have intensified population aging and will continue to do so in the context of low and fairly stable fertility. Thus, plausible projections of mortality are of chief importance to informing welfare and public policy planning about future trends in population aging.

Mortality trends

Over the last century, the annual number of deaths in Canada has generally increased, reaching 242,100 in 2011 (Figure 4.1).[1] On the other hand, the crude death rate (the number of deaths per thousand persons) has fluctuated around 7.0 per thousand since the 1980s, following decreases between the 1950s and 1970s. The increase in the number of deaths over time can be attributed mostly to population growth but also to population aging. As the age structure of the population becomes older, a relatively larger proportion of the total population is found in the older age groups that experience higher rates of mortality.

Figure 4.1 Number of deaths and crude death rate, Canada, 1926 to 2011



Sources: Statistics Canada, Canadian Vital Statistics, Deaths Database, 1926 to 2011, Survey 3233 and Demography Division, Population Estimates Program.

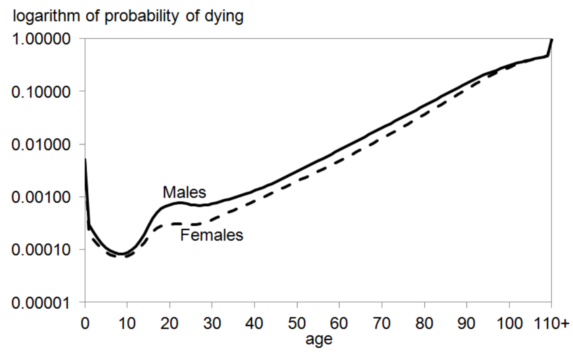
1. For more information on Canadian mortality for the years 2010 and 2011, see Martel (2013).

Mortality trends by age and sex

Over the lifespan, mortality rates follow a pattern similar to a checkmark shape: the mortality rate is higher in the first year of life; mortality rates then decline to their lowest levels in childhood and slowly increase throughout adulthood, reaching their highest levels at the very oldest ages (Figure 4.2). As in the past, in 2011, females experienced lower mortality rates than males at all ages.

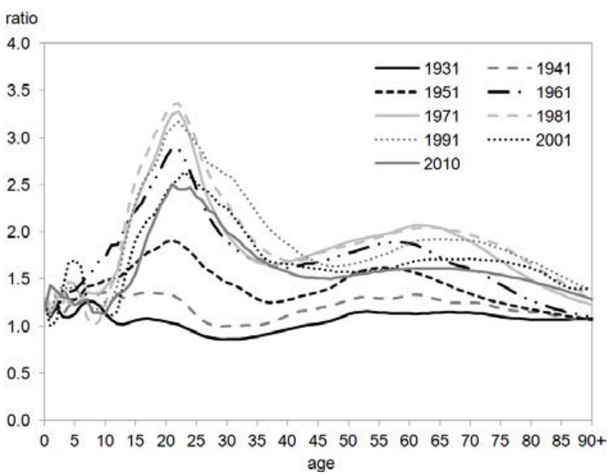
Life expectancy at birth is an indicator that is by nature strongly influenced by infant mortality trends. While reaching its lowest rate on record in 2011 (4.8 deaths per thousand live births), the infant mortality rate in Canada has been quite stable since the mid-1990s following a long period of decline. It is unlikely that this plateau of the infant mortality rate is a result of Canada approaching a 'natural limit', given that several other countries have posted lower rates in recent years.[2] Instead, it is likely that general reductions in infant mortality in Canada have been offset by various trends related to the increased prevalence of older mothers, in addition to increased recognition of birth registration requirements (Bohnert 2013).

Figure 4.2 Logarithms of probabilities of dying by age and sex, Canada, 2009/2011



Source: Statistics Canada. 2013. *Life Tables, Canada, Provinces and Territories 2009/2011*, Catalogue no. 84-537.

Figure 4.3 Male to female ratio of the probability of dying by age, Canada, selected years



Notes: Statistics Canada produces life tables for a three-year reference period. For ease of reading, each stated year refers to the middle ofthe three-year period. For example, '2010' refers to the period 2009 to 2011.

Sources: Statistics Canada, official life tables and Demography Division.

The elevated risk of death for males relative to females in young adulthood began to emerge as a pattern in the 1950s and reached its highest levels in the late 1970s and early 1980s (Figure 4.3), mostly a result of the higher risk among young males of deaths due to accidents, violence and suicide (Milan and Martel 2008). Since the 1980s, there has been a reduction in the sex differential in the probability of death in young adulthood, primarily the result of a larger decrease in the number of deaths from accidents and violence for males than for females in recent years. Between 1981 and 2010, a decline also occurred in the sex ratio of the probability of death in mid-adulthood (ages 45 to 69).[3] This trend is in part because the behavior of women (and associated risks of death) has become more similar to that of men over the last 40 years, particularly in the case of smoking behavior (Bélanger et al. 2001).

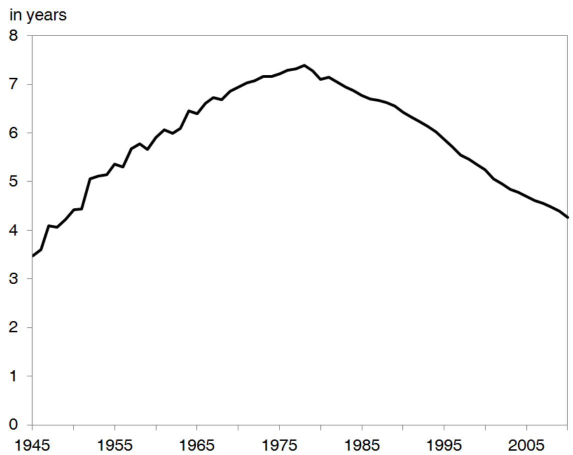
2. Canada's 2011 infant mortality rate was above the Organization for Economic Co-operation and Development (OECD) average for 2011 (or nearest year), that being 4.1 deaths per thousand live births. The OECD countries with the lowest 2011 infant mortality rates were: Japan (2.2), Sweden (2.1) and Iceland (0.9). Note that some variation in infant mortality rates may be due to differences among countries in the definition of live children following birth. Source: OECD Health Statistics (2013).

3. Note that in this chapter, statistics derived from Statistics Canada's official life tables (life expectancy at selected ages as well as probabilities of death) are based on a three-year reference period. For ease of reading, each stated year refers to the middle of the three-year period. For example, '2010' refers to the period 2009 to 2011. For details about mortality table calculations and methodology, see Martel et al. (2013).

In Canada, life expectancy has been increasing steadily throughout the 20th century. Between 1981 and 2010, male life expectancy at birth increased 7.4 years, from 71.9 to 79.3 years. Female life expectancy at birth gained 4.6 years, rising from 79.0 to 83.6 years. The gap in life expectancy at birth between Canadian males and females narrowed to 4.3 years in 2010 from its peak of 7.4 years at the end of the 1970s (Figure 4.4).

As seen in Figure 4.5, the average annual improvements in life expectancy for the period 1981 to 2010 have been higher for males than females at all ages. Particularly at ages 40 to 75, improvements for males have been on average more than 80% higher than for females of the same ages. For instance, male life expectancy at age 61 increased on average 0.9% per year during this period compared to an average increase of 0.5% for females of the same age. For males, the largest annual improvements have occurred during their early seventies (for example, a 1.1% annual increase at age 73) while improvements for females were largest during their late seventies (a 0.6% annual increase at age 79, for example).

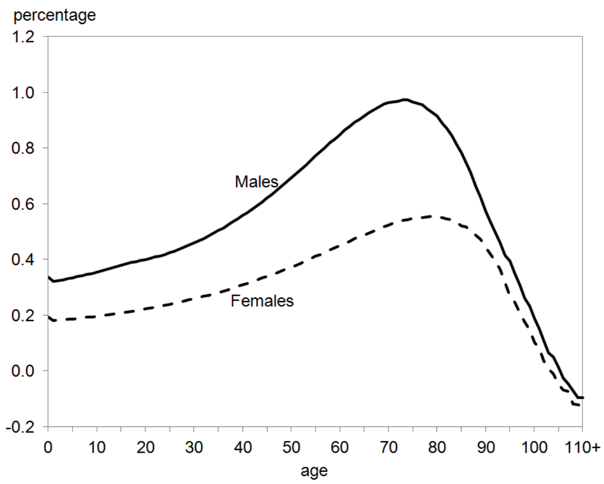
Figure 4.4 Difference (in years) between female and male life expectancy at birth, Canada, 1945 to 2010



Notes: Data for period the 1945 to 1980 are taken from annual life tables from the Canadian Human Mortality Database. Data for the period 1981 to 2010 are from life tables computed by the Demography Division based on a reference period of three years. For example, data for year '2010' in the chart are based on reference period 2009 to 2011.

Sources: Statistics Canada, Demography Division and Canadian Human Mortality Database.

Figure 4.5 Average annual percentage change in life expectancy, by age and sex, Canada, 1981/1982 to 2009/2010



Notes: Statistics Canada produces life tables for a three-year reference period. For ease of reading, each stated year refers to the middle of the three-year period. For example, '2010' refers to the period 2009 to 2011.

Sources: Statistics Canada, official life tables and Demography Division.

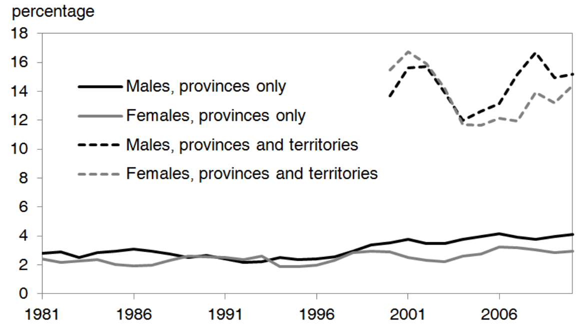
Mortality trends by region

As seen in Figure 4.6, there is no evidence that Canada's provinces and territories are becoming more similar, in terms of life expectancy at birth, over time. The provinces, while much closer to one another in terms of life expectancy at birth than the territories, have actually experienced a slightly increasing divergence over time, particularly among males: in 1981, the highest male provincial life expectancy at birth was 2.8% higher than the lowest provincial life expectancy. In 2010, this differential had increased to 4.1%. When including the territories, there is no evidence of either convergence or divergence of life expectancy since 2000.

Among the provinces and territories, British Columbia experienced the highest life expectancy at birth for both females and males in 2010, as has been the case for several consecutive years. The variation in life expectancy at birth among the provinces and territories was larger among males (11.5 years) than among females (10.5 years) that year. For both sexes, the lowest life expectancies were found in Nunavut (73.9 years for females and 68.8 for males).

Since its advent, Nunavut has experienced considerably higher mortality rates compared to other provinces and territories, especially among young adults (see a comparison with the province of Ontario in Figure 4.7). There is some evidence that in recent years, among regions with a high proportion of Aboriginal residents, "premature mortality"[4] was twice as high in young adulthood (ages 15 to 24) compared to regions with a low proportion of Aboriginal residents, with injuries (mainly suicides and motor vehicle accidents) being the largest contributor to the relatively elevated number of deaths at younger ages (Allard et al. 2004).

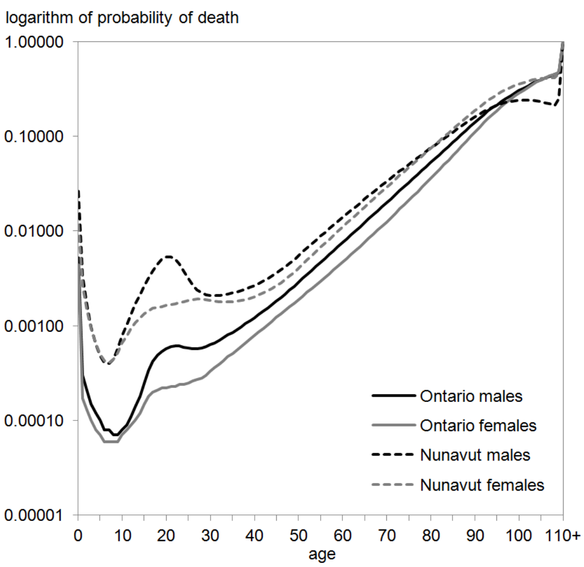
Figure 4.6 Difference (in percentage) between the highest and lowest life expectancy at birth, by sex, comparing the provinces only and the provinces and territories combined, 1981 to 2010



Notes: Statistics Canada produces life tables for a three-year reference period. For ease of reading, each stated year refers to the middle of the three-year period. For example, '2010' refers to the period 2009 to 2011.

Source: Statistics Canada, Demography Division.

Figure 4.7 Logarithm of probability of death by age and sex, Ontario and Nunavut, 2009/2011



Notes: Statistics Canada produces life tables for a three-year reference period. For ease of reading, each stated year refers to the middle of the three-year period. For example, '2010' refers to the period 2009 to 2011.

Sources: Statistics Canada, official life tables and Demography Division.

Nunavut and the Northwest Territories also tend to have higher infant mortality rates than the Canadian average, resulting in a widening of the variation in these rates among Canada's provinces and territories since the 1980s (Bohnert 2013).[5]

International trends in mortality

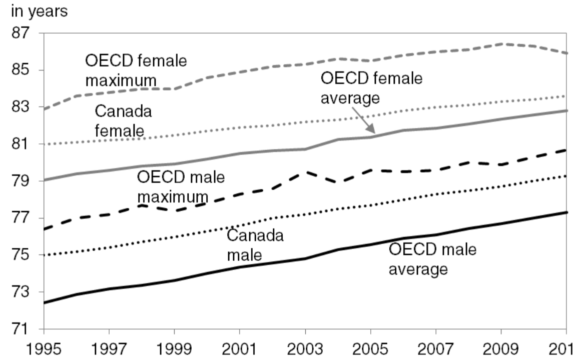
The evolution of best-practice life expectancy—the highest life expectancy observed among national populations—is an indication of the path that non-leading countries could follow. Shkolnikov et al. (2011) found that the best-practice life expectancy for both the years 1870 to 2008 and the birth cohorts 1870 to 1920 have increased steadily over time.

The life expectancies of Canadian males and females have both been above the average of OECD countries in recent decades (Figure 4.8), though they have never reached the maximum.[6] Taking the respective OECD average life expectancy at birth of the two sexes, the gap has narrowed from 6.6 years in 1995 to 5.5 years in 2011. In comparison, the gap was smaller

4. Allard et al. (2004) measure premature mortality in terms of "potential years of life lost". This measure gives greater weight to deaths at younger ages compared with other summary indices of mortality.
5. See Figure 4 of Bohnert (2013).
6. Since 1995, the maximum male life expectancy at birth has been registered in Japan, Switzerland or Iceland. The maximum female life expectancy at birth has been consistently registered in Japan since 1995. Source: OECD Health Statistics 2013.

between Canadian males and females (4.3 years). In recent years, the life expectancy at birth of Canadian males has been closer to the leading country than that of Canadian females, reflecting the fact that Canadian male life expectancy improvements have been relatively strong over the last few decades. For example, in 2011, the maximum male life expectancy at birth, registered in Iceland, was 1.8% higher than that of Canadian males; while the maximum female life expectancy at birth, registered in Japan, was 2.8% higher than that for Canadian females.

Figure 4.8 Life expectancy at birth, Canada, OECD average and OECD maximum, by sex, 1995 to 2011



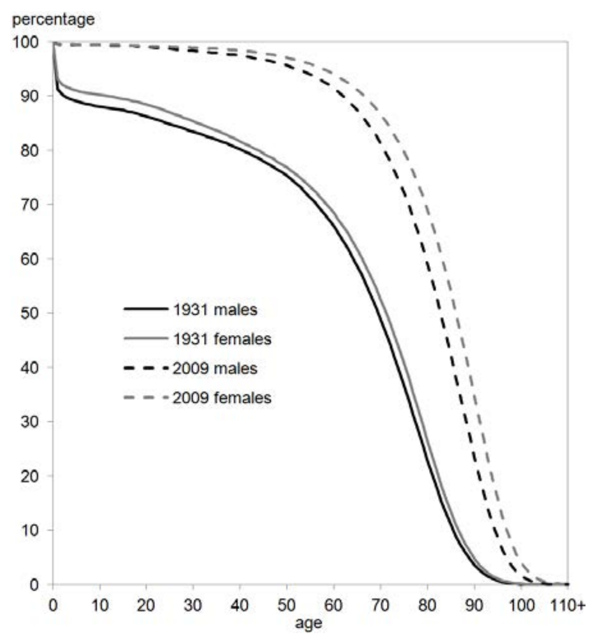
Note: 2011 life expectancy at birth data were available for 11 of the 34 OECD countries as of the time of writing of this report.

Source: OECD Health Status 2013 http://stats.oecd.org.

In many countries, a pattern referred to as 'rectangularization' or 'compression' of mortality has been observed to varying extents. Compression of mortality occurs when the proportion of persons in a population surviving to advanced ages increases. As a result, the survival curve increasingly takes on a rectangular shape as proportionally more mortality occurs at later and later ages. There is continuing debate as to whether complete rectangularization of mortality will eventually occur, meaning that all deaths would occur at roughly the same very advanced age. This would imply a fixed, predetermined biological limit to human survival (Manton and Singer 2002).

Figure 4.9

Proportion (in percentage) of persons in a synthetic cohort surviving from birth to age *x*, by sex, Canada, 1931 and 2010



Notes: Statistics Canada produces life tables for a three-year reference period. For ease of reading, each stated year refers to the middle of the three-year period. For example, '2010' refers to the period 2009 to 2011.

Sources: Statistics Canada, official life tables and Demography Division.

As seen in Figure 4.9, there is some evidence that mortality has become increasingly compressed (concentrated at older ages) in Canada. In 1931, 91.3% of males belonging to a synthetic cohort would have remained alive from birth to age one, compared to 99.5% of males in 2010. Similarly, in 1931, approximately three-quarters (75.2%) of males survived from birth to age 50, while by 2010, this proportion had increased to 97.3%. Similar improvements have occurred for females. While the curves in 2010 are more rectangular in shape than in 1931, the substantial extension in the length of the 2010 curves compared to those of 1931 suggests that Canada is not yet approaching a theoretical upper limit to life expectancy of a population.

Alternative approaches to measuring average human longevity, such as the modal age of death, suggest that rectangularization or compression of mortality, while still present among males in most countries, is no longer occurring among females in many low mortality countries including Canada. Instead, evidence of a "shifting mortality regime", whereby the majority of deaths shift to older and older ages, was found among females in Canada, the United States, France and Japan by Ouellette and Bourbeau (2011).

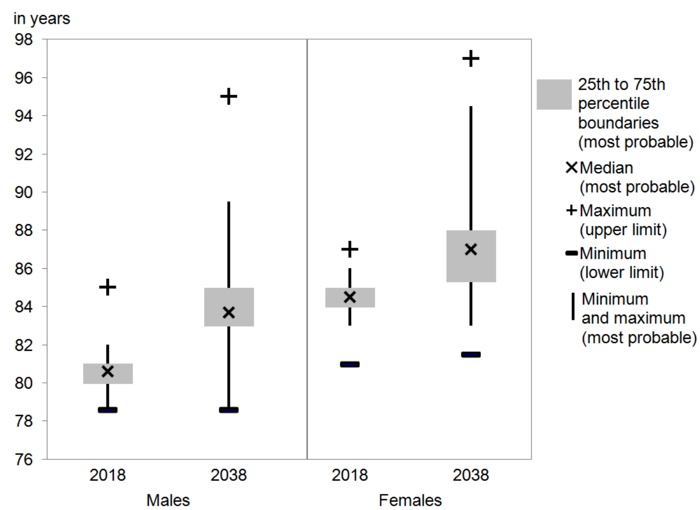
Ouellette and Bourbeau (2011) also find evidence that the long-lasting upward trend in the modal age of deaths slowed down substantially among Japanese men and has leveled off for Japanese women since the early 2000s. These recent developments could indicate that Japanese men and women—world leaders in human longevity—are approaching longevity limits in terms of modal lifespan. Indeed, Japanese female life expectancy at birth, while remaining the maximum registered among OECD countries, actually decreased slightly between 2009 (86.4 years) and 2011 (85.9 years). If, in the coming years, maximum female life expectancy were to stabilize, this might support theories that there is in fact an ultimate 'ceiling' or limit to human longevity. Many researchers, however, posit that future advancements in biomedical innovations and other genetic-environmental interactions could alter any genetically fixed limits to life expectancy, if indeed they might exist (Manton and Singer 2002).

Survey results

Results from the 2013 *Opinion Survey on Future Demographic Trends* suggest that Canadian demographers unanimously anticipate further improvement in life expectancy; however, differences emerged regarding the expected pace of this improvement and whether it might be of an indefinite or finite nature.

In the short term, respondents anticipate a considerable increase from the most recently observed levels of 78.6 years for males and 83.1 years for females, respectively: the median response of the most likely estimate of life expectancy at birth in 2018 is 80.6 years for males and 84.5 years for females (Figure 4.10). This would represent an increase of 2.5% for males and 1.7% for females from 2010. In comparison, the observed improvements between 2001 and 2010 were 3.5% and 2.0%, respectively.[7]

Figure 4.10 Summary statistics for the 2013 *Opinion Survey on Future Demographic Trends* regarding estimates of the life expectancy at birth, by sex, Canada, 2018 and 2038



Source: Statistics Canada, Demography Division.

Variation in the most probable estimates of life expectancy at birth in 2038 are relatively large, especially at the upper range of responses and more so for estimates of female life expectancy than for male life expectancy. This may reflects respondent knowledge of the fact that that previous projections (both in Canada and other countries) have consistently underestimated improvements in mortality (Lee and Miller 2001, Keilman 2007); consequently, respondents were perhaps more open to a wider range of possible improvements in the long-term future. For males, the estimates of the most likely life expectancy at birth range from 78.6 to 89.5 years while for females the range is between 83.1 and 94.5 years. Median values for the most probable estimates of life expectancy at birth in 2038 are 83.9 for males and 86.6 for females (Figure 4.10).

Additionally, while respondents generally estimated a closing of the mortality gap between the sexes, there remained a sizeable gap estimated in 2038: taking the median responses of the most probable estimates, the gap between the sexes would be 3.9 years in 2018 and 3.3 years in 2038 compared to the most recently observed gap of 4.3 years in 2010.

7. Table 4, Bohnert (2013).

To support their estimates, respondents most commonly mentioned the historical trend of continued decrease in mortality in Canada and other developed countries over the last century. In general, respondents mentioned that further advancements in medical technology, health care and health prevention could be expected; many also expected positive lifestyle changes at the population level related to smoking, diet and exercise. Respondents also mentioned factors that could slow the rate of mortality improvement in the future such as growing economic inequality and environmental changes.

Regarding mortality trends by sex, respondents generally expressed the view that there would be a continued convergence of male and female life expectancy in the future, but only to a certain point, which would be biologically fixed. In terms of age-specific mortality trends, little change in infant and child mortality was anticipated, while several respondents expected continued rectangularization of mortality and greater improvements at older ages.

Methodology

More than any other component of demographic growth, mortality lends itself to projections based on the extrapolation of past data. Indeed, life expectancy has been increasing steadily and generally following a linear trend, more so than trends for other demographic indicators such as the total fertility rate or the immigration rate. As in the past edition, the Li-Lee (2005) method (more details below in the "Method for coherent projections" section) was used for the projection of future mortality rates of the different provinces and territories. Some improvements have been incorporated in this edition, the most notable being the implementation of the 'Extended Lee-Carter' model for modeling the evolution of the age patterns of mortality decline (Li et al. 2013).

Input data

Mortality data from 1981 to 2010 were used for the projection of future mortality rates. More specifically, age- and sex-specific death rates from Statistics Canada's most recent life tables were used with some modifications.[8] The eventual life expectancies reached were not set in advance as they were determined by the extrapolation process (described below); however, the choice of the reference period has a large impact on the assumptions. The 1981 to 2010 period used in the projection of mortality was generally characterized by a decline in mortality and the steady narrowing of the gap in life expectancy at birth between males and females.

Note that using modeled[9] rates from the life tables rather than observed rates adds robustness to the trends while also addressing, to a certain extent, issues related to small numbers in some regions (of deaths, population or both) when projecting the individual provinces and territories separately. However, some further necessary adjustments were implemented. In the logic of Statistics Canada's life table formulation, when missing values prevented the calculation of mortality rates at some ages, data from a higher-level geography was used (for example, if a mortality rate was missing at a certain age for Prince Edward Island, the rates for all of the Atlantic provinces combined was substituted).

Distinct procedures were used for the projection of mortality rates in the territories where the issues of small numbers and missing values were considerable. In order to obtain plausible base rates for the projection, special aggregate life tables were built for each territory made from the most recent 12 years of observed data. This procedure was, however, insufficient to model the rates after age 80.

8. New life tables were produced to take into account updates to the population estimates following the 2011 Census. The updated intercensal population estimates from 2006 to 2011 included a revision of the size of the old-age populations and these revisions affected the remaining life expectancy of these populations, although the impact of their life expectancy at birth was minor.
9. For details on life table calculation and methodology see Martel et al. (2013).

For this reason, the rates for ages 80 and over were set to follow what was observed at the Canada level at these ages during the same 12 years period, that is, the growth rate of mortality rates from one age to the next is "borrowed" from the age structure of mortality rates at the Canada level. A last step consisted of adjusting those rates so that the life expectancy at birth was identical to the life expectancy published in the abridged life tables for the territories for the latest year (2010). All these steps were designed to preserve as much as possible the very distinct patterns of mortality observed in each territory and that serve as the starting point for the projection. Note that the aggregation of data in a temporal perspective had no consequence on the modeling of past trends for the territories because this modeling was based strictly from data at the Canada level only, due to the same issues of small numbers and missing data (more details follow in the next section).

Method for coherent projections

Projection methods that place emphasis on limiting divergence between groups are typically labeled 'coherent'. Coherence is often considered preferable over divergence when it is expected that the factors which influence mortality trends are likely to affect all groups or regions in a country in a similar way, thus, limiting the extent of divergences. There are many reasons to believe that this reasoning should be applied to Canada. As seen earlier, there is no strong evidence of divergence (nor convergence) of life expectancy among the provinces and territories to date (Figure 4.6).

The Li-Lee method (Li and Lee 2005) was adapted from the commonly-used Lee-Carter method (Lee and Carter 1992) specifically to handle situations where coherence of the mortality projections of different groups is desired. The demonstrated robustness of the Lee-Carter method (Lee and Miller 2001; Booth 2006), its ability to project all provinces and territories in a coherent manner in its modified version by Li and Lee (2005), combined with its relative simplicity are key advantages for the projection of future mortality patterns in Canada. Specifically, the Lee-Carter method permits the projection of age and time patterns as two separate components. While the age component exhibits little variance over time, the time component is a highly linear time series that can be easily extrapolated. However, unlike the Lee-Carter method, the Li-Lee method limits the divergence of projections calculated for separate groups—in this case, the individual provinces and the territories—by using two components: a factor common to all provinces and territories and another factor specific to each.

As per the Li-Lee method, the log of age-specific mortality rates for each group (individual province or territory, sexes separated) is modeled as follows:

$$\ln\left(m_{x,t}\right) = a_{x,i} + B_x K_t + b_{x,i} k_{t,i} + \varepsilon_{x,t,i} \qquad 4.1$$

where, $a_{x,i}$ is the average of $\ln\left(m_{x,t}\right)$, at age x over T number of years (t=1,2,…,T), $B_x K_t$ represents the common factor model applied equally to all groups i, and $b_{x,i} k_{t,i}$ represents the model specific to each group i. Note that through projecting the logarithm of age-specific mortality rates, the possibility of obtaining negative rates is avoided.

In the common model, $\boldsymbol{B}$ is a vector of coefficients quantifying the change in the death rate at all ages associated with the scalar K_t, the general time trend parameter. For a given sex, the common model applies to Canada. The first step consists of applying singular value decomposition (SVD) to a matrix $\boldsymbol{A}$ whose elements $a_{x,t}$ are calculated as $\ln\left(m_{x,t}\right) = a_x$. The SVD is used as a technique of data reduction to obtain, from the matrix $\boldsymbol{A}$, the first-order vectors $\boldsymbol{K}$ and $\boldsymbol{B}$, with the constraint that the sum of all elements of $\boldsymbol{B}$ must equal one, and the sum of all elements of $\boldsymbol{K}$ must equal 0.[10] These constraints ensure that only one solution is derived from the SVD. The second step consists of adjusting the K_t values from the $\boldsymbol{K}$ vector to match the observed life expectancy. Then, in a third step, the K_t values are extrapolated using the ARIMA time series method. Specifically, a Random Walk with Drift (RWD) process is used, which in this context is known for its good performance, simplicity and straightforward interpretation (Li et al. 2004):

$$K_t = K_{t-1} + d + e_t\sigma, e_t \sim N(0.1) \qquad 4.2$$

where d is the drift term, a deterministic component reflecting the time trend, and σ is a stochastic component, the standard deviation of random changes in K_t. The projection of an age-specific mortality rate over *n* years at the Canada level, $m_{x,t+n}$, is calculated as:

$$e^{a_x + B_x K_t} \qquad 4.3$$

The above model does not take into account specific mortality patterns in the provinces and territories. The calculation of these specific factors follows roughly the same logic as that of the common factor. In a first step, $b_{x,i}\,k_{t,i}$, the specific factor for a given region *i* is computed by applying a SVD decomposition to the matrix of the residuals of the common factor model, each matrix entry being computed as:

$$\ln(m_{x,t,i}) - a_{x,i} - B_x K_t \qquad 4.4$$

The $k_{t,i}$ values are then extrapolated using an ARIMA model, this time an auto-regressive model (AR1):

$$k_{t,i} = c0_i + c1_i K_{t-1,i} + e_{t,i}\sigma_i, e_{t,i} \sim N(0.1) \qquad 4.5$$

where $c0_i$i and $c1_i$ are coefficients and σ_i is the standard deviation of the model. The AR1 model allows the specific factor to eventually converge to a constant value (Li and Lee 2005).[11] Consequently, the specific factors create distinct patterns for each region that weaken over time, thus the achievement of coherent projections among the provinces and territories.

The Li-Lee method was used for the projection of mortality rates in all provinces. In the territories, it was deemed preferable to use only the common factor due to the small number of observations and small populations involved.[12]

It should be noted that using this method, coherence is obtained between regions, but nothing is explicitly done to preserve some coherence between males and females. Although mortality rates are projected

10. SVD permits the decomposition of any matrix $\mathbf{A}$ of *m* rows by *n* columns into three matrices: a matrix $\mathbf{U}$ of *m* by *m*, a matrix $\mathbf{V}$ of *n* by *n*, and a diagonal matrix $\mathbf{S}$ of *m* by *n*. Technically, the product of $\mathbf{U}$, $\mathbf{S}$ and the transpose of $\mathbf{V}$ equals $\mathbf{A}$, so that $\mathbf{A} = \mathbf{USV}^T$. Specifically, columns of $\mathbf{U}$ are orthonormal eigenvectors of $\mathbf{AA^T}$, columns of $\mathbf{V}^T$ are orthonormal eigenvectors of the matrix $\mathbf{A^T A}$, and entries $s_{i,i}$ of $\mathbf{S}$ are scaling factors for these eigenvectors, corresponding to the square root of eigenvalues of matrices $\mathbf{U}$ and $\mathbf{V}^T$. Matrix $\mathbf{A}$ is composed of 31 columns (years) and 111 rows (ages), $\mathbf{U}$ is a matrix of 31 by 31, $\mathbf{V}^T$ is a matrix of 111 by 111 and $\mathbf{S}$ is a matrix of 31 by 111. Vector $\boldsymbol{B}$ is then equal to the first (column) vector of the matrix $\mathbf{U}$ divided by a scalar consisting of the sum of all entries in this column (so that the sum of all entries B_x of the vector $\boldsymbol{B}$ is equal to one). The vector $\boldsymbol{K}$ is then defined as the first column of matrix $\mathbf{V}^T$ multiplied by the scalar consisting of the first entry of matrix $\mathbf{S}$, multiplied by the scalar consisting of the sum of all entries in the first column of matrix $\mathbf{U}$. While more than one set of factors could be used, first-order approximation tends to fit the data reasonably well when forecasting all causes of mortality simultaneously (Girosi and King 2007).
11. More specifically, the model eventually yields a stationary (independent of time) time series. Like the RWD model used for the common factor, the value at time *t* is regressed on the previous value (*t-1*) in the AR1 model. However, the deterministic factor of the lagged values slowly disappears with time (given that *c*1 is smaller than one, as should be the case) leaving only the stochastic factor.
12. This is similar to Lee and Nault's (1993, in Li and Lee 2005) suggestion: using the same B_x and K_t parameters for each province.

separately for males and females, results for the provinces, while not technically coherent, do not diverge as time goes by. Rather, they exhibit slow convergence in future life expectancy of males and females (as will be seen later), due to the fact that these trends were observed throughout the reference period chosen.[13] An adjustment was necessary in the territories however, without which the projected male life expectancy would eventually surpass that of females over the course of the projection. As this future trend is unlikely, the situation was remedied by setting the changes in mortality rates for males to adopt those projected for females in a gradual fashion over time.

Finally, the estimation of the B_x often lent negative values at old ages, which imply increasing mortality rates over time. While not impossible,[14] this is likely an artifact of the procedures used in the life tables to model mortality at old ages, necessitated by the presence of missing or volatile data. For this reason, the B_x values were set to decrease from age 90 to 110 following an exponential decay.

Rotation of the age patterns of mortality decline

Most models of projecting mortality rates, including the Li-Lee model, keep the age pattern of changes constant over time (B_x). However, as Li et al. (2013) note, this has important implications for long-term projections, as the projected age schedule of mortality tends to depart in the long-term from what it should be in light of evolution theory. For example, it is theorized that evolutionary forces shape the age schedule of mortality such that the lowest risk of mortality occurs at the peak reproductive ages. Based on these principles, Li et al. suggested that the curve of (log) mortality rates should keep its checkmark shape, as described earlier in this chapter.

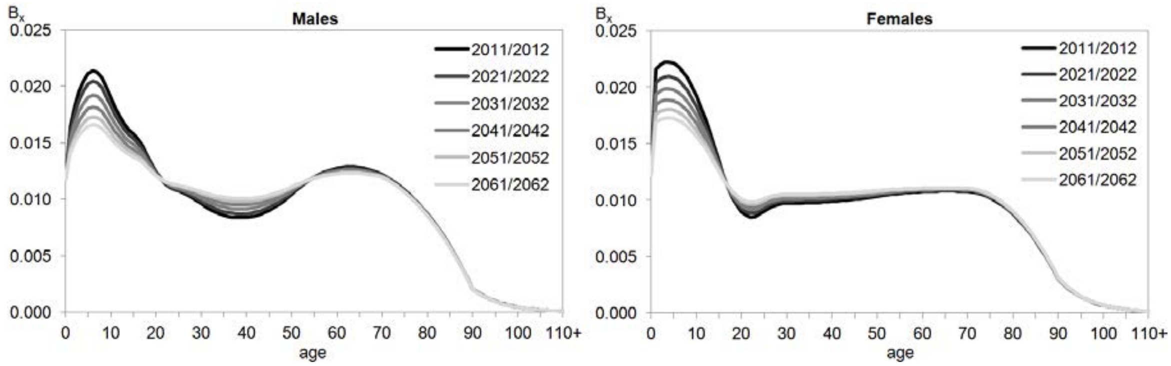
Li et al. note that in the past, rates of mortality decline have been changing, usually performing a "rotation" where rates of changes at older ages accelerated and those at younger ages slowed down. However, these changes are difficult to project. Consisting of second-order differences of the mortality rates, rates of age-specific mortality decline carry larger random fluctuations than changes in the mortality rates themselves. Moreover, Li et al. note that there is not a strong empirical basis that would allow for a data-driven method of accomplishing this task. For these reasons, they suggest to have the B_x structure evolve over time to reach a smoother shape that will help preserve the checkmark shape of mortality rates by age. As a result, the B_x structure becomes flatter and contains less and less information in terms of age heterogeneity over time, as uncertainty grows. The rotational model focuses primarily on the historical declining trend of the ratio or m_0 to m_{15-19}, but also makes assumptions at other ages (see Li et al. 2013 for more details).

A consequence of the rotational model is that by modifying the pattern of the B_x, the projected life expectancies may change in a somewhat arbitrary way. To prevent this, the K_t parameters are iterated so that the projected life expectancy remains unchanged in comparison to the results

13. While the projected life expectancy for males does not surpass that of females in the time span of the projection, it is possible that this could occur over a longer projection horizon.

14. Vaupel et al. (1979) showed that it is important to take into account the distribution of frailty among individuals in a cohort, although this is difficult to measure. The theory of heterogeneity suggests that when mortality is high, individuals that are more frail will tend to die at a relatively young age. In this context, the survivors can be seen as made of a more "robust" portion of the original cohort. When general mortality decreases, the selection effect is weaker and individuals who would have died earlier were they born from an earlier cohort, instead survive to older ages, thus increasing the frailty variance at these ages. Vaupel et al. (1979) showed that in some conditions, this can cause the mortality rates at old ages to be higher for cohorts with lesser general mortality. Other points of view exist however. For instance, some studies show that, from a cohort perspective, declines in mortality at younger ages are in large part the results of lower exposure to certain mortality risks or a higher resistance to these risks (that is, there is greater overall robustness in more recent cohorts), factors that have contributed to the decline in mortality rates at older ages in the past (see Zheng 2014 for a comparison of these theories on the evolution of old-ages mortality rates).

Figure 4.11 Projected B_x for selected years, by age and sex, Canada



Source: Statistics Canada, Demography Division.

obtained without rotation.[15] Hence, the method aims to achieve a more realistic age structure of the projected death rates without modifying life expectancy at birth. Figure 4.11 shows the evolution of the structure of the B_x during the projection.

Dealing with uncertainty

The model described up to this point has been used for the production of a medium mortality assumption. A low and a high mortality assumption were also built in order to reflect the uncertainty associated with the projection of future mortality. To obtain a plausible confidence interval around the medium assumption, the values for the 80% confidence interval of life expectancy at birth for 2038 estimated by experts in the *Opinion Survey on Future Demographic Trends* were used as targets for the low and high mortality assumptions. Specifically, the targets were set so that the variation between the medium assumption and the low and high assumptions was the same as that observed in the survey results between the median values for the 80% confidence intervals and the median for the most probable value.[16] The life expectancy targets were reached by modifying the K_t factors, through an iterative process, so that they depart gradually from the K_t factors of the medium assumption over time.

It should be noted that using the values from the survey ensures a consistent way to handle uncertainty from one component to the next. Moreover, using the survey values provides a reasonable level of uncertainty in the projection in comparison to what is obtained with the Li-Lee model, in which the uncertainty of the whole model is estimated from the variance associated with the projection of the mortality parameters—the time-varying factors. As D'Amato et al. (2011), Liu and Braun (2010), and Koissi et al. (2006) note, the Li-Lee model is expected to underestimate uncertainty as it excludes other sources of uncertainty such as the sampling errors in the parameters.

Although the uncertainty is instilled identically through the K_t factor in the same provinces and territories, the resulting variations in life expectancy are not identical. In fact, each region has a distinct age-structure of mortality rates that makes their life expectancy at birth more or less sensitive to changes. This is because life expectancy at birth will react more with changes at young ages than at old ages. Thus, regions where mortality rates are relatively high at young ages have more room for improvements at these ages, and generally show more variations in the low and high assumptions than others.

15. Only the common factor model is modified; the specific factor models remaining unchanged. Since each province and territory has unique life expectancy targets by sex, the original K_t values that were identical in the common factor for a given sex now diverge slightly.

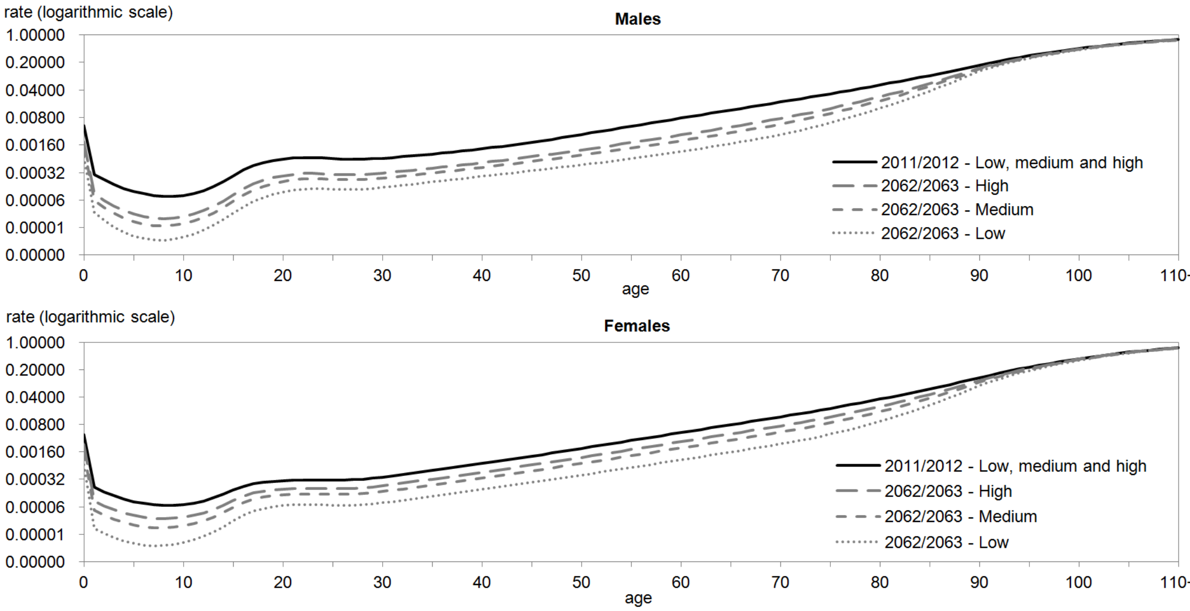
16. The projected values for life expectancy at birth were very close to the median of the most probable values obtained in the survey (see next section).

Assumptions

As described earlier, three distinct mortality assumptions were built, representing low, medium and high mortality situations. Figure 4.12 shows the projected age-specific death rates by sex at the Canada level for each assumption at the beginning and end of the projection. It can be seen that the checkmark shape has been preserved over the course of the projection, thanks in large part to changes in the age structure of the rates of mortality decline (the B_x parameter).

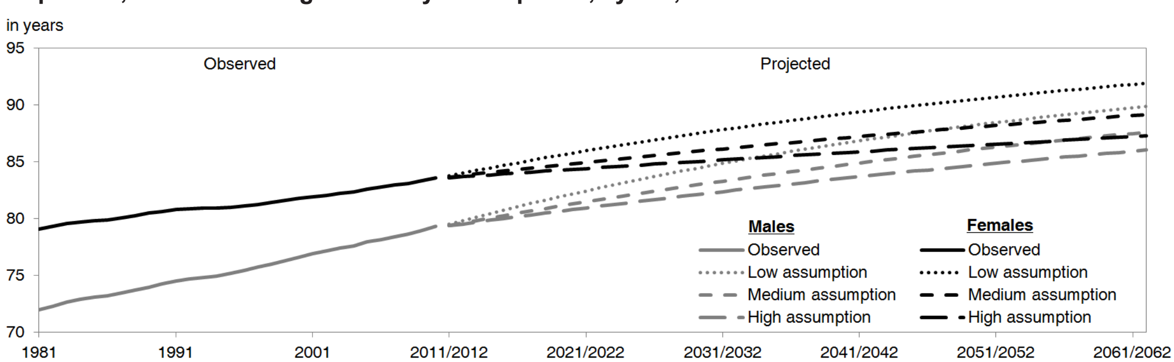
In all assumptions, life expectancy at birth at the national level would increase, but at different speeds (Figure 4.13). The increase in life expectancy at birth is projected in all provinces and territories for all assumptions (Tables 4.1, 4.2 and 4.3). The gap in life expectancy at birth between males and females is projected to continue decreasing in all assumptions.

Figure 4.12 Projected age-specific death rates at the beginning and at the end of the projection, for the low, medium and high mortality assumptions, by sex, Canada



Source: Statistics Canada, Demography Division.

Figure 4.13 Life expectancy at birth, observed (1981 to 2010) and projected (2011/2012 to 2062/2063) as per low, medium and high mortality assumptions, by sex, Canada



Notes: Statistics Canada produces life tables for a three-year reference period. For ease of reading, each stated year refers to the middle of the three-year period. For example, '2010' refers to the period 2009 to 2011.

Source: Statistics Canada, Demography Division.

Table 4.1 Life expectancy at birth, observed (1990 to 2010) and projected according to the medium mortality assumption (2012/2013 to 2062/2063), by sex, for Canada, provinces and territories, for selected years or periods

Region	1990	1995	2000	2005	2010	2012/ 2013	2017/ 2018	2022/ 2023	2027/ 2028	2032/ 2033	2037/ 2038	2042/ 2043	2047/ 2048	2052/ 2053	2057/ 2058	2062/ 2063
	in years															
Males																
Canada	74.1	75.1	76.5	77.8	79.1	79.6	80.7	81.7	82.6	83.5	84.3	85.1	85.8	86.4	87.0	87.6
Newfoundland and Labrador	73.1	74.5	75.1	76.0	77.2	77.7	79.0	80.2	81.3	82.2	83.1	84.0	84.7	85.4	86.1	86.7
Prince Edward Island	73.3	74.4	75.6	76.8	78.2	78.7	80.0	81.1	82.1	83.0	83.8	84.6	85.4	86.1	86.7	87.4
Nova Scotia	73.2	74.3	75.8	77.0	78.3	78.4	79.5	80.6	81.6	82.5	83.3	84.2	84.9	85.6	86.3	86.9
New Brunswick	72.9	73.9	75.4	76.5	77.9	78.8	80.0	81.0	82.0	82.9	83.8	84.5	85.3	86.0	86.6	87.2
Quebec	73.2	74.4	76.2	77.6	79.3	79.8	80.7	81.7	82.6	83.4	84.2	85.0	85.7	86.3	86.9	87.5
Ontario	74.6	75.5	77.0	78.3	79.6	80.1	81.1	82.1	83.0	83.8	84.6	85.4	86.1	86.7	87.3	87.9
Manitoba	74.0	73.9	75.0	76.0	77.5	78.1	79.4	80.6	81.7	82.6	83.5	84.4	85.1	85.8	86.5	87.1
Saskatchewan	75.2	75.2	76.3	77.4	77.2	77.7	79.1	80.3	81.4	82.5	83.5	84.4	85.2	86.0	86.7	87.3
Alberta	74.4	75.5	76.8	77.6	78.8	79.4	80.6	81.6	82.6	83.5	84.3	85.1	85.8	86.5	87.1	87.7
British Columbia	75.1	76.0	77.3	78.7	79.9	80.4	81.5	82.4	83.3	84.2	85.0	85.7	86.4	87.0	87.6	88.1
Yukon	71.5	72.5	73.2	74.1	75.4	75.9	77.1	78.2	79.2	80.2	81.1	81.9	82.7	83.4	84.1	84.7
Northwest Territories	73.9	73.6	74.5	76.0	76.2	76.7	77.9	78.9	79.9	80.9	81.7	82.5	83.3	84.0	84.6	85.2
Nunavut	66.3	65.9	67.1	69.4	69.7	70.3	71.9	73.4	74.7	75.9	77.1	78.1	79.0	79.9	80.7	81.4
Females																
Canada	80.6	80.9	81.7	82.5	83.4	83.8	84.5	85.1	85.7	86.3	86.8	87.3	87.8	88.3	88.7	89.2
Newfoundland and Labrador	79.1	79.9	80.2	80.8	82.1	82.3	83.1	83.8	84.4	85.0	85.6	86.1	86.6	87.1	87.6	88.1
Prince Edward Island	80.1	81.1	81.4	81.7	83.0	83.5	84.3	84.9	85.5	86.1	86.7	87.2	87.7	88.2	88.7	89.1
Nova Scotia	80.3	81.1	81.5	82.1	82.9	82.9	83.7	84.4	85.0	85.6	86.2	86.8	87.3	87.8	88.3	88.7
New Brunswick	79.9	80.2	81.0	81.7	82.5	83.4	84.2	84.9	85.5	86.0	86.6	87.1	87.6	88.1	88.5	89.0
Quebec	80.5	80.9	81.8	82.6	83.5	83.9	84.5	85.1	85.7	86.3	86.9	87.4	87.9	88.3	88.8	89.2
Ontario	81.0	81.4	82.1	82.9	83.8	84.1	84.8	85.4	86.0	86.5	87.0	87.5	88.0	88.5	88.9	89.3
Manitoba	80.2	80.7	81.0	81.6	82.0	82.4	83.3	84.1	84.8	85.5	86.2	86.8	87.3	87.8	88.3	88.8
Saskatchewan	81.3	81.4	82.0	82.0	82.1	82.5	83.3	84.1	84.9	85.6	86.2	86.8	87.4	87.9	88.4	88.9
Alberta	80.6	81.3	81.8	82.6	83.3	83.7	84.5	85.1	85.7	86.3	86.8	87.4	87.9	88.3	88.8	89.2
British Columbia	81.3	81.6	82.4	83.1	84.0	84.4	85.0	85.6	86.2	86.7	87.3	87.8	88.2	88.7	89.1	89.5
Yukon	78.0	78.5	79.3	77.6	80.3	80.7	81.4	82.1	82.8	83.5	84.1	84.7	85.2	85.8	86.3	86.8
Northwest Territories	76.8	78.7	77.7	80.7	79.9	80.3	81.0	81.8	82.4	83.1	83.7	84.3	84.9	85.5	86.0	86.5
Nunavut	69.9	72.2	71.0	74.7	73.8	74.2	75.2	76.1	77.0	77.9	78.8	79.6	80.3	81.1	81.8	82.4

Sources: Statistics Canada. 2013. *Life Tables, Canada, Provinces and Territories: 2009 to 2011*, catalogue no. 84-537 and Demography Division.

Table 4.2 Life expectancy at birth, observed (1990 to 2010) and projected according to the low mortality assumption (2012/2013 to 2062/2063), by sex, for Canada, provinces and territories, for selected years or periods

Region	1990	1995	2000	2005	2010	2012/ 2013	2017/ 2018	2022/ 2023	2027/ 2028	2032/ 2033	2037/ 2038	2042/ 2043	2047/ 2048	2052/ 2053	2057/ 2058	2062/ 2063
	in years															
Males																
Canada	74.1	75.1	76.5	77.8	79.1	79.8	81.3	82.7	84.0	85.1	86.1	87.0	87.9	88.6	89.3	89.9
Newfoundland and Labrador	73.1	74.5	75.1	76.0	77.2	77.9	79.7	81.3	82.7	83.9	85.1	86.1	87.0	87.8	88.5	89.2
Prince Edward Island	73.3	74.4	75.6	76.8	78.2	78.9	80.6	82.1	83.5	84.7	85.7	86.7	87.6	88.4	89.1	89.8
Nova Scotia	73.2	74.3	75.8	77.0	78.3	78.6	80.2	81.7	83.0	84.2	85.3	86.3	87.1	87.9	88.7	89.3
New Brunswick	72.9	73.9	75.4	76.5	77.9	79.0	80.6	82.1	83.4	84.6	85.6	86.6	87.5	88.3	89.0	89.6
Quebec	73.2	74.4	76.2	77.6	79.3	79.9	81.4	82.7	83.9	85.0	86.0	86.9	87.8	88.5	89.2	89.8
Ontario	74.6	75.5	77.0	78.3	79.6	80.3	81.7	83.1	84.3	85.4	86.4	87.3	88.1	88.8	89.5	90.1
Manitoba	74.0	73.9	75.0	76.0	77.5	78.3	80.1	81.7	83.1	84.4	85.5	86.5	87.4	88.2	88.9	89.5
Saskatchewan	75.2	75.2	76.3	77.4	77.2	77.9	79.8	81.4	82.9	84.3	85.5	86.5	87.5	88.3	89.0	89.7
Alberta	74.4	75.5	76.8	77.6	78.8	79.6	81.2	82.7	83.9	85.1	86.1	87.1	87.9	88.6	89.3	89.9
British Columbia	75.1	76.0	77.3	78.7	79.9	80.6	82.1	83.4	84.6	85.7	86.7	87.6	88.4	89.1	89.7	90.3
Yukon	71.5	72.5	73.2	74.1	75.4	76.1	77.8	79.4	80.8	82.1	83.3	84.4	85.3	86.2	87.0	87.7
Northwest Territories	73.9	73.6	74.5	76.0	76.2	76.9	78.6	80.1	81.5	82.7	83.8	84.9	85.8	86.6	87.3	88.0
Nunavut	66.3	65.9	67.1	69.4	69.7	70.6	72.9	75.0	76.9	78.6	80.1	81.5	82.7	83.8	84.8	85.7
Females																
Canada	80.6	80.9	81.7	82.5	83.4	84.0	85.1	86.2	87.1	88.0	88.8	89.5	90.2	90.8	91.4	91.9
Newfoundland and Labrador	79.1	79.9	80.2	80.8	82.1	82.5	83.8	84.9	85.9	86.8	87.7	88.5	89.2	89.8	90.5	91.0
Prince Edward Island	80.1	81.1	81.4	81.7	83.0	83.7	84.9	86.0	87.0	87.9	88.7	89.5	90.2	90.8	91.4	91.9
Nova Scotia	80.3	81.1	81.5	82.1	82.9	83.1	84.4	85.5	86.6	87.5	88.4	89.1	89.9	90.5	91.1	91.7
New Brunswick	79.9	80.2	81.0	81.7	82.5	83.6	84.9	85.9	86.9	87.8	88.6	89.3	90.0	90.6	91.2	91.7
Quebec	80.5	80.9	81.8	82.6	83.5	84.1	85.2	86.2	87.2	88.0	88.8	89.6	90.3	90.9	91.4	92.0
Ontario	81.0	81.4	82.1	82.9	83.8	84.3	85.4	86.4	87.4	88.2	89.0	89.7	90.4	91.0	91.5	92.0
Manitoba	80.2	80.7	81.0	81.6	82.0	82.6	84.0	85.3	86.4	87.4	88.3	89.1	89.8	90.5	91.1	91.7
Saskatchewan	81.3	81.4	82.0	82.0	82.1	82.7	84.1	85.3	86.5	87.5	88.4	89.2	90.0	90.6	91.3	91.8
Alberta	80.6	81.3	81.8	82.6	83.3	84.0	85.2	86.2	87.2	88.0	88.8	89.6	90.2	90.8	91.4	91.9
British Columbia	81.3	81.6	82.4	83.1	84.0	84.6	85.7	86.7	87.6	88.4	89.2	89.9	90.5	91.1	91.6	92.1
Yukon	78.0	78.5	79.3	77.6	80.3	80.9	82.2	83.4	84.5	85.4	86.4	87.2	88.0	88.7	89.3	89.9
Northwest Territories	76.8	78.7	77.7	80.7	79.9	80.5	81.8	83.0	84.1	85.1	86.1	86.9	87.7	88.4	89.1	89.7
Nunavut	69.9	72.2	71.0	74.7	73.8	74.5	76.2	77.8	79.2	80.6	81.8	82.9	84.0	84.9	85.8	86.6

Sources: Statistics Canada. 2013. *Life Tables, Canada, Provinces and Territories: 2009 to 2011*, catalogue no. 84-537 and Demography Division.

Table 4.3 Life expectancy at birth, observed (1990 to 2010) and projected according to the high mortality assumption (2012/2013 to 2062/2063), for Canada, provinces and territories, for selected years or periods

Region	1990	1995	2000	2005	2010	2012/2013	2017/2018	2022/2023	2027/2028	2032/2033	2037/2038	2042/2043	2047/2048	2052/2053	2057/2058	2062/2063
	in years															
Males																
Canada	74.1	75.1	76.5	77.8	79.1	79.5	80.3	81.1	81.8	82.5	83.2	83.8	84.4	85.0	85.5	86.0
Newfoundland and Labrador	73.1	74.5	75.1	76.0	77.2	77.6	78.7	79.6	80.5	81.2	82.0	82.6	83.3	83.9	84.5	85.0
Prince Edward Island	73.3	74.4	75.6	76.8	78.2	78.6	79.6	80.5	81.2	82.0	82.7	83.3	84.0	84.6	85.1	85.7
Nova Scotia	73.2	74.3	75.8	77.0	78.3	78.3	79.2	80.0	80.7	81.5	82.2	82.8	83.5	84.1	84.7	85.2
New Brunswick	72.9	73.9	75.4	76.5	77.9	78.7	79.6	80.4	81.2	81.9	82.6	83.3	83.9	84.5	85.0	85.6
Quebec	73.2	74.4	76.2	77.6	79.3	79.6	80.4	81.1	81.8	82.5	83.1	83.7	84.3	84.9	85.4	85.9
Ontario	74.6	75.5	77.0	78.3	79.6	80.0	80.7	81.5	82.2	82.9	83.5	84.1	84.7	85.3	85.8	86.3
Manitoba	74.0	73.9	75.0	76.0	77.5	78.0	79.0	80.0	80.8	81.6	82.3	83.0	83.7	84.3	84.9	85.4
Saskatchewan	75.2	75.2	76.3	77.4	77.2	77.6	78.7	79.6	80.6	81.4	82.2	83.0	83.7	84.4	85.0	85.6
Alberta	74.4	75.5	76.8	77.6	78.8	79.3	80.2	81.0	81.8	82.5	83.2	83.9	84.5	85.0	85.6	86.1
British Columbia	75.1	76.0	77.3	78.7	79.9	80.3	81.1	81.9	82.6	83.3	83.9	84.5	85.1	85.6	86.1	86.6
Yukon	71.5	72.5	73.2	74.1	75.4	75.8	76.7	77.5	78.3	79.0	79.7	80.4	81.0	81.6	82.1	82.7
Northwest Territories	73.9	73.6	74.5	76.0	76.2	76.6	77.5	78.3	79.1	79.8	80.4	81.1	81.7	82.2	82.7	83.2
Nunavut	66.3	65.9	67.1	69.4	69.7	70.2	71.4	72.5	73.5	74.4	75.2	76.0	76.7	77.3	77.9	78.4
Females																
Canada	80.6	80.9	81.7	82.5	83.4	83.7	84.1	84.5	84.9	85.2	85.6	86.0	86.3	86.6	87.0	87.3
Newfoundland and Labrador	79.1	79.9	80.2	80.8	82.1	82.2	82.7	83.1	83.5	83.9	84.3	84.7	85.0	85.4	85.7	86.1
Prince Edward Island	80.1	81.1	81.4	81.7	83.0	83.3	83.9	84.3	84.7	85.1	85.5	85.8	86.2	86.5	86.8	87.2
Nova Scotia	80.3	81.1	81.5	82.1	82.9	82.8	83.3	83.8	84.2	84.6	85.0	85.3	85.7	86.0	86.4	86.7
New Brunswick	79.9	80.2	81.0	81.7	82.5	83.3	83.8	84.3	84.7	85.0	85.4	85.8	86.1	86.4	86.7	87.1
Quebec	80.5	80.9	81.8	82.6	83.5	83.8	84.2	84.5	84.9	85.3	85.7	86.0	86.3	86.7	87.0	87.3
Ontario	81.0	81.4	82.1	82.9	83.8	84.0	84.4	84.8	85.2	85.5	85.9	86.2	86.6	86.9	87.2	87.5
Manitoba	80.2	80.7	81.0	81.6	82.0	82.3	82.9	83.4	84.0	84.4	84.9	85.3	85.7	86.1	86.4	86.8
Saskatchewan	81.3	81.4	82.0	82.0	82.1	82.4	82.9	83.5	84.0	84.4	84.9	85.3	85.8	86.2	86.5	86.9
Alberta	80.6	81.3	81.8	82.6	83.3	83.6	84.1	84.5	84.9	85.3	85.7	86.0	86.3	86.7	87.0	87.3
British Columbia	81.3	81.6	82.4	83.1	84.0	84.3	84.7	85.0	85.4	85.8	86.1	86.5	86.8	87.1	87.4	87.7
Yukon	78.0	78.5	79.3	77.6	80.3	80.5	81.0	81.5	81.9	82.4	82.8	83.2	83.6	84.0	84.4	84.8
Northwest Territories	76.8	78.7	77.7	80.7	79.9	80.1	80.6	81.1	81.5	81.9	82.4	82.8	83.2	83.5	83.9	84.3
Nunavut	69.9	72.2	71.0	74.7	73.8	74.0	74.6	75.2	75.8	76.4	76.9	77.5	78.0	78.5	79.0	79.5

Sources: Statistics Canada. 2013. *Life Tables, Canada, Provinces and Territories: 2009 to 2011*, catalogue no. 84-537 and Demography Division.

In the **medium mortality assumption**, the projected life expectancy for males increases from 79.3 years in 2010 to 87.6 years in 2062/2063, while for females it would increase from 83.6 years in 2010 to 89.2 years in 2062/2063 (Table 4.1).

In the **low mortality assumption**, life expectancy for males is projected to increase from 79.3 years in 2010 to 89.9 years in 2062/2063 while for females it would increase from 83.6 years in 2010 to 91.9 years in 2062/2063 (Table 4.2).

In the **high mortality assumption**, male life expectancy is projected to grow from 79.3 years in 2010 to 86.0 years in 2062/2063 while for female it would increase from 83.6 years in 2010 to 87.3 years in 2062/2063 (Table 4.3).

Notably, while mortality assumptions were calculated using extrapolation methods, the results for life expectancy at birth either match or are very close to the estimates provided by respondents to the *Opinion Survey on Future Demographic Trends*. In 2017/2018, the extrapolated values are 80.7 years for males and 84.5 years for females compared to median responses for the most probable estimate from the survey of 80.6 years for males and 84.5 years for females. In 2037/2038, the extrapolated values are 84.3 years for males and 86.8 years for females compared to survey values of 83.9 years for males and 86.6 years for females.

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Chapter 5: Projection of international immigration

By Nora Bohnert and Patrice Dion

Introduction

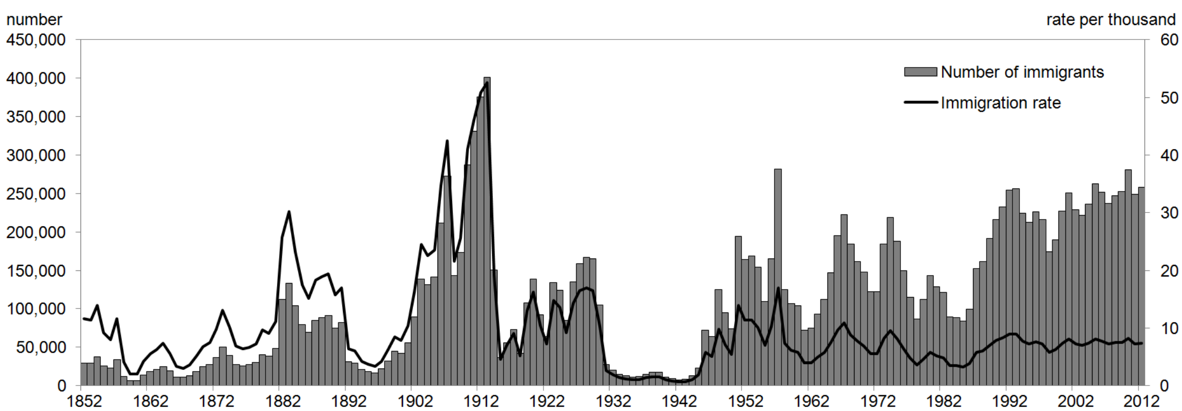
Immigration plays an increasingly critical role in the shaping of Canada's population. Since the mid-1990s, Canadian population growth has been attributed mostly to migratory increase and less to natural increase (the surplus of births over deaths). Immigration also contributes to the evolution of the population through its indirect impacts on the number of births experienced in the population. Given the established demographic trends of low fertility and population aging in Canada, this situation is likely to continue in the coming decades.

Compared to other components of population change such as births and deaths, projecting immigration is considered especially difficult (Wilson and Rees 2005). In the short term, immigration is often volatile, as it is influenced by unexpected movements relating to business cycles, political decision-making processes and geopolitical events (Howe and Jackson 2004). Migration processes are very complex, involving the interactions of economic, cultural, historical and political factors between countries (Bijak 2006). Moreover, no theory of migration provides a satisfactory means of projecting future flows, rather, different theories attempt to explain different aspects of the process (Massey et al. 1994). These theories are not easily applied in practice; this is in part due to the absence of suitable data about the contributing factors as well as the fact that those factors would also need to be projected, rendering the procedure undesirably complex.

Immigration trends

As seen in Figure 5.1, the annual number of immigrants to Canada has varied substantially over the last century. Since the early 1990s, however, immigration levels have been more consistent, averaging about 235,000 annually. Beaujot and Raza (2013) refer to the period 1989 to present as one of "sustained high immigration" in Canada; unlike the past, immigration levels in recent years have not declined in response to periods of higher unemployment and economic downturn. Similarly to trends in the annual

Figure 5.1 Number of immigrants and immigration rate, Canada, 1852 to 2012



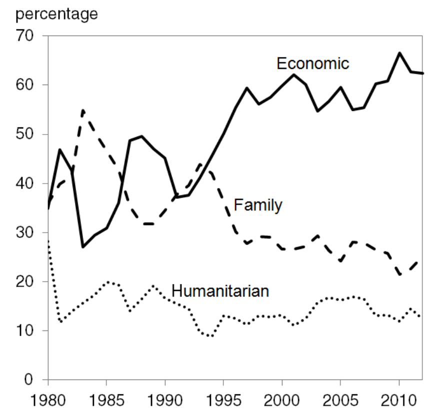
Sources: From 1852 to 1979: Employment and Immigration Canada. 1982. *1980 Immigration Statistics*, Immigration and Demographic Policy Group, Catalogue no. MP22-1/1980. From 1980 to 2012, Citizenship and Immigration Canada and Statistics Canada, Demography Division, Population Estimates Program.

number of immigrants, the immigration rate has been relatively stable over the last two decades, falling between seven and eight immigrants per thousand (resident) population.[1]

On the other hand, the composition of immigration in terms of the category of admission has evolved considerably in recent years. As seen in Figure 5.2, the proportion of immigrants admitted under economic visas has increased, accounting for about two-thirds (66.6%) of all immigrants in 2010 compared to 27.1% in 1983. In turn, the proportion of family class immigrants has declined, while the share admitted under humanitarian visas has held fairly constant. Notably, the trend of increasing economic immigration persevered even during the recent recession period of the late 2000s.

The regional distribution of immigrants to Canada has also changed in recent years. The most striking trend has been the decline in the share of immigrants whose province of landing is Ontario, from about 6 in 10 (59.3%) in 2001 to 4 in 10 (40.0%) in 2011 (Figure 5.3). Over the same period, the share

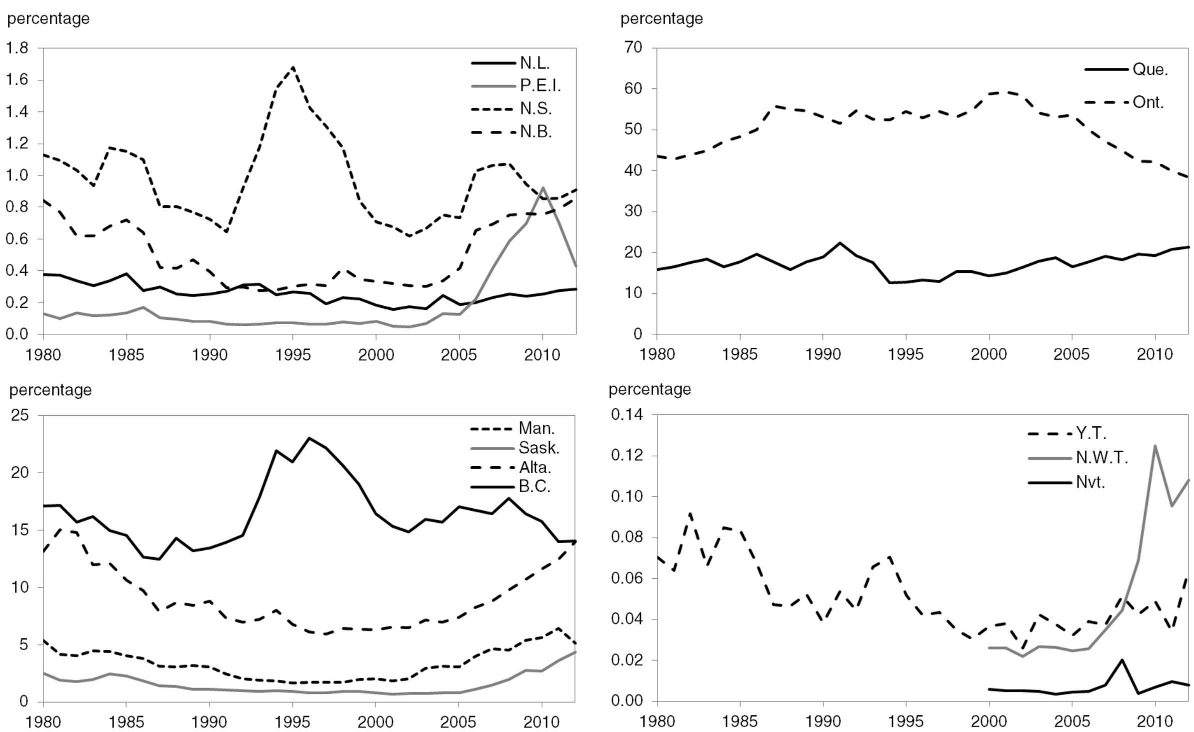
Figure 5.2 Proportion (in percentage) of immigrant admissions to Canada composed of economic, family and humanitarian categories, 1980 to 2012



Note: An "Other" category, the definition of which has varied over time, is not shown.

Source: Citizenship and Immigration Canada.

Figure 5.3 Provincial/territorial distribution of immigrants to Canada, 1980 to 2012



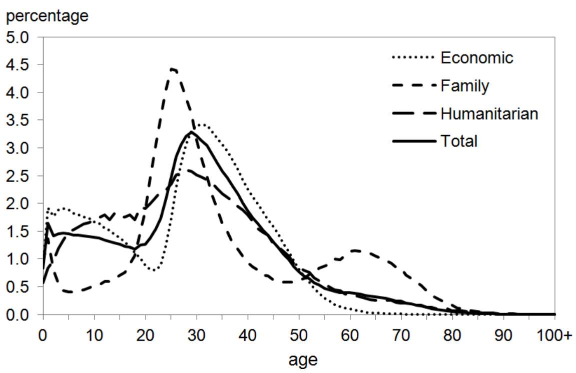
Source: Citizenship and Immigration Canada.

1. For further details on recent trends in international immigration to Canada, including place of birth and immigration category, see Chagnon, J. 2013. "International migration, 2010 and 2011", *Report on the Demographic Situation in Canada,* Statistics Canada Catalogue no. 91-209-X. For more information on historical trends in immigration to Canada, see Boyd and Vickers (2000) and Beaujot and Kerr (2004).

of immigrants choosing Alberta, Manitoba or Saskatchewan as a destination of landing has increased substantially, particularly during the 2009 to 2011 period.

In contrast, the share of Canada's immigrants who land in one of the Atlantic provinces or the territories has remained fairly low over time. Among these provinces and territories, Nova Scotia has generally received the highest share of Canada's immigrants; for example, the province received just under 1% of Canada's immigrants in 2012. The age distribution of immigrants to Canada has also evolved over time along with fluctuations in the predominant category of immigration. As seen in Figure 5.4, economic immigrants tend to be more highly concentrated in the peak working ages (those in their early twenties to late forties). Reflecting in part the fact that economic immigrants have become more prevalent in more recent years, the peak ages of immigration have become older over the last several decades (Figure 5.5).

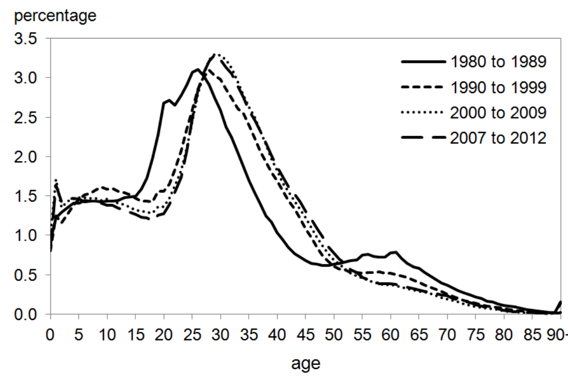
Figure 5.4 Age distribution (in percentage) of immigrants by category of admission, Canada, average of 2007 to 2012 period



Note: An 'Other' category, the definition of which has varied over time, is not shown.

Source: Citizenship and Immigration Canada.

Figure 5.5 Age distribution (in percentage) of immigrants, Canada, average of selected periods, 1980 to 2012



Source: Citizenship and Immigration Canada.

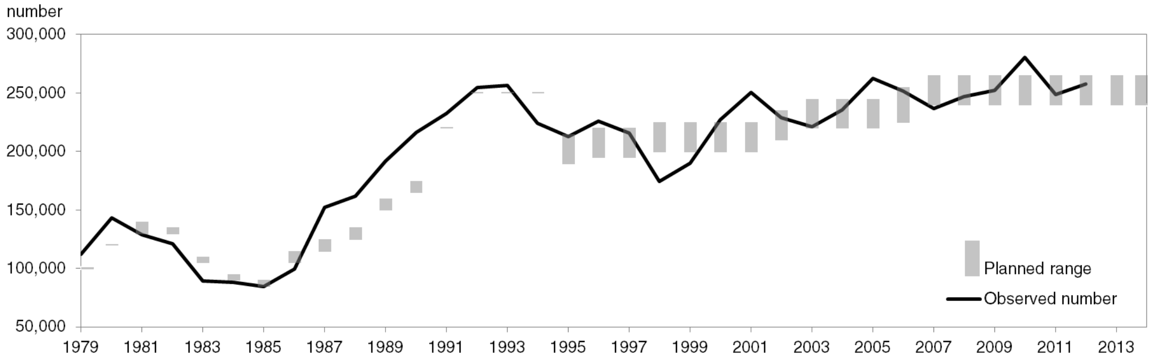
Immigration policy

Some very recent revisions in the area of Canadian immigration policy suggest that immigration may become more targeted in the future.[2] Changes to the Federal Skilled Worker Program, which came into effect in May 2013, included a revised points system which makes language proficiency and youth[3] the most important selection factors, as well as increased points for Canadian work experience. Additionally, applicants with qualifications to work in specific occupations, those with pre-existing offers of employment, or offers of residence from specific provinces or territories will be given greater emphasis.[4]

Despite the introduction of these various program revisions in 2013, the planned admissions range from Citizenship and Immigration Canada in 2014 remained unchanged from that which has been set for each year since 2007. Historically, the observed number of immigrants has fallen within or close to the planned admissions range in a given year (Figure 5.6), suggesting that, at least in the short term, immigration levels will remain close to their recently-observed levels.

2. For example, a new class of economic permanent residents, the Federal Skilled Trades Class, was established by regulation on January 2, 2013. An annual maximum of 3,000 new applications can be submitted for consideration in specific trades. See *Report on Plans and Priorities 2013-2014,* Citizenship and Immigration Canada.
3. The revised selection points system benefits younger immigrants by awarding a maximum of 12 points up to age 35, with diminishing points awarded from age 35 to 46. Previously, ages 21 to 49 were awarded maximum age points.
4. A new "Expression of Interest" immigration management system was created in 2013 to allow for Canadian employers, provinces and territories to select skilled immigrants from a pool of applicants.

Figure 5.6 Planned admission range and observed number of immigrants to Canada, 1979 to 2014



Note: Final numbers of immigrants admitted to Canada are not available for 2012 and 2013 as of the writing of this report.
Source: Citizenship and Immigration Canada.

Public opinion and media narratives regarding immigration

While no precise or direct link exists, public opinion on immigration is monitored by the Department of Citizenship and Immigration[5] and as a result, trends in this regard could have an influence on immigration policy.

Compared to most other countries, support for immigration and multiculturalism in the Canadian public is quite strong; yet this support has also been found to be 'conditional', according to Soroka and Robertson (2010), on the idea that "laws and norms should not be modified to accommodate minorities". The authors also find that a substantial minority of Canadians believes that immigrants should "blend into Canadian society". In recent years, topics such as the number of admissions, the integration of newcomers and multiculturalism have been the subjects of discussion in the media, academia and public debate across the country, as reviewed by Banting and Kymlicka (2010), Reitz (2005) and Bélanger (2013), among others.[6] Generally, Canadian media portrayals of immigration have tilted towards a negative rhetoric, with 'danger' and 'fear of immigration' being the most frequent themes of discourse (Bauder 2008).

Conversely, there is also much discourse in support of increased immigration to Canada. The availability of relatively inexpensive labour is an enduring desire for many employers. A prevalent existing media narrative is that Canada's aging population will soon result in a labour shortage 'crisis' with major consequences for public pension and taxation systems. Increased immigration has been proposed as a possible solution to these mounting issues, particularly when paired with the introduction of policies and programs which would ameliorate immigrant outcomes.[7]

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5. In the Canadian Press (2012) article, Minister Jason Kenney refers to an internal government poll that suggests there has been a slide in public support for the belief that immigration benefits the economy, a decline Kenney attributed to the difficulty many newcomers have at gaining an economic foothold in Canada. Minister Kenney has publicly stated "I'm very conscious of our obligation to maintain the very broad public consensus in favour of immigration in Canada to avoid the kind of anti-immigration backlash we've seen in western Europe. That kind of backlash happens when business and political elites become disconnected from popular opinion. When we look at all of the public opinion on the issue, we see that only 10% to 15% of Canadians are in favour of raising immigration levels" (Friesen, May 14 2012).
6. Other examples: Dubreuil and Marois (2011) question the pertinence of high levels of immigration in Quebec and the use of immigration to achieve certain objectives. Bouchard (2012) and Solomon (2013) question the multiculturalism model rather than the level of immigration. Picot and Sweetman (2005), Drummond and Fong (2010), Kustec (2012) and McMahon (2013), among others, highlight the declining economic outcomes and well-being of recent immigrants to Canada. Some recent media editorials such as that by Siddiqui (2013) posit that immigration may have negative impacts on the Canadian-born workforce.
7. See for example Friesen (May 4, 2012), TD Economics (2012) and Alexander et al. (2012).

Yet there is emerging evidence suggesting that a) there is not a general labour shortage in Canada; instead, it is limited to certain geographic areas and industries (Kustec 2012; McQuillan 2013), and b) increasing immigration levels do not resolve the issues of concern related to population aging (Caron Malenfant et al. 2011). The diversity in the public discourse about immigration highlights the complexity of the context and issues that surround this topic.

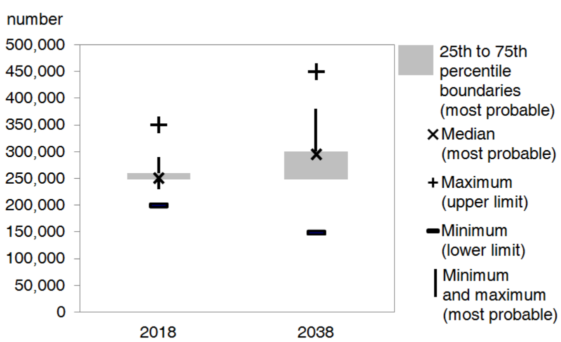
Opinion survey results

Results from the *Opinion Survey on Future Demographic Trends* show that Canadian demography experts anticipate that, in the short term, immigration levels will remain within the range which has been experienced over the last two decades, with levels increasing somewhat in the long term.

In terms of the number of immigrants, in the short term, survey respondents provided a quite narrow range of estimates of the most probable level in 2018, with the median and most frequent response being 250,000 (Figure 5.7), a number very close to the most recently observed admission level of 248,700 in 2011. In the longer term, respondents estimated the most probable situation would be an increase in the number of immigrants from current levels, the median response for 2038 being 295,000 immigrants.

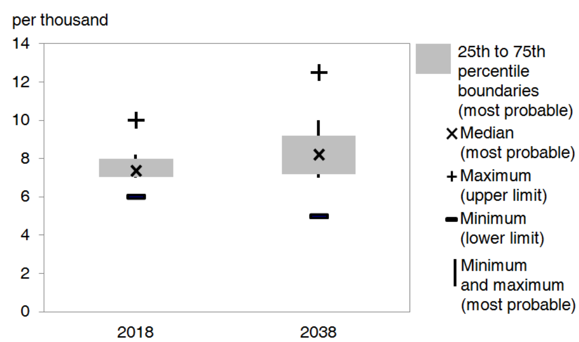
In terms of the immigration rate, again in the short term, survey respondents seemed to anticipate little change from the most recently observed rate of 7.2 immigrants per thousand Canadians: the median response for the most probable rate of immigration in 2018 was 7.4 immigrants per thousand (Figure 5.8). Notably, respondents generally expected an increase not only in the number of immigrants but also the rate of immigration in the longer-term future, a scenario with much larger impacts on the population since the associated number of immigrants is impacted by population growth in the Canadian population. The median response for the most probable immigration rate in 2038 was 8.2 immigrants per thousand, a rate that was recently observed in 2010. Overall, respondent estimates for 2038 showed considerable range, perhaps reflecting the fact that immigration levels have been quite volatile over the course of Canadian history.

Figure 5.7 Summary statistics for the 2013 *Opinion Survey on Future Demographic Trends* regarding estimates of the annual number of immigrants to Canada in 2018 and 2038



Source: Statistics Canada, Demography Division.

Figure 5.8 Summary statistics for the 2013 *Opinion Survey on Future Demographic Trends* regarding estimates of the annual immigration rate (per thousand) for Canada in 2018 and 2038



Source: Statistics Canada, Demography Division.

In support of their estimates, survey respondents mentioned trends and factors that could suggest alternatively an increase or decrease in the level of immigration to Canada in the future. Trends such as globalization, growing labour force needs and increased ease of communication and travel were mentioned by respondents to support increased immigration to Canada in the future. Further, it was also mentioned, as per Massey et al.'s (1994) theory, that established migration streams tend to be selfperpetuating over time, as those immigrants who have already arrived in Canada seek to bring family and various industries and institutions come to be anchored in sustained migration. In contrast, several respondents mentioned that the growth of Asian and African economies could lessen the 'push' factors to Canada, as well as the idea that there is a limited sociocultural capacity to absorb more immigrants to Canada. Furthermore, some respondents thought that the idea of a labour shortage in Canada, requiring more immigration to resolve, could be exaggerated.

Methodology

The low, medium and high immigration assumptions are based on an analysis of short and long-term trends in immigration to Canada, the estimates and views provided by the respondents of the *Opinion Survey on Future Demographic Trends* as well as recent developments in Canadian immigration policy. Consistent with the hybrid bottom-up approach utilized throughout the projections, an assumption at the Canada level is first established, but from it, specific assumptions are derived at the level of the provinces and territories. New immigrants are added to the Canadian population over the course of the projection using provincial and territorial immigration rates. Since the population size changes over the course of the projection (the magnitude of which is unknown at the time of elaborating the assumptions), a fixed rate implies a varying number of new admissions but a stable contribution to the growth rate of the provinces and territories (as long as the rate is unchanged).

The average annual immigration rates for the period 2007/2008 to 2011/2012 in each province and territory are used as a starting point for the calculation of the immigration assumptions. These rates are diminished or raised, depending on the assumptions, in order to match the initial rate of immigration desired at the national level. The rates for the first 10 years of the projection are then interpolated linearly so as to follow the changes envisioned at the Canada level during that period. The rates increase or decrease to reach the desired targets in 2022/2023 and remain stable thereafter. Notably, with this approach it is the provincial and territorial rates that are controlled, while the national immigration rate is not predetermined but is rather the result of the various provincial/territorial immigration rates.

While this provincial-rates approach is used for the projections, another sensible approach would be to use national rates with a constant provincial/territorial distribution pattern. Such an approach could be thought to conceptually better reflect the actual immigration planning process than the provincial-rates approach. However, the use of national immigration rates with fixed provincial distributions results in immigration rates that evolve mechanically in each province and territory along with changes in population growth at the national level (regardless of what is happening in terms of population change for the given province or territory). Since the direction and strength of this mechanism are not explicitly stated in the immigration assumptions (they are undefined at the time of assumption building), the use of a national immigration rate appears to be somewhat less transparent at the level of the provinces and territories. In contrast, because it relates the number of admissions to each province and territory's own population size, the use of provincial/territorial immigration rates ensures that the contribution of immigration to the growth of a given province or territory remains the same in proportion to all other components of the growth (births, deaths, interprovincial migration, etc.).

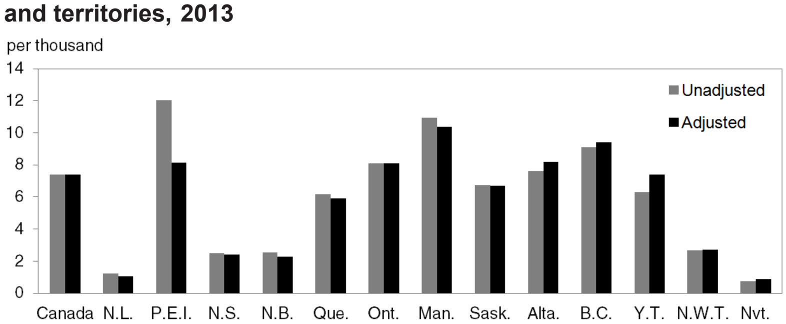
In the end, it is difficult to assess which option will better reflect the future path of immigration trends. Tied to economic trends and political events which can be unprecedented, and influenced by changes, closures or additions of various immigration programs and their varying importance in specific provinces and territories, the geographic distribution of immigrants to Canada has displayed substantial shifts in the past. As a result of its unpredictable nature, determining the distribution of immigrants to Canada among the provinces and territories over the course of the projection is very challenging for a long-term projection. Given that the national-rates based method is somewhat less compatible with the bottom-up approach favoured in these projections, the provincial-rates based method has been selected for the present edition of the projections.

Adjustment of immigration rates

As explained above, provincial and territorial immigration rates are used for the projection. The computation of these rates is done using the annual number of immigrants by age, sex and province/territory from Statistics Canada's Population Estimates Program (PEP). The PEP estimates are based on information from the Field Operational Support System (FOSS) files of Citizenship and Immigration Canada (CIC). A limitation of these files is that provincial and territorial immigration levels reflect the intended destination of immigrants upon arrival, rather than the province or territory in which the immigrant actually settles. This implies that an immigrant who migrates shortly after arrival (or simply settles in another destination immediately upon arrival in Canada) may be recorded as residing in the incorrect place. If this migration is captured in the interprovincial migration component, there is no issue. It appears, however, when examining other data sources, that some of these migrations are missed, and that using the intended destination as a proxy for actual residence results in an inaccurate portrayal of the geographic distribution of immigrants. In the intercensal estimates from the PEP, these differences can be corrected through the residual component. However, because this residual component is not projected, it is preferable to adjust instead the data used for projecting the geographic distribution of new immigrants.[8]

In an attempt to address these discrepancies, adjustment factors were calculated based on information from the Longitudinal Immigration Database (IMDB), a database combining linked immigration data from CIC's FOSS files and taxation records.[9, 10] Using the IMDB, the degree of matching between the intended destination stated before coming to Canada and the province or territory of residence reported in income tax files for the first (reference) year in Canada can be calculated. For a given province or territory and a given reference year, the adjustment factor consists of the number of immigrants actually recorded as residing there divided by the number who declared their intention to land there. An adjustment factor under one means that the province or territory loses more than it gains, the opposite being true for a factor surpassing one. These adjustment factors were calculated for the age groups 0 to 19, 20 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64 and 65 and over, using an average calculated for immigrants who landed between 2006 and 2011.[11]

Figure 5.9 Immigration rates (per thousand) according to the medium assumption, unadjusted and adjusted, Canada, provinces and territories, 2013



Source: Statistics Canada, Demography Division.

Figure 5.9 demonstrates the change in immigration rate assumptions which resulted from the adjustment using IMDB data. It can be seen that the adjustment factors result in fairly substantial changes in Prince Edward Island in particular. Elsewhere, adjustments are more subtle, leading to an increase of the rates in Alberta, British Columbia, Yukon and Nunavut and a decrease in other provinces.

8. See Chapter 1 for more details.
9. These data are available on the Statistics Canada CANSIM database, Table 054-0003.
10. The IMDB contains linked information for approximately 80% of all immigrants, the unlinked being for example those who do not file taxes or for whom, for various reasons, linkage was not possible. It is assumed that the residential behaviour of persons not linked in the IMDB are equal to those for whom linked information is available.
11. Special adjustments were needed for the 0 to 19 age group because the IMDB contains only immigrants who completed an income tax file; therefore, it does not include children who would be included on the files of their parent(s). To circumvent this issue, an assumption based on a plausible age of the child's mother was used. Assuming a mean age at childbearing of 30, the adjustment factor calculated for (immigrant) women aged 25 to 34 was applied to children aged 0 to 4, the adjustment factor for women aged 35 to 44 was used for children aged 5 to 14, and that of women aged 45 to 54 was applied to children aged 15 to 19.

Assumptions

Three distinct immigration assumptions—low, medium and high—were created on the basis of an analysis of past trends and the results from the *Opinion Survey on Future Demographic Trends*. As seen in Figure 5.6, Citizenship and Immigration Canada's planned range of immigration was unchanged for the last eight years (2007 to 2014) and the observed number of immigrants has generally fallen within or very close to the planned intake range. The 2014 immigration level plan contains not only minimum and maximum values, but also an intermediate 'admissions target'.[12] These values were considered to constitute the most plausible estimates of the range of immigration to Canada in the first year of the projection. These numeric targets, once converted into rates based on the 2013/2014 Canadian population,[13] were used in the first year of the projection (2013/2014), which resulted in rates of 6.8 immigrants per thousand population for the low assumption, 7.4 for the medium assumption and 7.5 for the high assumption. From 2014/2015 to 2022/2023, rates are transitioned in a linear manner (through interpolation) to the selected long-term target annual immigration rates (described below) and held constant for the remainder of the projection (Table 5.1 and Figure 5.10).

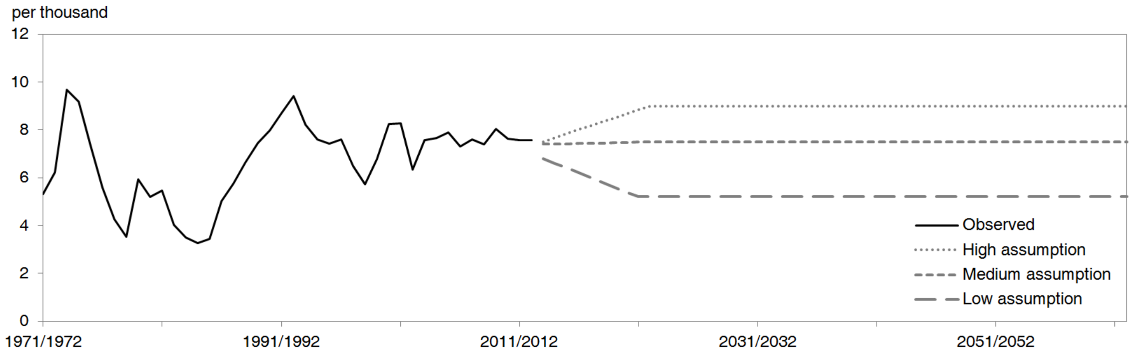
Table 5.1 Projected immigration rates (per thousand) for each immigration assumption, Canada, provinces and territories, 2013/2014 to 2062/2063

Assumption / Region	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023 to 2062/2063
	per thousand									
Low assumption										
Canada	6.8	6.6	6.4	6.2	6.0	5.8	5.6	5.4	5.2	5.0
Newfoundland and Labrador	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7
Prince Edward Island	7.5	7.3	7.1	6.8	6.6	6.3	6.1	5.9	5.7	5.5
Nova Scotia	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.7	1.6
New Brunswick	2.1	2.0	2.0	1.9	1.8	1.8	1.7	1.7	1.6	1.5
Quebec	5.5	5.3	5.1	5.0	4.8	4.6	4.5	4.3	4.2	4.0
Ontario	7.5	7.2	7.0	6.8	6.6	6.3	6.1	5.9	5.7	5.5
Manitoba	9.5	9.3	9.0	8.7	8.4	8.1	7.8	7.5	7.3	7.0
Saksatchewan	6.2	6.0	5.8	5.6	5.4	5.2	5.0	4.9	4.7	4.5
Alberta	7.5	7.3	7.1	6.9	6.7	6.4	6.2	6.0	5.8	5.5
British Columbia	8.6	8.4	8.1	7.9	7.6	7.3	7.1	6.8	6.6	6.4
Yukon	6.8	6.6	6.4	6.2	6.0	5.7	5.6	5.4	5.2	5.0
Northwest Territories	2.5	2.4	2.3	2.3	2.2	2.1	2.0	2.0	1.9	1.8
Nunavut	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6
Medium assumption										
Canada	7.4	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.5	7.5
Newfoundland and Labrador	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Prince Edward Island	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.3
Nova Scotia	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.5
New Brunswick	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Quebec	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Ontario	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2
Manitoba	10.4	10.4	10.4	10.4	10.4	10.4	10.5	10.5	10.5	10.5
Saksatchewan	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.8	6.8	6.8
Alberta	8.2	8.2	8.2	8.2	8.3	8.3	8.3	8.3	8.3	8.3
British Columbia	9.4	9.4	9.4	9.4	9.5	9.5	9.5	9.5	9.5	9.5
Yukon	7.4	7.4	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.5
Northwest Territories	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Nunavut	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
High assumption										
Canada	7.5	7.7	7.8	8.0	8.2	8.3	8.5	8.7	8.8	9.0
Newfoundland and Labrador	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3
Prince Edward Island	8.3	8.5	8.6	8.8	9.0	9.2	9.4	9.5	9.7	9.9
Nova Scotia	2.5	2.5	2.6	2.6	2.7	2.7	2.8	2.9	2.9	3.0
New Brunswick	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8
Quebec	6.0	6.2	6.3	6.4	6.6	6.7	6.8	7.0	7.1	7.2
Ontario	8.2	8.4	8.6	8.8	9.0	9.1	9.3	9.5	9.7	9.9
Manitoba	10.5	10.8	11.0	11.2	11.5	11.7	11.9	12.1	12.4	12.6
Saksatchewan	6.8	7.0	7.1	7.3	7.4	7.6	7.7	7.9	8.0	8.2
Alberta	8.3	8.5	8.7	8.9	9.1	9.2	9.4	9.6	9.8	10.0
British Columbia	9.5	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4
Yukon	7.5	7.7	7.8	8.0	8.2	8.3	8.5	8.7	8.8	9.0
Northwest Territories	2.7	2.8	2.9	2.9	3.0	3.0	3.1	3.2	3.2	3.3
Nunavut	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1

Source: Statistics Canada, Demography Division.

12. See Citizenship and Immigration Canada (2013). Note that the admission target in the immigration plan, 261,000 immigrants, is not equidistance from the 'low' and 'high' planning ranges, those being 240,000 immigrants and 265,000 immigrants, respectively.
13. As of January 2014, the 2013/2014 population is estimated by applying the same rate of growth observed between 2011/2012 and 2012/2013 to the 2012/2013 population.

Figure 5.10 Immigration rate (per thousand), observed (1971/1972 to 2012/2013) and projected (2013/2014 to 2062/2063) according to the low, medium and high immigration projection assumptions, Canada



Source: Statistics Canada, Demography Division.

Under the **low assumption**, Canada's immigration rate declines gradually over the projection period from 6.8 immigrants per thousand in 2013/2014 to 5.0 in 2022/2023, and remains at this level thereafter. Notably, a rate of 5.0 immigrants per thousand is somewhat lower than the median values obtained from respondents to the *Opinion Survey on Future Demographic Trends*. In fact, consultations with experts, including those working in the External Advisory Committee on Demographic Statistics and Studies, and the desire to capture a larger range of uncertainty, have strongly motivated the departure from survey results. Under the low assumption, immigration admissions would continue to become more targeted (and in turn somewhat more restricted) following recent immigration policy revisions. This assumption also represents the hypothetical situation where, for various reasons, 'push' and 'pull' factors which attract immigrants to Canada could lessen somewhat in the future. Finally, the presence of critical discourses toward immigration in public opinion and public debate on the integration of immigrants suggests that declining immigration levels should also be envisaged as a possibility for the future.

Under the **medium assumption**, the immigration rate transitions from 7.4 immigrants per thousand in 2013/2014 to 7.5 in 2022/2023 and later years. An immigration rate of 7.5 immigrants per thousand equals the average rate of the last 10 years of observed data, as well as being the mean response provided by survey respondents regarding the most probable immigration rate in 2018. This assumption is further supported by the recent period of relative stability in the immigration rate, the longest observed in Canadian history. While Citizenship and Immigration Canada has enacted many changes to the immigration program in 2013, they did not alter the targeted level of immigration that year, suggesting that the rate of immigration could continue to fluctuate around 7.0 to 8.0 immigrants per thousand in the coming years.

Under the **high assumption**, immigration rates rise gradually from 7.5 immigrants per thousand in 2013/2014 to 9.0 in 2022/2023, remaining constant thereafter. There is much to suggest that Canada's immigration levels could increase from their current levels in the future. Under this scenario, continued globalization, the interests of employers in available, relatively inexpensive labour and increasing ease of travel and communication would result in a higher level of immigration to Canada over time. Moreover, public opinion research suggests that Canadian support for immigration and multiculturalism is, for the most part and by international standards, relatively strong. Finally, the high assumption matches the general views of the *Opinion Survey on Future Demographic Trends* respondents who, for the most part, envisioned an increase in immigration rates over time.

Table 5.2 displays assumptions regarding the age and sex distribution of immigrants, held constant over the course of the projection and identical for the low, medium and high immigration assumptions.

Table 5.2 Assumptions regarding the age and sex distribution of immigrants, Canada, provinces and territories, 2007/2008 to 2011/2012

Region	0 to 14 years		15 to 44 years		45 to 64 years		65 years and over		All ages	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
	percentage									
Canada	11.0	10.3	30.2	33.7	6.1	6.0	1.3	1.5	48.6	51.4
Newfoundland and Labrador	9.6	9.7	33.9	31.7	7.5	5.6	1.4	0.7	52.3	47.7
Prince Edward Island	11.8	10.2	26.4	29.2	12.8	9.1	0.3	0.3	51.2	48.8
Nova Scotia	11.0	10.4	29.7	31.2	8.7	7.1	1.0	1.0	50.4	49.6
New Brunswick	13.1	12.0	29.5	30.2	8.3	6.0	0.5	0.4	51.4	48.6
Quebec	10.9	10.6	34.8	35.1	3.7	3.5	0.6	0.9	50.0	50.0
Ontario	10.6	9.8	28.9	33.3	6.6	7.0	1.8	2.1	47.8	52.2
Manitoba	14.5	13.5	29.9	31.2	5.3	4.6	0.5	0.5	50.1	49.9
Saskatchewan	14.5	13.5	30.9	31.3	5.0	4.0	0.4	0.4	50.8	49.2
Alberta	12.1	10.7	30.3	34.5	5.2	5.1	1.0	1.1	48.6	51.4
British Columbia	9.9	9.1	28.5	34.2	8.0	7.4	1.4	1.5	47.8	52.2
Yukon	9.9	9.7	32.4	35.3	6.4	5.0	0.4	0.9	49.2	50.8
Northwest Territories	7.8	11.4	25.5	42.7	4.0	6.5	1.1	1.0	38.4	61.6
Nunavut	8.1	12.4	31.2	35.9	7.5	4.1	0.9	0.0	47.7	52.3

Source: Statistics Canada, Demography Division.

The age and sex distribution assumptions are calculated using the average age and sex distribution of immigrants to each province and territory over the period 2007/2008 to 2011/2012 after adjusting for place of residence information in IMDB.

As can be seen in Table 5.2, the age distribution of immigrants varies considerably across regions of the country. For example, Manitoba and Saskatchewan have the highest proportion of immigrants aged 0 to 14 (28% for both sexes), while Newfoundland and Labrador, British Columbia, Yukon and the Northwest Territories have the lowest (less than 20% each).

Furthermore, recent trends exhibit differences in the distribution of immigrants by sex according to region of Canada: Quebec, Ontario, Alberta, British Columbia and the territories receive slightly more female immigrants than male, whereas the opposite is true for the Atlantic provinces, Manitoba and Saskatchewan.

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Chapter 6: Projection of emigration

By Nora Bohnert, Patrice Dion and Jonathan Chagnon

Introduction

According to the Population Estimates Program (PEP), emigration consists of emigrants, returning emigrants and net temporary emigrants. Together, these three components are estimated to have contributed to a relatively small portion of population change in recent history.

Of all the demographic components that are used in the PEP, these components are the most difficult to estimate with precision. Since there is no legal provision in Canada to maintain records for persons leaving the country (on a temporary or permanent basis), indirect and constantly evolving techniques are used for the estimation of the number of persons leaving the country. For this reason, available statistics regarding these three components have historically been of a lower quality than other components.[1]

Emigration components

Emigration

Emigrants are defined as Canadian citizens or landed immigrants who have left Canada to establish a permanent residence in another country. While the annual number of emigrants fluctuates from year to year, it remained relatively stable in recent years, averaging approximately 48,400 in the 1990s and 55,000 from 2000/2001 to 2011/2012. Respondents to the *Opinion Survey on Future Demographic Trends* were not asked to provide precise future estimates of emigration, but rather to provide open-ended comments on the component. Generally, respondents expressed the sentiment that emigration is a minor component of population projections in the case of Canada. Overall, large changes in the levels of this component in the future were not anticipated by survey respondents.

While variation in past emigration trends appear to be, in absolute terms, relatively small (at least in comparison to other components of population growth), the measurement of emigration introduces uncertainty in the projection of its future levels. Indeed, the difficulties in measuring emigration and the constantly positive sign of the residual component in the intercensal estimates (reflecting an overestimation of the population in postcensal estimates) indicate that a non-negligible portion of the residual is composed of non-recorded emigrants.[2] In fact, estimates of emigration from the Reverse Record Check (RRC) census coverage surveys for the periods 2001/2006 and 2006/2011 are considerably higher than those from the PEP for the same periods.[3] Even though these differences are statistically significant in only two provinces—Ontario and British Columbia—these two account for approximately three-quarters of Canada's estimated emigration in recent years.[4]

To reflect the uncertainty associated with emigration estimates, three distinct assumptions have been formulated for the provinces of Ontario and British Columbia. Emigration assumptions are based on age and sex-specific rates estimated in the reference period 2002/2003 to 2011/2012. For the medium

1. For more details, see Statistics Canada (2012).
2. See Chapter 1 for more information on this topic.
3. The RRC is one of three studies used for the estimation of census coverage error. It uses a sample of all persons who were enumerated (or missed) in the previous census, along with all persons who were either born or entered into Canada over the intercensal period. The RRC sampling frame includes all persons who could potentially be part of the census target universe (with the exception of a very small sub-population of returning emigrants).
4. In other provinces and territories, the RRC sample sizes and the number of emigrants were too small to provide reliable estimates of emigration.

emigration assumption, adjustment factors were calculated based on a ratio of the number of emigrants from the PEP to the number estimated from the RRC for each of the periods 2001/2002 to 2005/2006 and 2006/2007 to 2010/2011. These factors were used to modify the number of emigrants estimated in the reference period 2002/2003 to 2011/2012, the factors for the period 2001/2002 to 2005/2006 being applied to estimates of the period 2002/2003 to 2005/2006, and those for the period 2006/2007 to 2010/2011 being applied to the period 2006/2007 to 2011/2012.[5] These modified estimates were then used to compute the average emigration rates by age, sex and province.

Low and high emigration assumptions for Ontario and British Columbia were formulated in the same manner, using this time the bounds of the 95% confidence interval of the RRC emigration estimates. In all of the other provinces and in the territories, a single emigration assumption is formulated based on average emigration rates estimated from the PEP in the period 2002/2003 to 2011/2012. For all emigration assumptions, a single set of rates is held constant throughout the projection period.

Returning emigration

Returning emigrants are defined as Canadian citizens or landed immigrants who, having previously emigrated from Canada, have subsequently returned to Canada or re-established permanent residence. The annual number of returning emigrants has increased somewhat over the last two decades. From 1990/1991 to 1999/2000, the average annual number of returning emigrants was estimated to be 17,300, while the average for the period 2000/2001 to 2011/2012 was estimated to be 31,900.

To reflect recent trends, a single assumption for return emigration is formulated using the average rates estimated through the PEP for the period 2002/2003 to 2011/2012. This assumption is 1.0 return emigrant per thousand population at the national level.

Net temporary emigration

Temporary emigrants are Canadian citizens or landed immigrants who are living abroad temporarily and no longer have a usual place of residence in Canada. Data available on this component provide an annual balance that is the result of two flows: persons leaving Canada temporarily and those returning to Canada after living temporarily outside of the country.[6] As with the other components of emigration, the assumption for net temporary emigration is formulated using the average rate observed over the period 2002/2003 to 2011/2012 by age, sex and province/territory. At the Canada level, the net rate equals 0.7 temporary emigrants per thousand.

Net emigration

Net emigration is calculated as emigrants, minus return emigrants, plus net temporary emigrants. Since 1991/1992, net emigration, as estimated through the PEP, has ranged between 1.0 and 2.0 emigrants per thousand, with a slight declining trend in the rate observed since the 2000s. With the adjustments made to Ontario and British Columbia, the net emigration assumptions for Canada as a whole are slightly higher than the historical average (1.4), ranging between 1.6 and 2.1 net emigrations per thousand.

Assumptions for each of the components of emigration are summarized in Table 6.1.

5. Precisely, in Ontario, only estimates of the period 2005/2006 to 2011/2012 were adjusted since those for the previous period did not show differences that were statistically significant in comparison to the RRC estimates.
6. Data from the RRC are used to estimate the number of persons leaving Canada temporarily. Data from the census, combined with the PEP's estimates of returning emigrants, are used to estimate the number of temporary emigrants returning.

Table 6.1 Assumptions for each component of emigration, Canada, provinces and territories

Assumption / Region	Emigration	Return emigration	Net temporary emigration	Net emigration
	per thousand			
Low assumption				
Canada	1.9	1.0	0.7	1.6
Newfoundland and Labrador	0.5	0.4	0.4	0.5
Prince Edward Island	0.7	0.4	0.4	0.6
Nova Scotia	1.1	0.7	0.4	0.8
New Brunswick	0.7	0.6	0.4	0.5
Quebec	1.1	0.7	0.4	0.8
Ontario	2.5	1.2	0.7	2.0
Manitoba	1.4	1.0	0.5	0.8
Saksatchewan	0.6	0.5	0.3	0.4
Alberta	1.8	1.3	0.8	1.3
British Columbia	3.1	1.3	1.3	3.1
Yukon	0.6	0.5	0.7	0.8
Northwest Territories	0.9	0.1	0.7	1.5
Nunavut	0.2	0.0	0.6	0.9
Medium assumption				
Canada	2.2	1.0	0.7	1.9
Newfoundland and Labrador	0.5	0.4	0.4	0.5
Prince Edward Island	0.7	0.4	0.4	0.6
Nova Scotia	1.1	0.7	0.4	0.8
New Brunswick	0.7	0.6	0.4	0.5
Quebec	1.1	0.7	0.4	0.8
Ontario	2.9	1.2	0.7	2.4
Manitoba	1.4	1.0	0.5	0.8
Saksatchewan	0.6	0.5	0.3	0.4
Alberta	1.8	1.3	0.8	1.3
British Columbia	4.1	1.3	1.3	4.0
Yukon	0.6	0.5	0.7	0.8
Northwest Territories	0.9	0.1	0.7	1.5
Nunavut	0.2	0.0	0.6	0.9
High assumption				
Canada	2.5	1.0	0.7	2.1
Newfoundland and Labrador	0.5	0.4	0.4	0.5
Prince Edward Island	0.7	0.4	0.4	0.6
Nova Scotia	1.1	0.7	0.4	0.8
New Brunswick	0.7	0.6	0.4	0.5
Quebec	1.1	0.7	0.4	0.8
Ontario	3.3	1.2	0.7	2.8
Manitoba	1.4	1.0	0.5	0.8
Saksatchewan	0.6	0.5	0.3	0.4
Alberta	1.8	1.3	0.8	1.3
British Columbia	5.0	1.3	1.3	4.9
Yukon	0.6	0.5	0.7	0.8
Northwest Territories	0.9	0.1	0.7	1.5
Nunavut	0.2	0.0	0.6	0.9

Source: Statistics Canada, Demography Division.

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Chapter 7: Projection of non-permanent residents

by Jonathan Chagnon, Nora Bohnert and Patrice Dion

Introduction

Flows of temporary migrants have increased in numerous industrialized countries over the last decade. There are many reasons for this phenomenon, including the emergence of new temporary worker programs (Castles and Miller 2009), the entry of many countries into economic communities such as the European Union (Ibid) and more vigorous efforts to attract international students (Ibid; Florida 2005).

Canada is no exception. In recent years, the number of non-permanent residents (NPRs) has grown rapidly in Canada, mainly a result of the increasing number of temporary residence permits issued to workers. Despite these trends the admission of temporary workers relates more to federal government policies than to demographic factors; as a result, projecting future trends in non-permanent residents remains a difficult exercise.

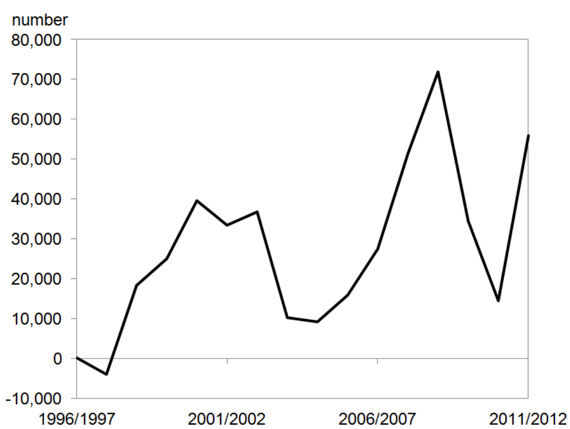
Trends in the number of non-permanent residents

At Statistics Canada, data on non-permanent residents have been available since 1971. However, changes in accounting methods render it difficult to compare data collected pre- and post-1996.

The net number of NPRs to Canada fluctuated substantially between 1996/1997 and 2011/2012 (Figure 7.1). It has nevertheless remained positive since 1998/1999, peaking at nearly 72,000 in 2008/2009. In 2011/2012, the net number of NPRs was about 56,000, representing a non-negligible proportion of the growth of the Canadian population (14%) for that period.

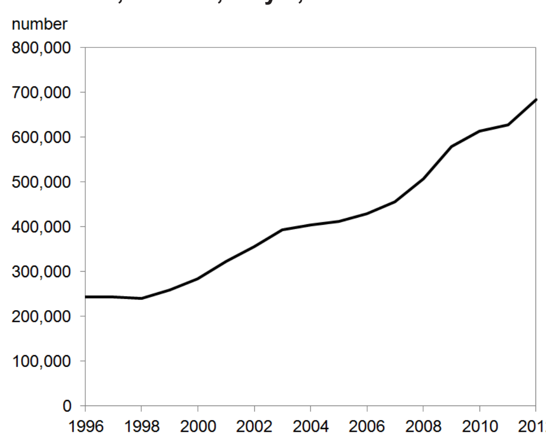
Overall, the total number of non-permanent residents present in Canada almost tripled between 1996 and 2011, rising from 243,700 to 684,200 (Figure 7.2). This growth has become particularly rapid since 2007.

Figure 7.1 Net annual number of non-permanent residents, Canada, 1996/1997 to 2011/2012



Source: Statistics Canada, Demography Division, Population Estimates Program.

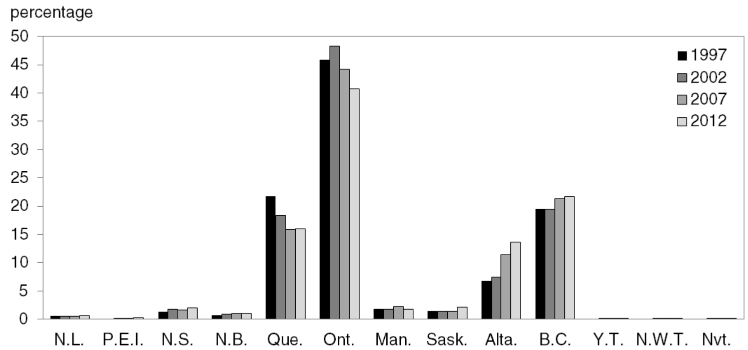
Figure 7.2 Total number of non-permanent residents, Canada, July 1, 1996 to 2012



Source: Statistics Canada, Demography Division, Population Estimates Program.

The majority of NPRs admitted to Canada tend to settle in just four provinces: Ontario, Quebec, British Columbia and Alberta (Figure 7.3). The proportion of NPRs settling in Ontario or Quebec have generally declined over the past 20 years, while it has substantially increased in British Columbia and particularly Alberta, where the proportion has doubled.

Figure 7.3 Geographic distribution (in percentage) of non-permanent residents, Canada, July 1, 1997 to 2012

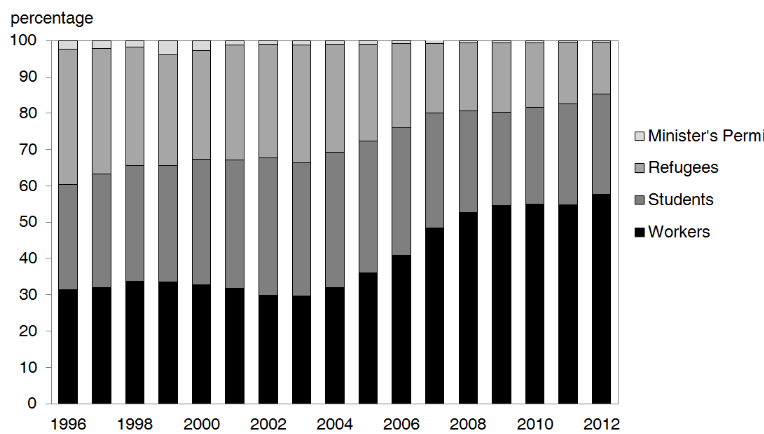


Source: Statistics Canada, Demography Division, Population Estimates Program.

Individuals are granted temporary residence in Canada for various reasons. NPRs can be divided, for example, into four major categories: foreign workers, international students, refugees[1] and ministerial permit holders. At the turn of the 21st century, workers, students and refugees each accounted for about a third of all NPRs (Figure 7.4). However, the number of persons admitted under the worker category grew rapidly during subsequent periods, reaching 58% in 2012.

Generally stable between 2003 and 2009, the number of international students has increased considerably in the subsequent years, from nearly 150,000 in 2009 to 187,700 in 2012.[2] The proportion of international students in Canada's total NPR population nevertheless declined from its peak of 38% in 2004 to 27% in 2012.

Figure 7.4 Distribution (in percentage) of non-permanent residents by category, Canada, July 1, 1996 to 2012



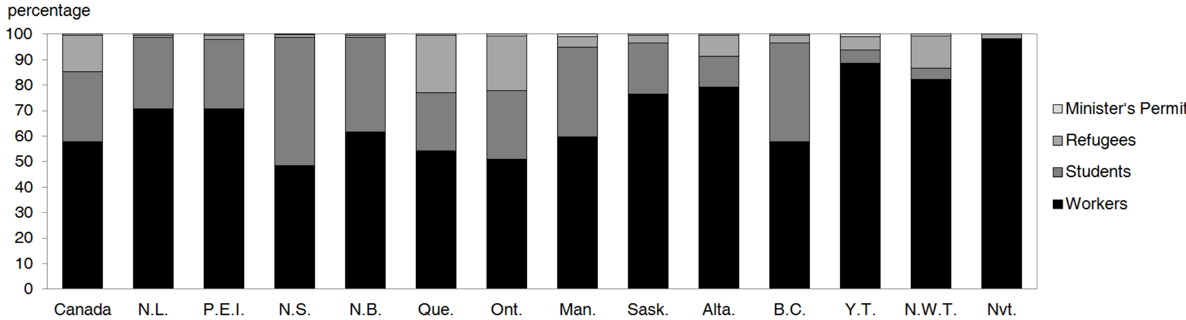
Source: Statistics Canada, Demography Division, Population Estimates Program.

From about a third of all NPRs in 2003, the proportion of refugees decreased steadily to 14% in 2012. Over the past 10 years, the number of ministerial permit holders has represented no more than 1.1% of all NPRs.

The distribution of NPRs by category of admission varies widely from province to province (Figure 7.5). For example, in 2012, more than three-quarters of NPRs who had settled in Saskatchewan, Alberta and the territories were temporary workers, compared with about one-half in Nova Scotia, Quebec and Ontario. Nova Scotia was the only province in which more than half of the NPRs were international students. More than 20% of the NPRs admitted to Quebec and Ontario in 2012 were refugees, the highest proportions in the country.

1. Refugees are persons claiming refugee status. Citizenship and Immigration Canada generally includes these persons in the 'humanitarian' category.
2. Note that in some cases, students may be in Canada on a visitor's permit, in which case they are not counted as international students.

Figure 7.5 Distribution (in percentage) of non-permanent residents by category, Canada, provinces and territories, July 1, 2012



Source: Statistics Canada, Demography Division, Population Estimates Program.

Various factors suggest that the number of NPRs could increase over the next few years in Canada. According to recent labour projections, the labour force growth rate is likely to decrease in the coming years (Martel et al. 2011).[3] This situation could lead to an increase in the number of NPRs as a short-term response by the government to possible sectoral labour shortages. The temporary admission of foreign workers is intended in part to address these shortages and "[…] meet acute and short-term needs in the labour market that could not be filled by the domestic labour force." (Citizenship and Immigration Canada 2013). Moreover, in contrast to the number of immigrants, there are no targets associated with the annual number of non-permanent residents admitted to Canada, and therefore the number of NPRs is likely to fluctuate substantially from year to year, particularly in response to the country's economic situation.

As with the number of foreign workers, the number of international students admitted to Canada has generally increased over the years. Because they have Canadian educational credentials, and because they have interacted with other Canadian students, international students are well prepared for the Canadian labour market and tend to integrate rapidly into Canadian society (Citizenship and Immigration Canada 2013). As a result, many measures have been taken to attract and retain international students, such as the Work Permits and Post-Graduation Work Permits Program, which allows them to acquire off-campus experience (Ibid).

A few years ago, Citizenship and Immigration Canada (CIC) also introduced the Canadian Experience Class (CEC) program to facilitate the retention of "skilled individuals who have already demonstrated their ability to integrate into the Canadian labour market"; this program was enhanced in 2013. The CEC allows temporary foreign workers and international student graduates with Canadian work experience to apply for permanent residence. For some foreigners, it is an alternative and potentially faster way of gaining admittance to Canada as an immigrant. On January 2, 2013, the criteria were modified to allow candidates to apply following 12 months of full-time work experience in Canada (instead of the 24 months previously required). In addition, the period for meeting these requirements was extended to a maximum of 36 months. CIC notes that the CEC is currently the fastest-growing immigration program (Citizenship and Immigration Canada 2013).

3. According to these projections, the annual labour force growth rate would be less than 1% in 2016 and, depending on the scenario, between 0.2% and 0.7% during the 2021/2026 period. In comparison, the labour force grew an average of about 1.4% annually between 2006 and 2010.

The Comprehensive Economic and Trade Agreement (CETA), recently negotiated between Canada and the European Union, could also have an impact on the number of applications for temporary residence. The agreement is expected to contain a provision on worker mobility and skills recognition that will ease certain rules to facilitate the temporary entry of certain classes of workers.[4]

On the other hand, there are factors that could reduce the number of NPRs, or at least slow the growth thereof, over the next few years. For example, changes in and tightening of the Temporary Foreign Workers Program's admission rules,[5] announced in the 2013/2014 federal budget, will be put in place to ensure that Canadians are given the first chance at available jobs. These measures are intended to ensure that Canadian workers take priority over foreign workers in hiring decisions, and that, in the event that temporary foreign workers are needed, employers have a plan to eventually replace them with Canadian workers (Economic Action Plan 2013).[6] More recently, the federal government announced further revisions to the program, mainly with the aim of "restricting access to the Temporary Foreign Worker Program" (Government of Canada 2014). These revisions, some of which will be phased in over several years, are intended primarily to restrict the number of admissions of unskilled temporary workers in industries and regions where unemployment rates are relatively high. Although the report does not specify targets, the combined effect of these numerous revisions may be to stabilize or reduce the number of temporary workers in the future.[7]

Methodology

The NPR population is projected in parallel with the permanent resident population. However, unlike the permanent resident population, the NPR population is not subjected to the risks of dying or emigrating during the projection. In addition, immigration does not affect the number of NPRs, since immigrants are, by definition, permanent residents. With regard to births, since children born in Canada are automatically Canadian citizens, regardless of the parents' status (permanent residents, NPRs or visitors), the fertility of female NPRs only affects the projected population of permanent residents.[8] Consequently, the growth of the NPR population depends solely on the annual net counts, that is, the difference between the number of NPRs who enter Canada and the number who leave. Hence the assumptions concerning the evolution of the NPR population apply to the annual net number of NPRs.

In addition to the flow volumes, the characteristics of people entering and leaving the country have to be determined. In this regard, a very simple assumption is made: every person who leaves is assumed to be replaced by a person of the same sex and age and living in the same province or territory. Canada's NPR population is therefore projected as a stable population that does not age and always keeps a similar age structure, even becoming a stationary population, with an invariable count in years when the projected annual net number is zero.

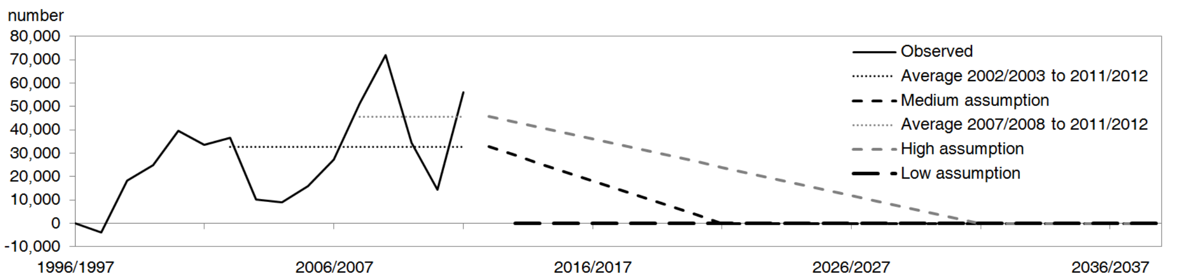
4. For more details, see Government of Canada (2013).
5. These changes do not affect all foreign worker programs equally. For example, the Seasonal Agricultural Worker Program is exempted. However, on average, this program has accounted for just 3.5% of NPR admissions since 2009 (Citizenship and Immigration Canada 2012).
6. More specifically, businesses will now have to pay fees to have their applications processed; new language restrictions will be introduced so that English and French will be the only languages for which there can be proficiency requirements; new job advertising requirements will be introduced; and additional questions concerning labour market impacts will be added to the application form (Employment and Social Development Canada 2013).
7. The revisions that are most relevant to the projections include a cap (10%) on the proportion of workers in low-wage positions (based on the total number of hours worked) for each work site, to be phased in between 2014 and 2016; refusal of applications for positions in the accommodation, food services and retail trade sectors in economic regions with an unemployment rate at or above 6.0%; reduction of the duration of work permits to a maximum of one year (from two years) for all low-wage positions; and changes in the agreements with some provinces and territories concerning exemptions for various types of positions (Government of Canada 2014).
8. For this reason, female NPRs are subjected to the fertility component during the projection, and their children join the cohort of newborns in the permanent resident population. Note that specific fertility rates for non-permanent residents are used in this edition for the first time. See Chapter 3.

Assumptions

The projection assumptions regarding NPRs are based on recent trends, the current demographic situation and recent policies of the Canadian government. Three assumptions were developed; this aspect differs from previous editions, which had only one assumption for the NPR component.

The **medium assumption** has an initial net number of NPRs equal to the average annual net number from 2002/2003 to 2011/2012 (Figure 7.6). The projected net number then declines linearly from 2012/2013 to reach zero in 2021/2022. This level is kept constant until the end of the period. The provincial/territorial distribution of this net number and its age and sex composition are the same as those observed during the period 2010 to 2012. Under this assumption, the total number of non-permanent residents in Canada would reach 864,600 in 2021 and would remain constant for the remainder of the projection (Figure 7.7 and Table 7.1).

Figure 7.6 Net annual number of non-permanent residents, observed (1995/1996 to 2011/2012) and projected (2013/2014 to 2037/2038) according to three assumptions, Canada, July 1

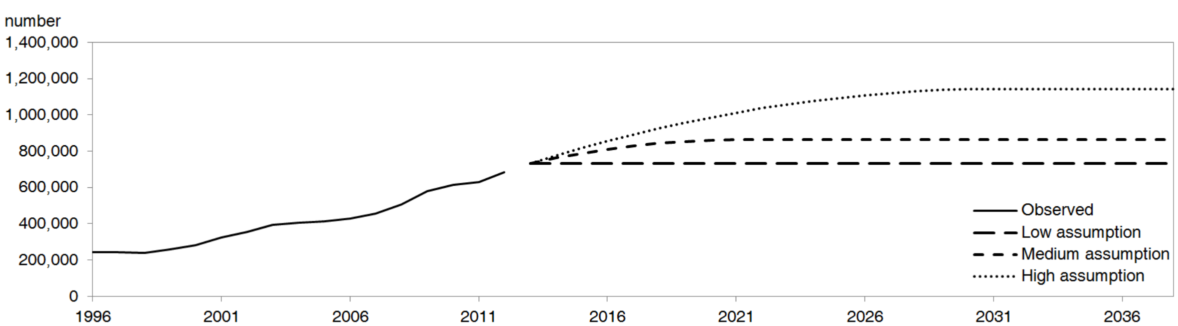


Notes: The projection of net non-permanent residents begins in 2012/2013 since 2011/2012 was the last period for which observed data were available. The 2012 /2013 projected values are, however, not directly utilized in the projections.

Source: Statistics Canada, Demography Division.

The **high-growth assumption** is an extension of recent trends in the net number of NPRs and its composition. In fact, it suggests in broad terms a larger increase in the number of temporary workers to address specific needs in the labour market. The initial annual net number, higher than in the medium assumption, is equal to the observed average annual net number from 2007/2008 to 2011/2012 (Figure 7.6). It also declines less rapidly than in the medium assumption, reaching zero in 2031/2032. This level is kept constant until the end of the period. Under this assumption, the total number of non-permanent residents would reach 1,144,300 by 2031 and would remain constant for the remainder of the projection (Figure 7.7).

Figure 7.7 Total number of non-permanent residents, observed (1996 to 2012) and projected (2013 to 2038), according to three assumptions, Canada, July 1



Source: Statistics Canada, Demography Division.

In this assumption, the distribution of NPRs among the provinces and territories takes account of the differential growth of the NPR population based on admission class and uneven distribution across Canada, as previously noted. The method involves first projecting the national net numbers by NPR category and then weighting the geographic distribution by category. Initially, the net is distributed by NPR category based on the estimated average proportions for 2010 to 2012, which are then linearly extrapolated over a five-year period based on estimated changes over the last 10 years. Then the nets by category were distributed across the provinces and territories on the basis of the observed average proportions for the period from 2010 to 2012 (Table 7.1). Compared with the medium assumption, the method increases the proportion of temporary workers in the NPR population (Table 7.2), thus favouring the western provinces, where they are more heavily concentrated.

Lastly, the **low-growth assumption** simply keeps the total number of non-permanent residents and their distribution across the country identical to what was observed in 2013. It reflects recent changes in the Temporary Foreign Worker Program that could result in the stabilization of the number of non-permanent residents in Canada over the course of the projection.

Table 7.1 Total number of non-permanent residents, observed (2013) and projected (2014 to 2063) according to three assumptions, Canada, provinces and territories, July 1

Assumption / Year	Canada	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.	Nvt.
	number													
Low assumption														
2013	733,555	4,855	2,201	13,761	6,969	113,323	286,024	14,186	18,304	112,893	159,946	563	460	70
2014 to 2063	733,555	4,855	2,201	13,761	6,969	113,323	286,024	14,186	18,304	112,893	159,946	563	460	70
Medium assumption														
2013	733,555	4,855	2,201	13,761	6,969	113,323	286,024	14,186	18,304	112,893	159,946	563	460	70
2014	762,671	5,022	2,275	14,315	7,259	118,050	297,761	14,722	18,857	116,930	166,342	589	476	72
2015	788,148	5,169	2,339	14,800	7,513	122,187	308,031	15,191	19,342	120,462	171,938	612	489	75
2016	809,985	5,294	2,395	15,216	7,731	125,732	316,834	15,593	19,757	123,490	176,734	632	501	76
2017	828,183	5,399	2,441	15,562	7,912	128,687	324,169	15,928	20,103	126,013	180,732	648	511	78
2018	842,741	5,482	2,478	15,839	8,057	131,051	330,038	16,196	20,379	128,031	183,930	662	519	79
2019	853,659	5,545	2,505	16,047	8,166	132,823	334,439	16,397	20,587	129,545	186,328	671	525	80
2020	860,938	5,587	2,524	16,185	8,238	134,005	337,374	16,531	20,725	130,555	187,927	678	529	81
2021 to 2063	864,578	5,608	2,533	16,255	8,275	134,596	338,841	16,598	20,794	131,059	188,726	681	531	81
High assumption														
2013	733,555	4,855	2,201	13,761	6,969	113,323	286,024	14,186	18,304	112,893	159,946	563	460	70
2014	776,788	5,110	2,313	14,581	7,407	120,233	303,139	14,992	19,155	119,142	169,553	604	484	74
2015	817,618	5,355	2,421	15,353	7,823	126,711	319,166	15,758	19,971	125,160	178,670	644	508	78
2016	856,047	5,587	2,523	16,078	8,218	132,766	334,126	16,483	20,751	130,931	187,290	683	530	81
2017	892,074	5,808	2,620	16,755	8,590	138,406	348,042	17,166	21,493	136,437	195,401	720	552	85
2018	925,700	6,013	2,710	17,387	8,937	143,670	361,030	17,803	22,185	141,577	202,972	755	572	88
2019	956,923	6,204	2,794	17,974	9,259	148,558	373,090	18,395	22,828	146,350	210,003	787	591	91
2020	985,745	6,381	2,872	18,516	9,557	153,070	384,222	18,941	23,421	150,755	216,492	817	608	94
2021	1,012,165	6,542	2,943	19,012	9,829	157,206	394,427	19,441	23,965	154,793	222,441	844	624	97
2022	1,036,183	6,689	3,007	19,463	10,077	160,966	403,704	19,897	24,459	158,464	227,848	869	638	99
2023	1,057,799	6,822	3,065	19,870	10,301	164,350	412,053	20,306	24,904	161,769	232,716	891	651	101
2024	1,077,014	6,939	3,117	20,231	10,499	167,358	419,475	20,670	25,300	164,706	237,042	911	663	103
2025	1,093,827	7,042	3,162	20,547	10,672	169,990	425,969	20,989	25,646	167,275	240,827	929	673	105
2026	1,108,237	7,130	3,201	20,817	10,821	172,246	431,535	21,262	25,943	169,478	244,072	944	682	106
2027	1,120,246	7,204	3,233	21,043	10,945	174,126	436,174	21,490	26,190	171,314	246,776	956	689	108
2028	1,129,854	7,262	3,259	21,224	11,044	175,630	439,885	21,672	26,388	172,782	248,939	966	694	109
2029	1,137,059	7,307	3,278	21,359	11,119	176,758	442,668	21,808	26,536	173,884	250,561	973	699	109
2030	1,141,863	7,336	3,291	21,449	11,168	177,510	444,523	21,899	26,635	174,618	251,643	978	702	110
2031 to 2063	1,144,265	7,351	3,298	21,494	11,193	177,886	445,451	21,945	26,684	174,985	252,184	981	703	110

Source: Statistics Canada, Demography Division.

Table 7.2 Proportion (in percentage) of non-permanent residents by category, observed (2010/2012) and projected according to the high assumption (2013 to 2017), Canada, July 1

Category	Estimated average 2010/2012	Projected 2013	2014	2015	2016	2017
	percentage					
Workers	55.9	58.4	60.8	63.1	65.4	67.6
Students	27.3	26.1	25	23.8	22.6	21.5
Refugees	16.3	15	13.9	12.7	11.7	10.7
Minister's Permit	0.5	0.4	0.4	0.3	0.3	0.3

Source: Statistics Canada, Demography Division based on data from Citizenship and Immigration Canada.

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Chapter 8: Projection of interprovincial migration

by Patrice Dion

Introduction

Interprovincial migration is the most important component of population growth in some provinces and territories (Dion and Coulombe 2008). Plausible projections of interprovincial migration are therefore of paramount importance to the credibility of the projections.

To reflect the inherent uncertainty of interprovincial migration, Statistics Canada creates numerous scenarios in which the migration assumptions vary. These assumptions are created by varying the reference period, each one reflecting different migration patterns. However, even if the possible variations in internal migration are considered, this component is often the source of the largest gaps when subsequent comparisons are made with observed data.[1] In fact, because this component is extremely volatile over time, internal migration is often recognized as the most difficult component to project (Smith 1986).

As in the past, the present edition of the *Population Projections for Canada, Provinces and Territories* uses the multiregional model to project interprovincial migration, but this time with the addition of an out-migration rate adjustment model. The purpose of this model is to minimize the variation in net migration rates over the course of the projection and make the assumptions more transparent.

This chapter first presents a brief description of the multiregional model and an introduction to the out-migration rate adjustment model. The final part of the chapter contains a description of the projection assumptions.

Methodology

The multiregional model

Since the 1984/2006 edition of *Population Projections for Canada, Provinces and Territories*, Statistics Canada has been projecting internal migration using rates of out-migration from each region of origin to each region of destination.[2] This model, often described as a multiregional model, was developed in the 1970s, and its use has since become more widespread (Wilson and Rees 2005).

The multiregional model has numerous advantages for projecting internal migration. First, it is capable of projecting a large number of regions simultaneously and coherently, rather than projecting each one separately (Plane and Rogerson 1994), thus avoiding many conceptual pitfalls. Unlike the use of net migration rates or counts, the use of multiregional rates allows migration flows to change dynamically as a function of the size, geographic distribution and age-sex composition of populations (Wilson and Bell 2004); it also adheres to the "person at risk" principle (Isserman 1992). Second, in the multiregional

1. For example, Dion (2012) performed an a posteriori evaluation of the agreement between the 2005/2031 projections published by Statistics Canada and observed data; even when the migration scenario that was closest to the actual situation for each province and territory was selected, interprovincial migration was the component that exhibited the largest differences in 8 of the 13 provinces and territories.
2. The edition published in 2001 is a notable exception. In those projections, the out-migration rates and proportions of in-migrants in the regions were sometimes adjusted using an iterative process to yield more stable net migration figures. Therefore, "[a]lthough interprovincial migration projections are developed in the context of a cohort-component multiregional model using assumed age-sex specific out-migration rates and origin-destination proportions, the assumptions are assessed in terms of the resulting levels of net migration … for each province and territory." (Statistics Canada 2001). The problem is that these adjustments do not follow explicit methodological principles. They were made solely according to the judgment of the analysts and reduced two important characteristics of a projection assumption: transparency and reproducibility.

model, the number of in-migrants is always equal to the number of out-migrants, a conceptual argument that is not assured through the alternative use of net migration rates (for example, see Rogers 1990). Third, its popularity is due in particular to the fact that it fits perfectly into a matrix model such as the one used for cohort projections (Le Bras 2008), so that all the components of population growth can be combined using transition matrices (Markov chains).[3]

Calculating multiregional out-migration rates

In the multiregional model, age-sex-specific rates of out-migration from each region to each other region are applied directly to persons at risk of migrating, which is consistent with the way in which the other components of population growth are normally projected. These rates are calculated in several steps. In the first step, age-sex-specific central out-migration rates are calculated for each province and territory, for all destinations combined and for all the years in the selected reference period (for a given assumption). Then the average of these rates is calculated for the period. Averages are used so that all of the years can be assigned equal weights, regardless of the population sizes and number of out-migrants.

The second step is to disaggregate these age-sex-province/territory-of-origin-specific out-migration rates by province/territory of destination. To that end, origin-destination matrices by sex and age (or age group) are formed, based on averages calculated for the selected reference period. These matrices yield the proportion of migrants from each region of origin to each region of destination. Multiplying the origin-specific out-migration rate obtained in the first step by the proportions obtained from the origin-destination matrices produces origin-destination-specific out-migration rates. Thus, multiregional out-migration rates take age-sex-specific characteristics into account not only with regard to out-migration from the provinces and territories but also with respect to destination preferences.[4]

Adjusting the out-migration rates

Projecting a population using transition matrices in the multiregional model eventually results in a stable state, in which the population maintains a constant age-sex distribution and a regional distribution completely independent of the characteristics of the initial population (Le Bras 2008). In the multiregional model, changes due to migration are linear in nature and tend to favour growth in the slowest-growing regions at the expense of the fastest-growing regions. By helping to balance growth in the regions during the projection, the multiregional model gives rise to assumptions that are generally more conservative than those of other models. For example, projections based on net migration rates tend to instead create an "acceleration" effect (Isserman 1992), because the projected net migration changes in parallel with the population, reinforcing existing trends.

It is worth noting that this outcome is inherent to the use of time-invariant out-migration rates, which leads to the assumption that migration depends solely on population changes in the region of origin and not in the region of destination. However, unlike other events such as births and deaths, migration involves more than one region (Plane and Rogerson 1994; Feeney 1973). In fact, interregional out-migration rates for a particular point in time are empirically linked to the distribution of the population in the various regions of destination (Plane 1993; Courgeau 1991; Poulain 1982). In this context, using constant out-migration rates amounts to denying the potential effect of changes in the distribution of the population in the regions of destination, thereby painting an incomplete picture of migration dynamics (Plane 1993; Plane and Rogerson 1994).

3. Using matrices, survival probabilities derived from the various components of population growth can be applied to cohorts, and probabilities of migrating to each of the other regions in the system can be assigned to cohorts.
4. This is another innovation: in previous editions, a single origin-destination matrix was used, so that age and sex were not considered.

This assumption is not without consequences: by ignoring changes in population sizes in the regions of destination,[5] the multiregional model causes changes, sometimes significant ones, in the projected net migration rates, changes that are due exclusively to a purely mechanical process, i.e., an increase or decrease in the number of out-migrants from a given region of origin based solely on the growth of that region. Typically, the selection of the reference period is based on an analysis of the net migration counts or, preferably, the net migration rates. In this context, it is expected that the projection assumptions will reproduce what was observed in the selected historical period, and that the regions which gained or lost population will be mostly the same ones. However, this is not what happens during the projection: projecting internal migration with the multiregional model introduces latent effects that are difficult to anticipate (Pittenger 1978), that are not necessarily known to or expected by the analyst, and over which the analyst has limited control. Another consequence of using the multiregional model is that it does not produce a wide range of possibilities (Werschler and Nault 1996). When the different scenarios show similar growth patterns, the projected net migration figures for the regions tend to converge over time, thereby reducing the variability of the results, and the uncertainty associated with the internal migration component decreases over time, when it should normally increase.

The limitations of the multiregional model are especially apparent in the context of projections for the Canadian provinces and territories. The large disparities observed in population growth and size among the provinces and territories intensifies the variations in net migration rates (Werschler and Nault 1996).

With the ultimate goal of projecting net migration rates that are much more stable and consistent with those observed during the selected reference period, this edition takes a new approach, using a simple, intuitive method of adjusting the out-migration rates during the projection. The approach is similar to those based on gravity models, in that it adjusts the provincial out-migration rates according to the relative population sizes to balance the migration flows between the regions. The adjustment consists of modifying the out-migration rates, for each year projected, on the basis of the average out-migration rates and population sizes observed during the reference period and on the basis of the population sizes at time t, i.e., at the beginning of the year to be projected. Hence, the out-migration rate between t and $t+1$ ($m_{ij}^{t,t+1}$) is modified as follows:

$$m_{ij}^{t,t+1} = m_{ij}^{ref} \frac{P_j^t / \sum_k P_k^t}{P_j^{ref} / \sum_k P_k^{ref}} \qquad 8.1$$

where m_{ij}^{ref} is the average rate observed during the reference period, P_j^t is the size of the population of destination, and P_j^{ref} is the average size of the population of destination during the reference period.

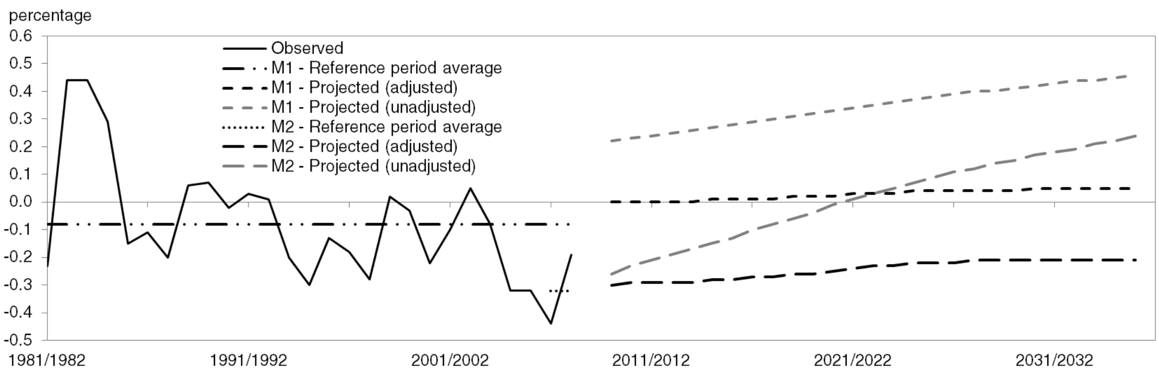
Alternatively, the adjustment could be calculated as follows, on the basis of the rates and populations for the preceding year:

$$m_{ij}^{t,t+1} = m_{ij}^{t-1,t} \frac{P_j^t / \sum_k P_k^t}{P_j^{t-1} / \sum_k P_k^{t-1}} \qquad 8.2$$

5. It could reasonably be argued that the time-invariance of the out-migration rates has more to do with assumptions than with methods. If so, the challenge is to set, before the projections are made, migration parameters that change over the projection period, which is all the more complicated since the projected demographic weights of the regions vary in part as a result of migration.

Even though it is similar to the models proposed by Feeney (1973) and Plane (1982; 1993) and is based more generally on spatial interaction research, the adjustment model proposed here is informed by a different perspective: the aim is not to try to predict migration flows on the basis of incomplete information but to project internal migration on the basis of clear assumptions about net migration rates.[6] In addition, it can easily be combined with the matrix cohort projection model and retains that model's major advantages. Results show that the method projects migration flows that give rise to net migration rates that are quite close to those observed during the reference period and are relatively stable over time, and whose changes can be explained in a fairly intuitive way. The method also makes it possible to develop more varied assumptions than in previous editions. Figures 8.1 and 8.2 show the effect that the adjustment method has on projected net migration rates when it is applied to scenarios M1 and M2 of the 2009/2036 edition of the *Population Projections for Canada, Provinces and Territories*, for the provinces of Nova Scotia and Ontario respectively.

Figure 8.1 Net interprovincial migration rate (in percentage) observed (1981/1982 to 2007/2008) and projected (2009/2010 to 2035/2036) according to various scenarios, Nova Scotia



Source: Statistics Canada, Demography Division.

Figure 8.2 Net interprovincial migration rate (in percentage) observed (1981/1982 to 2007/2008) and projected (2009/2010 to 2035/2036) according to various scenarios, Ontario

Source: Statistics Canada, Demography Division.

6. Nevertheless, considering the region of destination in the equation is not inappropriate from a theoretical perspective. On the contrary, it is conceivable that in the model, the sizes of the regions of destination serve as a proxy variable for a large number of characteristics of the region of destination, such as employment opportunities (Feeney 1973; Plane 1982; Vanderkamp 1976), greater job variety (Vanderkamp 1976) and capacity to publicize employment opportunities (Vanderkamp 1976).

Assumptions

The various interprovincial migration assumptions differ in their reference periods. Each of these references periods reflects a different context, marked notably by particular labour market conditions in the provinces and territories, which have been shown to greatly influence interprovincial migration patterns (Finnie 2000; Bernard et al. 2008). Together, these assumptions illustrate the high volatility of this component over time.[7]

Five projection assumptions were developed, for the express purpose of presenting a wide range of scenarios for each province and territory. The 1991/2011 period was selected for the scenario that is traditionally referred to as 'historical' because it is a relatively long period (20 years) and it is the longest period for which data are available for all provinces and territories (following the creation of Nunavut).

The alternative scenarios reflect shorter periods within the 1991/2011 range. The reference periods were selected in such a way that a most favourable scenario and a least favourable scenario could be identified for each province and territory. To that end, the first and third quartiles of the annual net migration rates for the 1991/2011 period were taken as targets for the low-growth and high-growth migration assumptions respectively.[8, 9] Table 8.1 shows the quartiles of the average annual net migration rates observed during the 1991/2011 period and the net migration rates observed during the various reference periods associated with the assumptions. With the new model for projecting interprovincial migration used in this edition, the projected average net migration rates will remain closer to the rates observed during the reference periods associated with the various scenarios, which was not the case in previous editions.

Table 8.1 Quartiles of net migration rates observed during the reference period (1991/2011) and average net migration rates from each interprovincial migration assumption, by province and territory

Region	Quartiles for period 1991/2011			Average in each scenario (period)				
	Q1	Q2	Q3	M1 (1991/2011)	M2 (1991/2000)	M3 (1999/2003)	M4 (2004/2008)	M5 (2009/2011)
	percentage							
Newfoundland and Labrador	-0.9	-0.8	-0.2	-0.6	**-1.1**	-0.7	-0.6	**0.2**
Prince Edward Island	-0.3	0.0	0.1	0.0	**0.1**	0.1	**-0.4**	-0.1
Nova Scotia	-0.3	-0.1	0.0	-0.1	-0.1	-0.1	**-0.3**	**0.0**
New Brunswick	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	**-0.3**	**0.0**
Quebec	-0.2	-0.1	-0.1	-0.1	**-0.2**	-0.1	-0.1	**-0.1**
Ontario	-0.1	0.0	0.1	0.0	0.0	**0.1**	**-0.1**	0.0
Manitoba	-0.5	-0.4	-0.3	-0.4	-0.4	-0.3	**-0.5**	**-0.2**
Saskatchewan	-0.7	-0.4	0.1	-0.3	-0.5	**-0.8**	-0.3	**0.1**
Alberta	0.2	0.4	0.9	0.6	0.5	0.7	**1.0**	**0.1**
British Columbia	-0.2	0.2	0.4	0.2	**0.4**	**-0.2**	0.3	0.1
Yukon	-2.0	0.2	0.8	-0.4	**-1.2**	-1.1	0.2	**1.0**
Northwest Territories	-1.4	-0.9	-0.3	-1.0	-1.3	**-0.3**	-1.3	-0.6
Nunavut	-0.5	-0.3	-0.1	-0.3	-0.3	0.0	**-0.7**	**0.0**

Note: Estimates in bold figures indicate lowest and highest net migration rates for each province or territory among all scenarios.

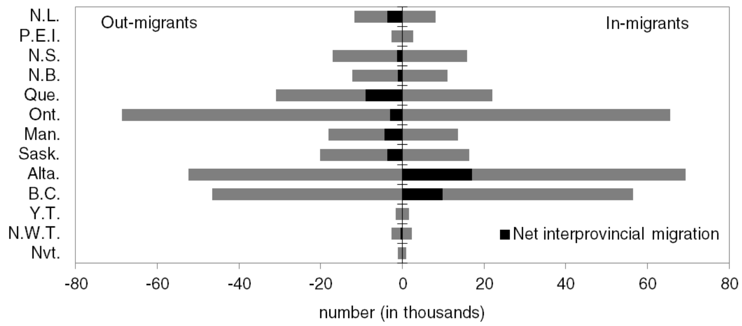
Source: Statistics Canada, Demography Division.

7. A brief description of the net migration counts and rates observed in the 1971 to 2006 censuses is provided in Dion and Coulombe (2008). Supplementary analyses of interprovincial migration trends can also be found in the *Report on the Demographic Situation in Canada,* http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=91-209-X201300111787&lang=eng.
8. Clearly, it is difficult to hit these targets precisely with only a limited number of scenarios. Hence, the goal was to come close to the targets.
9. In previous editions, the various scenarios represented an attempt to reproduce distinct periods without necessarily offering significant variations in net migration for each province and territory. This innovation, together with the interregional migration rate adjustment method described previously, should make it possible to better reflect the fluctuating nature of interprovincial migration.

Assumption M1 (historical)

Assumption **M1**, which can also be referred to as the historical assumption, is based on the longest reference period, from 1991/1992 to 2010/2011. Under this assumption, only Alberta and British Columbia experience positive net migration (Figure 8.3), while Prince Edward Island and Ontario experience close to zero net migration.

Figure 8.3 Average annual number of interprovincial in- and out-migrants and net interprovincial migration, 1991/1992 to 2010/2011

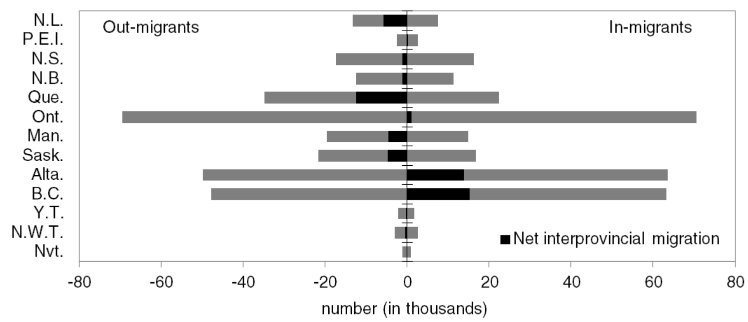


Source: Statistics Canada, Demography Division.

Assumption M2

Assumption **M2** reflects the period 1991/1992 to 1999/2000. Of all the assumptions presented, it is the most favourable to Prince Edward Island and British Columbia and the least favourable to Newfoundland and Labrador, Quebec and Yukon (Figure 8.4).

Figure 8.4 Average annual number of interprovincial in- and out-migrants and net interprovincial migration, 1991/1992 to 1999/2000

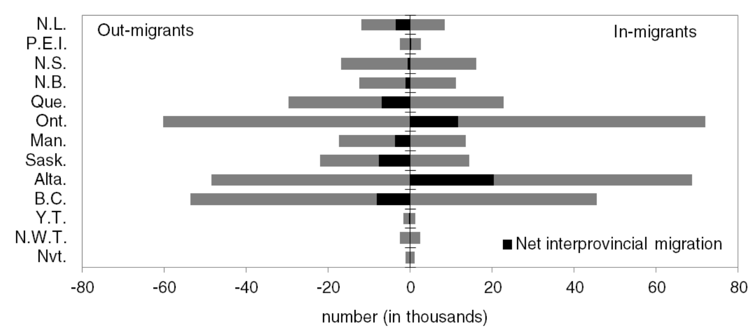


Source: Statistics Canada, Demography Division.

Assumption M3

Assumption **M3** is based on a brief four-year period, 1999/2000 to 2002/2003, in which Saskatchewan and British Columbia had particularly disadvantageous net migration figures (Figure 8.5). In contrast, assumption M3 features the largest migration gains for Ontario and the smallest losses for the Northwest Territories (the latter experiences negative net migration in every migration assumption).

Figure 8.5 Average annual number of interprovincial in- and out-migrants and net interprovincial migration, 1999/2000 to 2002/2003

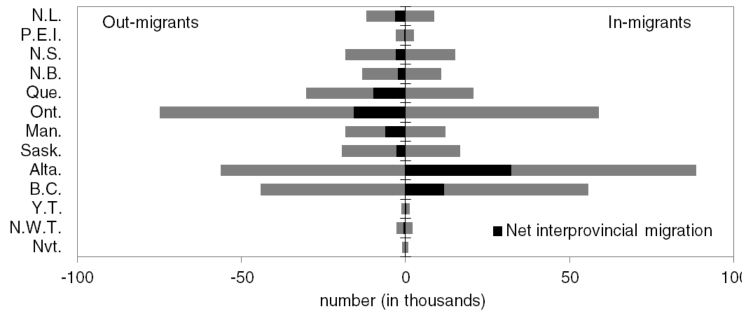


Source: Statistics Canada, Demography Division.

Assumption M4

Assumption **M4** is based on the period 2004/2005 to 2007/2008, which is characterized by migration flows that were particularly advantageous to Alberta (Figure 8.6). The flows to Alberta largely account for the fact that various provinces and territories (Prince Edward Island, Nova Scotia, New Brunswick, Ontario, Manitoba and Nunavut) experienced their most disadvantageous net migration figures in this assumption.

Figure 8.6 Average annual number of interprovincial in- and out-migrants and net interprovincial migration, 2004/2005 to 2007/2008

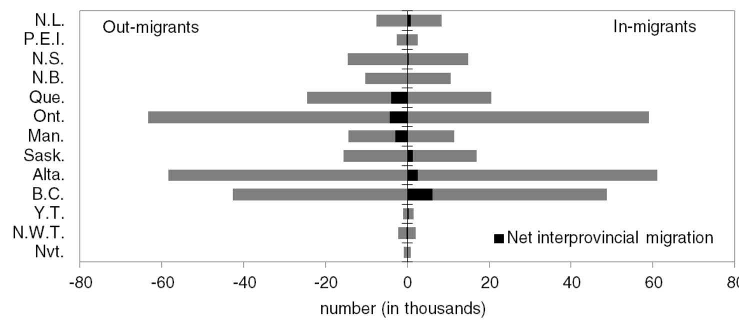


Source: Statistics Canada, Demography Division.

Assumption M5

Assumption **M5** reflects the period 2009/2010 to 2010/2011 and can be described as the 'recent trends' assumption. Though brief, this period reflects substantial changes in the general trends observed in Canada. First, migration to Alberta diminished appreciably in intensity, to the point where the province's net migration, though positive, was at its lowest (Figure 8.7). Second, provinces that typically had negative net migration, such as Newfoundland and Labrador, Nova Scotia, New Brunswick and Saskatchewan, experienced gains. While Manitoba had a net migration loss, this was the least disadvantageous scenario for the province. In addition, assumption M5 had the largest migration gains for Yukon and Nunavut.

Figure 8.7 Average annual number of interprovincial in- and out-migrants and net interprovincial migration, 2009/2010 to 2010/2011



Source: Statistics Canada, Demography Division.

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