Skills Research Initiative
Initiative de recherche sur les compétences

Population Ageing, High-skilled Immigrants and Productivity

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B. Employer-Supported Training;
C. Adjustments in Markets for Skilled Workers;
D. International Mobility of Skilled Workers.

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B. la formation en entreprise;
C. l'adaptation du marché du travail aux travailleurs spécialisés;
D. la mobilité des travailleurs spécialisés dans le monde.

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Abstract

This paper evaluates the potential economic and labour market effects of attracting more high-skilled immigrant workers in Canada in the context of an ageing workforce. The analysis is done using a computable overlapping generations model, which accounts for differences in the skill composition of immigrant and non-immigrant workers. The analysis first indicates that selecting the same proportion of high-skilled immigrants as in the second half of the 1990s would raise labour productivity and living standards in the long run. It could also reduce the expected negative impact of population ageing on growth in real GDP per-capita by about one-quarter. In addition, raising the proportion of high-skilled immigrants by 0.25% of the population each year could reduce by another 50% the anticipated decline in real GDP growth. However, these gains are conditional upon the recognition of permanent residents' credentials. Finally, attracting more high-skilled immigrants may significantly reduce the skill premium, which on one hand lowers earnings inequality between high and low skilled workers, but on the other hand may reduce incentives for young adults to invest in human capital.

Résumé

Cette étude évalue l'impact économique possible d'attirer plus de travailleurs immigrants hautement qualifiés au Canada et ses répercussions sur le marché du travail, dans le cadre d'une main-d'oeuvre vieillissante. L'analyse est effectuée à l'aide d'un modèle calculable à générations imbriquées qui prend en compte les différences dans la composition des travailleurs, immigrants et non immigrants, selon les compétences. Les résultats indiquent tout d'abord que sélectionner le même taux d'entrée d'immigrants hautement qualifiés, comme durant la deuxième milieux des années 90, augmenterait la productivité du travail et le niveau de vie à long terme. Cela pourrait amoindrir également l'impact négatif anticipé du vieillissement démographique sur la croissance du PIB réel par habitant d'un quart environ. De plus, augmenter la proportion d'immigrants hautement qualifiés de 0.25% de la population chaque année pourrait réduire d'un autre 50% la baisse anticipée sur la croissance du PIB réel. Finalement, attirer plus d'immigrants hautement qualifiés pourrait diminuer de façon importante la prime de compétence, ce qui d'un côté réduirait les inégalités de revenus entre les travailleurs hautement et faiblement qualifiés, mais d'un autre côté pourrait réduire les incitatifs pour les jeunes adultes d'investir en capital humain.

1. Introduction

According to standard demographic projections, the ageing of the baby boom generation will lead to slower labour force growth over the next several decades and to a sharp increase in the proportion of the older population. Also, according to the conventional view, population ageing will result in a relative scarcity of labour and possibly in skill shortages. This may in turn affect Canada's ability to continue developing an innovative, knowledge-based economy built on a highly skilled workforce and lead to slower growth in living standards. This situation is not unique to Canada as most OECD countries are confronted with the same phenomenon, although at different degrees.[1]

Although the slowing of labour force growth is inevitable, the consequences on productive capacity could be offset to a certain extent by a rise in labour productivity via policy measures. The productivity gains could result from a more intensive capitalization of the Canadian economy, from a shift towards more skilled workers and/or from technical progress. If we look specifically at skilled workers, increasing the quality of the workforce could be achieved by raising incentives for young adults to invest in higher education, by removing barriers for employers and workers to invest in firm-specific training and reduce skill mismatches, and/or by attracting more high-skilled immigrants. In this paper, we focus on the latter policy option and provide a quantitative evaluation of the potential effects of raising the proportion of high-skilled immigrants in Canada.

Canada's immigration policy traditionally reflects a wide range of socio-economic objectives, including economic growth, family reunification and humanitarian considerations. Since the early 1990s, Canada's immigration has been dominated by the selection of an increased proportion of skilled immigrants. Hence, recent Canadian immigrants tend to be better educated than previous cohorts of immigrants. According to Citizenship and Immigration Canada (CIC), over the period 1995-1999, 33% of landed immigrants had a university-level education, compared to 13% in the period 1980-1984.

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[1] See, for example, Auerbach and Kotlikoff (1987), Auerbach *et al,* (1989), Group of Ten (1998) and Hviding and Mérette (1998). It must be noted however, that the conventional view has been challenged by a number of authors including Emery and Rongve (1999), Denton and Spencer (2000), Fougère and Mérette (2000a and 2000b) and Mérette (2002).

The economic impact of immigration has been examined by several authors, including Borjas (1994) who concludes that: "immigration policy matters, so that host countries which filter applicants in terms of observable skills attract immigrants who are more skilled, have higher earnings and are less likely to participate in public assistance programs". He also adds that there is a strong positive correlation between the first generation of skilled immigrants and the skill of the second-generation.

In this paper, we focus on two substantive questions. First, to what extent raising Canada's immigration and the proportion of high-skilled immigrants can temper the effect of an otherwise ageing population through increased labour productivity. Second, what impact would alternative immigration quotas of skilled immigrants have on the earnings gap between high and low-skilled workers (the skill premium)?

The framework for our analysis is a six-region dynamic general equilibrium model with overlapping generations (OLG), parameterized for Canada. In each region, households include 15 overlapping generations of adult agents, natives or immigrants. In each cohort, we distinguish between agents that are active on the labor market, and those that are not (inactives and/or retired). In addition, whether they are natives or immigrants, workers differ according to their skills (high, medium and low-skilled). Labour is assumed regionally immobile, and immigration to each region is exogenous. Each region in the model produces one differentiated good and is open to trade. National and regional governments collect taxes on labour and capital income as well as on consumption, and spend on health, education and other goods and services. The national government also distributes transfers to regional governments and both national and regional governments distribute transfers to individuals. The public pension system is modeled as a two-tier pension program. The first-tier, the Quebec Pension Plans (QPP) in Quebec and the Canada Pension Plan in the rest of Canada, are modeled as pay-as-you-go and financed through payroll taxes. The second tier, the Old Age Security (OAS) system is modeled as a national transfer program to the elderly and is financed through general taxes from the national government.

The paper is organized as follows. In section 2, we briefly review the literature on the economic and labour market impacts of immigration in the context of an ageing population. Section 3 presents some stylized facts on the contribution of immigration to the labour market and

the proportion of skilled immigrants in Canada. In section 4, we provide a description of the model and discuss some key parameters. Section 5 discusses the calibration procedure. The main simulation results are reported in section 6. Finally, Section 7 raises some policy implications and draws some conclusions.

2. Ageing and the Economic and Labour Market Implications of Immigration

As mentioned in introduction, immigration is seen as a potentially important policy instrument to help mitigate the negative impact of population ageing. Several empirical studies have examined the economic impact of immigration on the host country, either from the perspective of specific groups of native workers or the country as a whole. In this section, we summarize some of the key results found in the literature.

2.1 Impact on Specific Groups of Workers

According to Tu (1991), the native labour force whose skills are complementary to those of immigrants should experience an improvement in their relative position with respect to native workers whose skills is substitutable to those of immigrants. These findings are supported by Borjas (1995) who indicates that the economic benefits on natives would emerge from complementarities between immigrant workers and other factors of production. These benefits are larger, according to him, when immigrants are sufficiently different from the stock of native productive inputs.

Borjas (1994, 1995) and Borjas *et al.* (1991, 1996) argue that the inflow of low-skilled immigrant workers to the U.S. contributed to reduce wages and employment to low-skilled native workers and to widen the wage distribution between high-skilled and low-skilled workers. De New and Zimmermann (1994) found similar results in Germany among blue-collar workers. However, the net economic benefits of immigration on the labour market and national income are positive, according to Borjas (1994, 1995) and would range between $6 billion and $20 billion annually. He also argues that these benefits would increase if U.S. immigration policy targets more skilled immigrants.

Freidberg and Hunt (1995) also examine the economic impact of immigration on wages, employment and growth in the host country, based on empirical analysis from several countries.

They find that it would require a 10% increase in the proportion of immigrant to the host country's population to reduce native wages by 1%. They also find that the impact of immigration on employment opportunity of natives, even workers who are close substitutes is marginal. Finally, Green (1995) finds that targeted skilled immigrants to Canada are more occupationally mobile than native workers and contribute to improve economic efficiency through a more flexible labour market.

Finally, using the Survey of Earned Doctorates and the Survey of Doctoral Recipients, Borjas (2005) finds that a foreign student influx into a particular doctoral field who graduated at a particular time had a significant and adverse effect on the earnings of doctorates in that field who graduated at roughly the same time. More specifically, a 10% immigration-induced increase in the supply of doctorates would lower the wage of competing workers by about 3%.

2.2 Macroeconomic Impact to the Host Country

A number of studies have used partial or applied general equilibrium models to evaluate the economic impact of immigration. Most of these studies focus on the fiscal implications to the host country of attracting more immigrants.

Hellwig *et al.* (1992) and the Centre for International Economics (1988) evaluate the economic impact of immigration using macroeconomic models and find that immigration raises real per-capita GDP. Auerbach and Oreopoulos (1999) for the U.S. and Bonin et al. (2000) for Germany use generational accounting models to evaluate the long run fiscal implications of attracting more immigrants. The results for the U.S. suggest that the fiscal effects are rather small, but for Germany the effects seem potentially large.

Fougère *et al*. (2004) use a regional CGE model with overlapping generations for Canada to evaluate the effects of raising the proportion of immigrants from 0.75 to 1% of the population each year. They find small but positive results on real-per capita GDP at the national level and the benefits come much later. However, at the regional level, the results vary more substantially depending on the regional location decision of recent immigrants. Under the baseline scenario, the province of Ontario receives the largest economic benefits from immigration. Fehr, Jokisch and Kotlikoff (2003) use a three-region multi-country OLG model for the U.S., E.U. and Japan and

examine the scenario of doubling the number of immigrants. This corresponds to adding 1 million new immigrants (0.36% of the population) to the U.S., 450,000 (0.12% of the population) to E.U. and 54,000 (0.04% of the population) to Japan. Like Fougère *et al.* (2004), they find some welfare gains but small macroeconomic and fiscal effects.

The studies discussed so far do not consider targeting more skilled immigrants. Storesletten (2000) uses a computable general equilibrium model with overlapping generations to investigate whether a reform of immigration policy can resolve the fiscal problem associated with population ageing. His results indicate that selective immigration policies that involve increasing the inflow of high and medium-skilled immigrant workers would remove the need for fiscal reform in the United States.

Lundborg and Segerstrom (2002) develop a two-country endogenous-growth CGE model with quality ladders. In their simulations, immigration from the low-tech to the high-tech country raises growth in both countries, but reduces wages in the destination country. Finally, Fehr, Jokisch and Kotlikoff (2004) extend their previous work by examining the effects of increasing the number of immigrants by skills. Among several simulation experiments, in two separate scenarios they double the number of low-skilled (e.g. an additional 1 million low-skilled workers to the U.S.) and high-skilled immigrant workers (e.g. an additional 100,000 new high-skilled workers in the U.S.). It must be noted that according to the calibration in their model, a high-skilled worker is considered 4 times more productive than a low-skilled. Their results indicate that attracting more low-skilled immigrants has bad macroeconomic, fiscal and economic-welfare implications for the three countries examined. It reduces real wages and raises payroll taxes and wage tax rates substantially. On the other hand, compared to previous immigration policies examined, doubling the number of high-skilled immigrants "comes out on top in terms of its mitigation of future tax hikes".

3. Some Stylised Facts on Immigration

In this section we review some facts on immigration in Canada during recent years, in particular on the number and skill composition. We also provide some discussion on the social-economic welfare situation of the immigration population in Canada compared to the non-immigrant population.

Chart 1 presents the evolution in the number of permanent residents coming to Canada since the early 1960s. As shown in the chart, the number of recent immigrants has moved up and down during the past 40 years. From 71,700 or 0.4% of the population in 1961, the number of recent immigrants fluctuated sharply until 1986. It reached 222,876 in 1967 or 1.1% of the population and 218,465 in 1974, followed by a pause between 1977 and 1986. However, as Canada adopted a more aggressive immigration policy during the 1980s, the number of recent immigrants increased sharply thereafter and annual inflows remained steadily high. Over the period 2000 to 2003, the number of permanent residents averaged, 226,000 or 0.75% of the population per year.

Chart 1
Number of Permanent Residents to Canada, 1961 to 2003
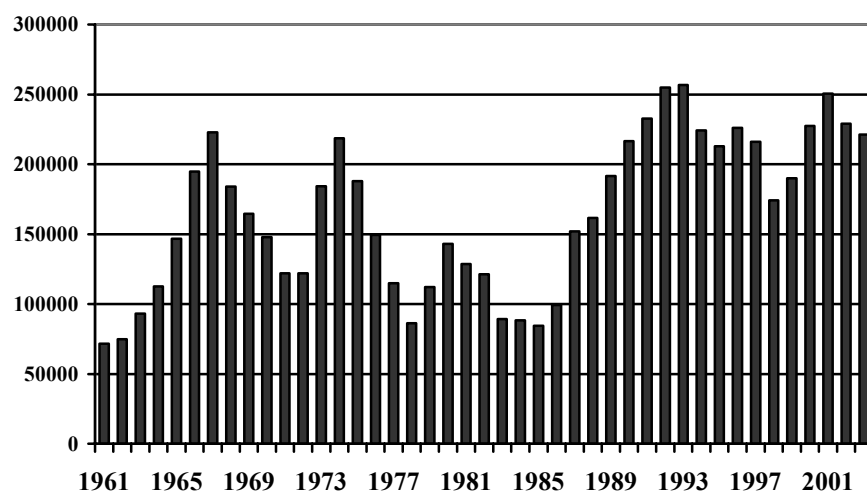
Source: Citizenship and Immigration

The share of permanent residents by immigrant status also fluctuates overtime. Permanent residents are separated in three main categories, family class, economic immigrants and refugees. When we look at the trend by category over the past 10 years (Chart 2), it can be seen that the category of economic immigrants represents the vast majority of permanent residents and their share has increased since 1998. Recent immigrants in the family class category are the second largest group, followed far behind by immigrants with the refugee status.

Chart 2
Permanent Residents by Category, 1994 to 2003
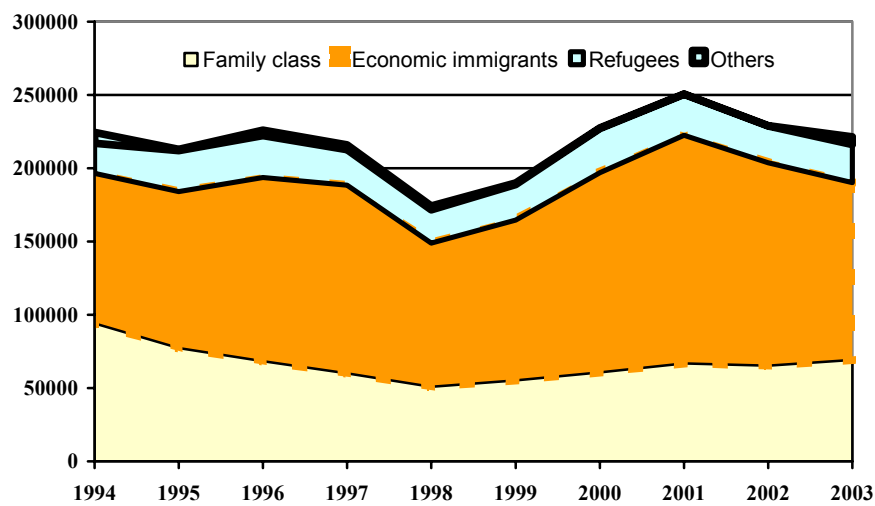
Source: Citizenship and Immigration

Another important characteristic of immigration trends in Canada over the past ten years is that most of the increase in recent immigrants comes from the economic immigrant category. As shown in Chart 3, the economic immigrant category is composed mostly of skilled workers, either from the principal applicant or the spouse, partners and dependants. The remaining group includes entrepreneurs, self-employed, investors and live-in caregivers.

Finally, an alternative way to look at the evolution of recent immigrants by skills is to focus on occupational skill levels (National Occupational Classification) for recent immigrants intending to work. It must be noted, however, that among permanent residents intending to work, only about 58% (1994-2003 average) have occupational skill level identified.[2] Chart 4 present the number of permanent residents in occupational skill level identified for the period 1994 to 2003. As shown in the chart, immigrants of skill level A (professional occupations) represents by far the largest group and their share has increased significantly since 1994. They are followed by recent immigrants of skill level B (technical occupations). Skill levels C and D (which combine lower-skilled jobs) represent a much smaller share and their number has significantly decreased since 1994.

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[2] Among new immigrant workers whose occupational skill level has not been identified, 30% of them in 2003 had a bachelor degree or more, 10.7% a non-university diploma and 6.2% a trade certificate.

Finally, although the proportion of skilled and well-educated immigrants has increased significantly over the past ten years, recent studies indicate that the entry level earnings of immigrants has declined compared the non-immigrant earnings.[3] Frenette and Morissette (2003) also show that earnings declines were as great among university educated immigrants than among less educated immigrants.

Chart 3
Economic Immigrants, 1994 to 2003
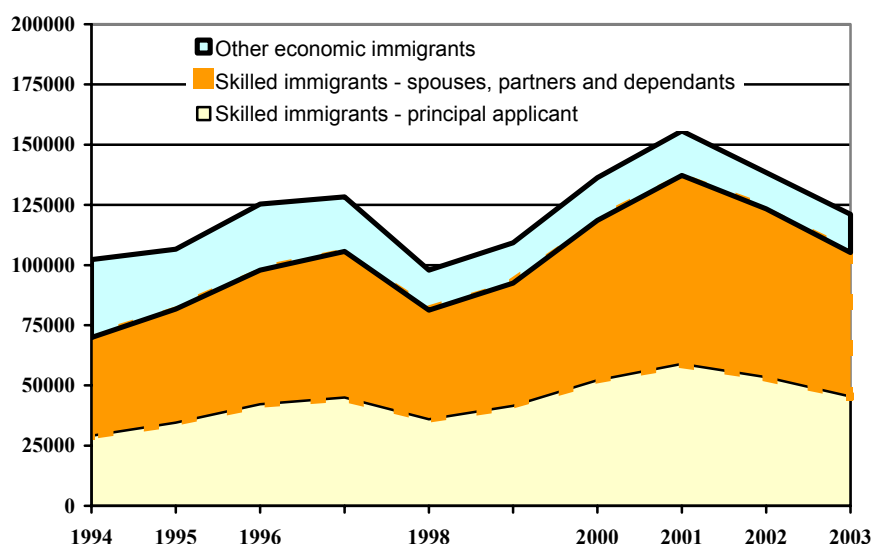
Several factors might explain the deterioration in the economic welfare of immigrants. Picot and Hou (2003) argue that part of the reason could be associated to the changing characteristics of immigrants. Over the period 1981-2001, a decreasing share of immigrants came from the U.S. Northern and Southern Europe, the Caribbean, South and Central America, while regions increasing their share include Eastern Europe, South, East and Western Asia and Africa. Picot (2004), Baker and Benjamin (1994) and Frenette and Morissette (2003) argue that even with comparable levels of education, the human capital of immigrants from these regions may be less transferable due to potential issues regarding language, cultural differences, education quality and

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[3] See for example, Picot (2004), Frenette and Morissette (2003) and Picot and Hou (2003).
[4] Among new immigrant workers whose occupational skill level has not been identified, 30% of them in 2003 had a bachelor degree or more, 10.7% a non-university diploma and 6.2% a trade certificate.
[5] See for example, Picot (2004), Frenette and Morissette (2003) and Picot and Hou (2003).

possibly discrimination. Sweetman (2003) also finds some evidence that the education system in some of these regions may possibly be of lower quality.

Chart 4
Permanent Residents in Occupational Skill Level Identified, 1994 to 2003
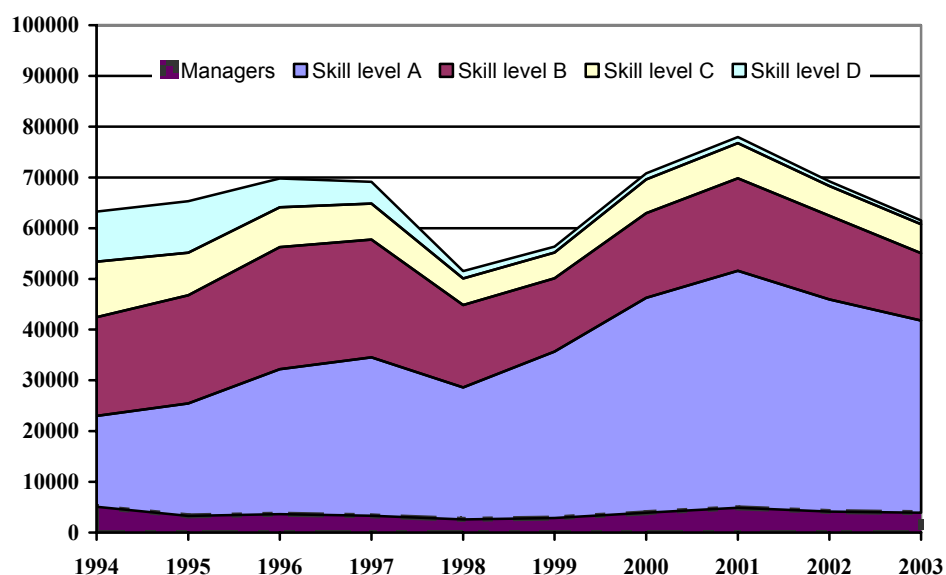
Among other possible factors, Ferrer and Riddell (2003) and Aydemir and Skuterud (forthcoming) argue that the returns to years of schooling may have declined among immigrants from the newer countries. Green and Worwick (2002) find that the declining returns to foreign labour market experience is an important factor explaining the rising earnings gap at entry level for immigrants.

4. An Applied Regional Overlapping Generations Model

Our framework is a six-region dynamic general equilibrium model with an overlapping generations (OLG) structure, parameterized on Canadian data. The six regions are Atlantic (Newfoundland, Prince-Edward Island, Nova Scotia and New Brunswick), Quebec, Ontario, the Prairies (Manitoba and Saskatchewan), Alberta and British Columbia. Each region in the model produces one differentiated goods and is open to trade. Production technology is standard and depends on physical capital and labour. Ownership titles on capital and bonds issued by both

provincial and federal governments are the assets available in the economy. Perfect substitutability and perfect capital mobility assumptions ensure identical ex ante rates of returns across regions.

In each region and at each period of time, 15 overlapping generations of adult agents coexist. In each cohort, we make a distinction between native and foreign-born individuals. Each representative agent is interpreted as an aggregation of heterogeneous individuals, the heterogeneity being in terms of their labour force characteristics: we identify three skill levels, and distinguish between actives and non-actives). Immigration flows into the country are exogenous and there is no regional labour mobility.

National and regional governments collect taxes on income and on consumption expenditures. Government spending is divided into three components: health, education and other government expenditures. The national government distributes transfers to regional governments, and both national and regional governments distribute transfers to individuals. The public pension system is modeled as a two-tier pension program. The first-tier, the Old Age Security (OAS) system is modeled as a national transfer program to the elderly and is financed through general taxes from the national government. The second-tier, the Quebec Pension Plans (QPP) in Quebec and the Canada Pension Plan in the rest of Canada, are modeled as a pay-as-you-go program and financed through payroll contributions. We now turn to a more detailed description of the model.

4.1 The production sector

In each region j, a representative firm produces a single good using a Cobb-Douglas technology. The firm hires labor and rents physical capital. Both factors are region specific. With Y representing the region's output, K and L the capital and (effective) labor inputs respectively, we have:

$$(1) \quad Y_{j,t} = A_j K_{j,t}^{\alpha_j} L_{j,t}^{1-\alpha_j}$$

where α is the share of capital in value added. Firms are assumed perfectly competitive and factor demands follow from profit maximization:

(2) $\quad \dfrac{re_{j,t}}{P_{j,t}} = \alpha_j A_j \left(\dfrac{K_{j,t}}{L_{j,t}} \right)^{\alpha_j - 1}$,

(3) $\quad \dfrac{w_{j,t}}{P_{j,t}} = (1 - \alpha_j) A_j \left(\dfrac{K_{j,t}}{L_{j,t}} \right)^{\alpha_j}$,

where *re* and *w* are the rental rates of capital and labor, and *P* is the output price. Labour is a CES aggregate of differently-skilled manpower so that firms' demands *Lqual* for a specific qualification, are:

(4) $\quad Lqual_{j,qual,t} = \varsigma_{j,qual} * \left(\dfrac{w_{j,t}}{wqual_{j,qual,t}} \right)^{\sigma_j^L} * L_{j,t}$

where *wqual* is the local market price per unit of a specifically skilled labor, and ς, σ^L are respectively share and substitution-elasticity parameters. It follows from optimization that the price *w* of the firm's aggregate labor input is related to market wages *wqual* by the following expression:

(5) $\quad w_{j,t}^{1-\sigma_j^L} = \sum_{qual} \varsigma_{j,qual} * wqual_{j,qual,t}^{1-\sigma_j^L}$.

4.2 Investment and Asset Returns

The accumulation of each region's capital stock (*Kstock*) is subjected to exponential depreciation:

(6) $\quad Kstock_{j,t+1} = Inv_{j,t} + (1 - \delta_j) Kstock_{j,t}$,

where *Inv* represents investment and δ the depreciation rate of capital. The investment technology is characterized by a CES function that combines goods from the six different regions; the optimal mix implies that region *i*'s goods are demanded by region *j* for investment purposes in amount

(7) $\quad InvI_{i,j,t} = \alpha_{i,j}^{Inv} \left(\dfrac{P_{j,t}^{Inv}}{P_{i,t}} \right)^{\sigma_j^{Inv}} * Inv_{j,t}$,

where α^{Inv} and σ^{Inv} represent share and substitution-elasticity parameters, and P^{Inv} is the unit price of the investment good, defined (as a result of optimization) as:

$$(8) \qquad P_{j,t}^{Inv(1-\sigma_j^{Inv})} = \sum_i \alpha_{i,j}^{Inv} * P_{i,t}^{(1-\sigma_j^{Inv})} \quad .$$

Financial markets are fully integrated within Canada. This means that financial capital is perfectly mobile across regions and undifferentiated so that interest parity holds. Let us denote by R the net rate of return on physical assets; it is defined as the rental rate minus the depreciation rate, plus capital gains:

$$(9) \qquad 1 + R_{j,t} = \frac{re_{j,t} + (1-\delta_j) * P_{j,t}^{Inv}}{P_{j,t-1}^{Inv}} \quad .$$

Bonds and shares are perfect substitutes and therefore bear the same *ex ante* return:

$$(10) \qquad 1 + R_{j,t+1} = \left(1 + ri_{j,t}\right) * \left(\frac{P_{j,t+1}^{Gov}}{P_{j,t}^{Gov}}\right) ,$$

where ri and P^{Gov} are respectively the rate of interest promised on, and the price of, bonds issued by the local government. Perfect financial capital mobility implies that, *ex ante*,

$$(11) \qquad 1 + r_t = \left(1 + ri_{j,t}\right) * \left(\frac{P_{j,t+1}^{Gov}}{P_{j,t}^{Gov}}\right) .$$

4.3 Household Behaviour

In each region, the population is represented by 15 representative Canadian-born households and 15 representative immigrant households, in an Allais-Samuelson overlapping generations structure. Consequently, at each period of time, 15 Canadian-born plus 15 foreign-born generations live side by side. At any new *t*, a new generation is born and the eldest dies. Each native-born individual enters the labour market at the age of 17 and dies at the age of 77. This implies that each period of the model corresponds to 4 years. Younger individuals are assumed to be dependent on their parents, implying that they play no active role in the model. The Canadian

population grows at an exogenous rate. Immigrants enter the country in their late twenties. Because they have not had access to local schooling in their youth, they have different lifetime productivities than natives. Furthermore, they are assumed not to inherit. Except for those two differences, they are identical to locals of the same age cohort. The children of immigrants are assumed to have similar labour force characteristics than other Canadian-born individuals.

In the description that follows of a household's decision problem, to ease the notation, we shall therefore drop indices *j* (for the region) and *nat* (for nationality status, Canadian v.s. non-Canadian) except when necessary. Flow immigration rates are exogenous. Observe that second generation immigrants are treated as locals.

A household's optimization problem consists of choosing a profile of consumption over the lifecycle, in order to maximizes a CES type inter-temporal utility function of consumption and bequests, subject to discounted lifetime income. Inter-temporal preferences of an individual born at time *t* are as follows:

$$(12) \quad U_t = \frac{1}{1-\theta} \sum_{g=1}^{15} \left(\frac{1}{1+\rho} \right)^g (C_{g,t+g-1}^\theta + \beta_g Beq_{g,t+g-1}^\theta)$$

with $0 < \theta < 1$, $\beta_g = 0$ for all generations except for the oldest. *C* denotes consumption and *Beq* denotes bequests; ρ is the pure rate of time preference and θ the inverse of the inter-temporal elasticity of substitution. β is a parameter expressing how intensely last generation individuals value the possibility of leaving bequests to their children. Note that leisure does not enter in the utility function: labour supply is exogenous.

We assume households face no borrowing constraints. They earn labor incomes Y^L, transfers from both local and federal governments (*Tr* and *TrF*), receive pensions when old (*pens*), earn interest on their asset position (*Lend*), possibly inherit (*inh*) and have access to old age security *OAS*. Most incomes are taxed by both governments (τ_t^w and τ_t^{wF} denote local and federal taxes on non-capital income, and τ^K and τ^{KF} on capital income). Income is spent on consumption (net of taxes τ^C, τ^{CF} to both governments), on bequests to younger generations, and

on accumulation of new assets. Households also contribute to the public pension plan, at contribution rate c^P, which is the CPP rate for Quebec and the QPP rate for other regions. *OAS* includes the Old Age Security, the Guaranteed Income Supplement (GIS) and the Spouse's Allowance (SPA**)**. The household's inter-temporal budget constraint writes as follows:

$$
\begin{aligned}
(13) \quad & (1-\tau_t^w-\tau_t^{wF} -c_t^P)\sum_{qual} Y_{qual,g,t}^L + \\
& (1-\tau_t^w-\tau_t^{wF})\left(\sum_{qual}\left(Tr_{qual,g,t+g-1}+TrF_{qual,g,t+g-1}\right)+pens_{g,t}\right)+ \\
& \left(r_t-\tau_t^K-\tau_t^{KF}\right)*Lend_{t,g} + \\
& inh_{g,t}+OAS_{g,t} \\
& = \\
& \left(1+\tau^C+\tau^{CF}\right)*P_{g,t}^C*C_{g,t}+Beq_{g,t}+Lend_{t+1,g+1}-Lend_{t,g}
\end{aligned}
$$

Labour incomes Y^L depend on market wages *wqual*, participation rates *PaR*, productivity profiles *EP*, and the amount of labour supplied by an individual of age group *g*:

$$(14) \quad Y_{nat,qual,g,t}^L = wqual_{qual,t}*PaR_{qual,g,t}*EP_{nat,qual,g}*LS_g \ .$$

We distinguish between 3 different labour qualification levels—high skill, medium skill and low-skill—and a 4th category of working-age individuals, which are unattached to the labour market or inactive. For the unattached, $PaR_{qual,g,t}= 0$ for all regions, age groups and time periods. Lifetime earning profiles *EP* are hump-shaped, generated by a cubic polynomial function that depends on the qualification and the nationality status of the individual:

$$(15) \quad EP_{nat,qual,g} = \gamma_{nat,qual}g^3 - \lambda_{nat,qual}g^2 + \psi_{nat,qual}g - \omega_{nat,qual} \quad , \gamma, \psi \geq 0 \ \text{ and } \ \lambda,\omega \leq 0 \ .$$

Parameters are chosen to reproduce the earnings profile observed in 2001; although they differ between individuals according to skills and nationality, the maximum earnings are achieved for all between mid-life and retirement.

CPP and QPP pension benefits of the retirees are a fraction of their average labour earnings. The fraction is determined by the public pension replacement rate *PensR* that may differ across Canada:

$$(16) \qquad Pens_{g,t} = PensR_{g,t} * \sum_{s=1}^{14} Y^L_{qual,g-s,t-s} \quad , \quad g = 15.$$

Maximizing (12) subject to constraint (13), the household chooses consumption and bequests so as to satisfy the first-order conditions (17) and (18):

$$(17) \qquad C_{g+1,t+1} = \left(\frac{\left(1 + \left(1 - \tau_t^K + \tau_t^{KF}\right) * r_t\right) * P^C_{g,t}}{\rho * P^C_{g+1,t+1}} \right)^{\theta} * C_{g,t} \quad ,$$

where P^C is the consumption price index of the individual. Bequests depend on the level of consumption as in Blinder (1974):

$$(18) \qquad Beq_{g,t} = \beta_g * P^C_{g,t} C_{g,t}, \quad g = 15 \quad ,$$

and are distributed at the end of each generation's lifetime as inheritances to all working generations:

$$(19) \qquad Inh_{g,t} * Pop_{g,t} = \chi_g * Beq_{15,t} * Pop_{15,t} \quad ,$$

where *Pop* is the age cohort's population and χ is the inheritance distribution parameter across working generations.

As already stated, goods from different regions are treated as imperfect substitutes in demand: the next step in the household's optimization problem consists to allocate aggregate consumption between the six different final goods using CES sub-utilities. Hence, using the first order conditions, a region j individual's consumption demand of region i goods, *CI*, is:

$$(20) \qquad CI_{i,j,g,t} = \alpha_{i,j}^{CI} * \left(\frac{P^C_{j,g,t}}{P_{i,t}} \right)^{\sigma^C_{j,g}} * C_{j,g,t} \quad ,$$

where α^{CI} and σ^C are respectively share parameters and substitution elasticities. The consumption price index is consistently defined as a non-linear weighted average of local prices:

$$(21) \qquad P_{j,g,t}^{C}{}^{(1-\sigma_{j,g}^{C})} = \sum_i \alpha_{i,j}^{CI} * P_{i,t}^{(1-\sigma_{j,g}^{C})} \quad .$$

4.4 The Government Sector

Regional governments spend on goods, health care and education (respectively: $Gov, GovH, GovE$), transfer resources to their residents through social programs (Tr) and pay interests on previously issued bonds. They tax private consumption, capital and labour incomes, as well as pensions and transfers to households from both local and federal (TrF) sources. They also, receive transfers from the national government ($TrFJ$) and issue bonds. Hence, the regional government's budget constraint is:

$$
P_t^{Gov} * \left(Gov_t + GovH_t + GovE_t \right) + \sum_{nat,g} Pop_{nat,g,t} * \sum_{qual} Tr_{qual,t} + r_{t-1} * P_{t-1}^{Gov} * Bond_t
$$
$$
=
$$
$$(22) \qquad \sum_{nat,g} Pop_{nat,g,t} * \left(\begin{array}{l} \tau_t^C * P_{g,t}^C * C_{nat,g,t} + \tau_t^K * r_t * Lend_{nat,g,t} + \\[2mm] \tau_t^w * \left(\sum_{qual} Y_{nat,qual,g,t}^L + Pens_{nat,g,t} + \sum_{qual} \left(Tr_{qual,t} + TrF_{qual,t} \right) \right) \end{array} \right)$$
$$
+ TrFJ_t + P_t^{Gov} * Bond_{t+1} - P_{t-1}^{Gov} * Bond_t \quad .
$$

The pay-as-you-go pension program is modeled separately, and assumed self supported at (therefore endogenously determined) contribution rate c^P:

$$(23) \qquad \sum_{j,nat,g} \left(Pop_{j,nat,g,t} * Pens_{j,nat,g,t} \right) = c_{j,t}^P * \sum_{j,nat,g} \left(Pop_{j,nat,g,t} * \sum_{qual} Y_{j,nat,qual,g,t}^L \right) .$$

The national government's budget constraint is similarly defined as:

$$P_t^{GovF} * GovF_t + \sum_{j,nat,g} Pop_{j,nat,g,t} * \left(\sum_{qual} TrF_{j,qual,t} + OAS_{g,t} \right) +$$

$$\sum_j TrFJ_{j,t} + r_{t-1} * P_{t-1}^{GovF} * BondF_t$$

(24) $=$

$$\sum_{j,nat,g} Pop_{j,nat,g,t} \left(\begin{array}{l} \tau_t^{CF} * P_{j,g,t}^C * C_{j,nat,g,t} + \tau_t^{KF} * r_t * Lend_{j,nat,g,t} + \\ \tau_t^{wF} * \left(\sum_{qual} Y_{j,nat,qual,g,t}^L + Pens_{j,nat,g,t} + \sum_{qual} \left(Tr_{j,qual,t} + TrF_{j,qual,t} \right) \right) \end{array} \right) +$$

$$P_t^{GovF} * BondF_{t+1} - P_{t-1}^{GovF} * BondF$$

The notation should be clear: P^{GovF} represents the price of federal consumption, and *BondF*, the stock of national bonds. The national universal pension program is denoted *OAS* which includes the Old Age Security, the Guaranteed Income Supplement (GIS) and the Spouse's Allowance (SPA**)**. In simulations, OAS is assumed to remain constant per capita.

4.5 Equilibrium Conditions

The model assumes perfectly competitive markets, agents with perfect foresight and free financial capital mobility within Canada. Moreover, the assumption of differentiated regional goods implies that exchange rates are flexible between regions. It is also assumed that regional physical capital is entirely detained by local residents and that portfolio choice is subject to home bias with the rest of the world. This is consistent with Helliwell and McTitrick (1999) who find evidence that national borders divert flows of savings to domestic investments, but Canadian provincial borders have no such effect. The equilibrium condition for goods markets states that each region's output is demanded:

(25) $\quad Y_{j,t} = \sum_i \left[\sum_{nat,g} CI_{j,i,nat,g,t} + InvI_{j,i,t} \right] + Gov_{j,t} + GovH_{j,t} + GovE_{j,t} + \varepsilon_{j,t} * GovF$,

where ε is the share of Canadian population in region *j*: the national government's spending is equal across regions, on per capita basis.

Labour and physical capital are both immobile across regions, so that a market exists for each factor in each region. The stock of effective labour supplied is the number of individuals times their corresponding productivity level:

$$(26) \quad L_{j,qual,t} = \sum_{nat,g} Pop_{j,nat,g,t} * PaR_{j,nat,g,t} * EP_{j,nat,qual,g} * LS_{j,g} \quad ,$$

$$(27) \quad K_t = Kstock_t \quad .$$

Asset markets are fully integrated: there is a single market within Canada that continuously balances:

$$(28) \quad \sum_{j,nat,g} Pop_{j,nat,g,t} * Lend_{j,nat,g,t} = \sum_{j} (P^{Gov}_{j,t-1} * Bond_{j,t} + P^{Inv}_{j,t-1} * K_{j,t}) + P^{GovF}_{t-1} * BondF_{j,t} \quad .$$

5. Calibration

The computable general equilibrium model compares two states of the six regional economies in the context of an ageing population, according to alternative assumptions on the level and skill composition of immigrant individuals. To accomplish the comparison we first generate an initial steady state equilibrium with constant demographic changes across age groups by calibrating the parameters of the model to replicate what is observed in the data. Since the model is dynamic, the initial equilibrium is in fact a steady state that repeats every period and where the elderly dependency ratio remains constant. A demographic shift is then introduced in the simulation experiments according to the assumptions made in the demographic model. The state of the regional economies will thus change in comparison to the initial steady state. The impact of alternative immigration scenarios are compared with a baseline scenario of population ageing.

5.1 Behavioural and Policy Parameters

Table 1 reports variable and parameter values that are imposed in the calibration procedure, while Table 2 presents government policy and programs at both the federal and regional levels, which include effective tax rates, public expenditure to GDP and government debts. The inter-

temporal elasticity of substitution is assumed to be the same across regions and consistent with values found in the literature. The intra-temporal elasticity of substitution is also assumed identical across the different types of consumption and investment demands and across regions.

A matrix of interregional flows is calculated between the six regions and serves to estimate the ownership distribution of wealth (physical capital plus government bonds) across individuals and regions. It is assumed that regional physical capital is owned by regional residents first. This means that residents have a stock of wealth composed of local physical capital ownership titles plus bonds issued by regional governments. Given the above parameter values, regional rate of time preference was calibrated to ensure equilibrium in the Canadian financial asset market. For simulation purposes, the general equilibrium of the economy is replicated over the 100 period horizons. The length of horizon is determined to ensure that after the demographic shift the economy converges to a long-run steady state.

Table 1
Calibration Parameters

Region	Atlantic	Quebec	Ontario	Prairies	Alberta	B-C
Regional Share of GDP	.062	.217	.387	.070	.137	.128
Share of capital in production	.278	.280	.280	.324	.324	.270
Intertemporal elast. of substitution	1.0	1.0	1.0	1.0	1.0	1.0
Elast. of substitution between consumption and investment goods from different regions	9.0	9.0	9.0	9.0	9.0	9.0
Elast. of substitution for investment	9.0	9.0	9.0	9.0	9.0	9.0

Table 2
Government Policy and Program Parameters

Federal/Regional Gov't	Federal	Atlantic	Quebec	Ontario	Prairies	Alberta	B-C
Wage income tax rate	.140	.178	.234	.173	.155	.164	.178
Capital income tax rate	.220	.165	.258	.342	.187	.164	.226
Consumption tax rate	.100	.134	.119	.100	.093	.037	.099
Public Education/GDP	0	.060	.052	.032	.039	.041	.045
Government debt	.111	.421	.431	.288	.226	.018	.110
Public Health Care/GDP	0	.077	.066	.053	.066	.045	.070

5.2 Distribution of workers by skill

Table 3 describes the classification of skill levels in the model. The occupational composition of high-skilled workers used in the model is the same as the definition of highly qualified workers used in Laroche (2000) and OECD (2000). Using the National Occupation Classification (NOC) Matrix, high-skilled workers include managers, skill level A occupations (usually requiring university education) and part of occupations in skill level B (usually require college education). We also separate the remaining workforce between medium and low-skilled workers. Low-skilled workers include all workers in skill levels C and D (requiring secondary school or occupation-specific training or on-the-job training). Finally, medium-skilled workers are the remaining workers in skill level B, whose occupation usually require apprenticeship training. The model also includes a group of unattached individuals. These individuals of working-age are defined as people with a low attachment to the labour market.

Table 3
Classification of skill levels in the model

High Skill	National Occupational Classification Matrix 2001 (NOC) Skill level 0 (managers), Skill level A and the following Skill level B occupations: – Major group 12, Skilled administration and business occupations, except minor group 124, Secretaries, Recorders and Transcriptionists. – Major group 22, Technical Occupations related to natural and applied sciences. – Major group 32, Technical and skilled occupations in health. – Major group 42, Paraprofessional occupations in law, social services, education and religion. – Major group 52, Technical and skilled occupations in art, culture, recreation and sport.
Medium Skill	National Occupational Classification Matrix 2001 (NOC) Following occupations found in Skill level B: – Minor group 124, Secretaries, Recorders and Transcriptionists. – Major group 62, Skilled Sales and Service occupations. – Major group 72/73, Trade and skilled transport and equipment operators. – Major group 82, Skilled occupations in primary industry. – Major group 92, Processing, manufacturing and utilities supervisors & skilled operators.
Low skill	National Occupational Classification Matrix 2001 (NOC) Skill level C and Skill level D

Table 4 reports the distribution of immigrant and non-immigrant workers by skill levels, for each region, by region as calibrated in the initial steady state and in the baseline simulation scenario with population ageing (Scenario 1). The distribution of non-immigrant workers by skills has been fairly stable in Canada over the past 10 years. The values imposed at the national and regional levels are based on the 2001 Census data. For permanent residents, the proportion of skilled immigrants has changed radically over the 1990s. In the steady state and baseline scenario, we use skill-share information from the 1996 Census. This assumption is then modified in alternative scenarios.

Table 4
Skill Share of Immigrant and Non-Immigrant Workforce by Region
(Baseline Scenario)

Skill level	National	Atlantic	Quebec	Ontario	Prairies	Alberta	B-C
Non-Immigrants							
High skill	0.267	0.182	0.237	0.315	0.220	0.264	0.303
Medium Skill	0.222	0.180	0.206	0.217	0.256	0.263	0.253
Low skill	0.293	0.282	0.284	0.290	0.306	0.288	0.329
Unattached	0.219	0.356	0.273	0.177	0.218	0.185	0.116
Immigrants							
High skill	0.156	0.303	0.168	0.148	0.148	0.147	0.164
Medium Skill	0.136	0.146	0.123	0.136	0.148	0.154	0.139
Low skill	0.302	0.186	0.285	0.318	0.378	0.348	0.256
Unattached	0.406	0.365	0.423	0.399	0.326	0.351	0.441

5.3 Demographic Assumptions

The main assumptions related to demographics are collected in Table 5. Chart 5 reports the projected national and regional elderly dependency ratio over the period 1996 to 2046, as computed using the demographics model MEDS. [6] As can be seen, Canada's elderly dependency ratio is expected to double over the next 40 years and the regional increase in the elderly dependency ratio is expected to vary considerably across regions over the same period. The Atlantic region and Quebec will experience the largest increase in the elderly dependency ratio,

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[6] See Models of economic-demographic system (MEDS), Research Institute for Quantitative Studies in Economics and Population, McMaster University, Hamilton.

while Alberta will have the third largest increase, although its initial level in 2000 was well below the national average. In contrast, the Prairies and Ontario will come across a smaller increase in the elderly dependency ratio. Finally, the rising proportion of the older population in British Columbia is projected to be similar to the national average.[7]

Table 5
Main Demographic Assumptions

Province	NF	P.E.I.	NS	NB	Qc	Ont.	Man	Sask.	Alb	B-C
Fertility rate	1.21	1.56	1.42	1.45	1.47	1.53	1.81	1.81	1.70	1.45
Life expectancy (2044) Men Women	78 82	79 85	79 85	81 85	80 85	82 86	80 84	80 86	81 84	81 85
Annual share of emigrants (% of Pop)	0.05	0.03	0.07	0.04	0.16	0.28	0.16	0.11	0.26	0.22
Annual share of new immigrants	0.21	0.07	1.04	0.35	14.3	55.4	1.85	0.80	6.26	19.6

Chart 5
Projected Elderly Dependency Ratio by Region in Canada

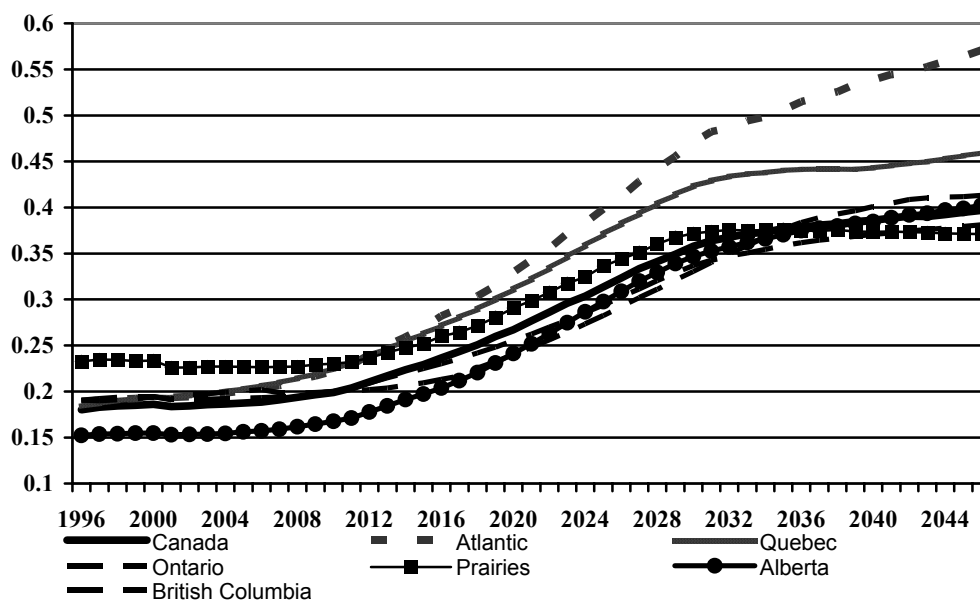[7] For more information on Canada's demographic trends, see for example, Statistics Canada (2001, 2003).
[8] See Models of economic-demographic system (MEDS), Research Institute for Quantitative Studies in Economics and Population, McMaster University, Hamilton.

5.4 Assumptions on the Effective Retirement Age

As indicated in Table 6, we assume in all scenarios that in each region, the effective retirement age remains constant in the future, equal to its 2001 level. We also assume that the average retirement age of immigrants is the same as that of non-immigrants. Although it can be argued that immigrant workers retire later than non-immigrants to accumulate sufficient retirement wealth, no information is currently available to quantify such a claim.[9]

Table 6
Assumption on the Effective Retirement Age for Immigrant and Non-Immigrants

Region	Canada	Atlantic	Quebec	Ontario	Prairies	Alberta	B-C
Baseline and alternative scenarios	61.2	60.0	59.7	61.4	63.0	64.4	62.3

5. Simulation Analysis

5.1 Simulation Scenarios

In the simulation experiments, we provide 4 scenarios. Scenario 1 (the baseline scenario) assumes that the distribution by skills of recent immigrant workers observed during the mid-1990s (1996 Census) remains unchanged in the future. This would imply that 70% of permanent residents are either low-skilled workers or unattached individuals, while the remaining 30% are about evenly split between high and medium-skilled workers. In addition, the proportion of permanent residents is set to average 0.75% of the population each year, which corresponds to the 2000 to 2003 average. Table 6 provides a summary of the baseline and alternative assumptions.

Scenario 2 maintains the proportion of permanent residents to 0.75% of the population. In contrast with Scenario 1, we impose in the calibration the distribution of skills among (foreign born) permanent residents observed during the period 1996-2001 based on the 2001 Census; this distribution is assumed to remain constant ever after. It is worth stressing that the flow of recent high-skilled immigrant workers has increased substantially during the 1990s. Between the first and

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[9] The model indicates that a one-year increase in the retirement age of immigrants raises real per-capita GDP by 0.15%.

the second half of the 1990s, the share of high-skilled immigrant workers rose from 16% to 24%. In comparison, over the same period, the proportion of medium and low-skilled workers remained roughly unchanged from 14% and 30% to 13% and 28%, respectively. Finally, the proportion of unattached immigrant individuals came down from 40% to 35%. Thus, scenario 2 should be interpreted as an evaluation of the effects of the change in the skill distribution of immigrants since the early 1990s, if this change were to be permanent.

Finally, in Scenarios 3 and 4, we examine the marginal effect of increasing the proportion of permanent residents from 0.75% to 1% of the population, beginning in 2002. In addition to the assumptions made in Scenario 2 on the skill composition of the first 0.75% of recent immigrants, we use alternative assumptions on the skill composition of the additional 0.25%. In Scenario 3, we assume that the skill-composition is proportionally the same than the first 0.75%. Scenario 3 is

Table 7
Summary of Alternative Assumptions for Scenarios 1 to 4

Scenario	Flow of recent immigrants by skills in 1998	Immigration target in 2002 and in the future	
		Proportion of recent immigrants	Skill share
Scenarios with proportion of permanent residents at 0.75% of the population			
Scenario 1 (baseline)	High: 16% Medium: 14% Low: 30% Unattached: 40%	0.75% of the population	Skill share unchanged from 1994
Scenario 2	High: 24% Medium: 13% Low: 28% Unattached: 35%	0.75% of the population	Skill share unchanged from 1998
Scenarios to examine the marginal effect of increasing the proportion of permanent residents by 0.25% of the population			
Scenario 3	High: 24% Medium: 13% Low: 28% Unattached: 35%	From 0.75% to 1% of the population	Proportional increase in skill share
Scenario 4	High: 24% Medium: 13% Low: 28% Unattached: 35%	From 0.75% to 1% of the population	Increase in high-skilled immigrant workers

26

similar to the simulation experiments examined in Fougère et al. (2003). In Scenario 4, we assume that the proportion of high-skilled permanent residents is raised by 0.25% of the population.

5.2 Simulation Results

We first summarize the baseline solution in Table 8. As expected, population ageing has a large negative impact on real per-capita GDP in the long run. However, over the short to medium-term (between 1998 and 2014), the impact of ageing on real GDP is positive due to a more experienced labour force, which raises the quality of labour across all skills and labour productivity. Real per-capita GDP is projected to decline by more than 11% by 2050 compared to a situation with no population ageing, corresponding to an average annual reduction of 0.2% in growth of real GDP per-capita between 2002 and 2050, and 0.4% average annual reduction in growth between 2015 and 2050.

The decline in real GDP per-capita is explained by two main factors. The first is the decline in effective units of labour[10] due to population ageing, which begins after 2014 as the baby boom generation gradually reaches retirement. The second factor leading to the fall in real GDP is the negative impact of ageing on national savings and investment. The national savings rate declines by more than 10 percentage points by 2050. The life-cycle theory of savings is a key assumption in the model and explains this result. The rising proportion of the retired population reduces savings through a shrinking of the tax base and through the dissaving behaviour of retired households. On the firm side, the decline in real investment can be explained by an abundance of physical capital relative to labour. This reduces firm's incentives to invest in physical capital, which in turn reduces total investment compared to a scenario without ageing.

Although, real investment and savings decline, the ratio of physical capital to effective labour increases substantially. This capital deepening effect contributes to reduce real interest rates by about 100 basis points over the long run. The real interest rate decline is of similar magnitude than Boersch-Supan *et al.* (2001) and Ingénue (2001), who have simulated the global effect of population ageing and the impact on world interest rates using multi-country OLG models.

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[10] Effective units of labour is an indicator which combines both the number of workers and its quality (experience and skills).

Not surprisingly, the real wage rises with ageing, by 9% by year 2042. Real before-tax wage rates increase. Initially, real after-tax wages increase faster than before-tax real wages. Over the period 1998 to 2026, population ageing has a positive influence on the overall taxation base and the effective wage tax rate falls. These favourable fiscal effects are reversed after 2026, which lead to a slower increase in real after-tax wages. By 2050, real after-tax wages rise by 3.5% compared to 8.3% for real wages before-tax. The induced fiscal pressures caused by ageing reduce the wage income-tax base and taxes have to rise to maintain the public debt per capita constant. This leads to a reduction in the growth rate of real after-tax wage rates in the long run.

Table 8
Baseline Scenario (Scenario 1), Main Macroeconomic Indicators
% Shock minus Control
(National Level)

| | Real GDP per Capita | Savings Rate (p.p.) | Capital-Labour Ratio | Effective Units of Labour | Real Wage Rate | | Real Interest Rate |
					Before Tax	After Tax	
1998	0.9	-0.1	2.5	3.1	0.7	1.2	-0.1
2002	1.4	-0.5	5.6	5.2	1.7	2.4	-0.2
2006	1.7	-1.0	7.8	7.0	2.4	3.2	-0.3
2010	1.8	-1.5	10.2	7.8	3.1	4.0	-0.5
2014	1.7	-2.1	12.7	7.3	3.8	4.8	-0.6
2018	1.4	-2.8	15.3	5.5	4.6	5.5	-0.7
2022	0.8	-3.5	18.1	2.5	5.4	6.0	-0.8
2026	0.0	-4.1	20.9	-1.5	6.2	6.5	-0.9
2030	-1.1	-4.8	23.7	-6.4	7.1	6.8	-1.0
2034	-2.6	-5.6	26.3	-12.0	7.8	6.9	-1.1
2038	-4.3	-6.6	28.3	-17.8	8.5	6.8	-1.1
2042	-6.4	-7.8	29.2	-23.7	8.9	6.3	-1.1
2046	-8.7	-9.2	28.4	-29.3	8.9	5.2	-1.0
2050	-11.2	-10.7	25.2	-34.3	8.3	3.5	-0.7

In Scenario 2 (see Table 9), the number of immigrants is the same as in Scenario 1, but the proportion of high-skilled workers increases. This rise is mostly compensated by a reduction in the proportion of unattached immigrant individuals, since the proportion of medium and low-skilled workers declines only mildly. As can be seen in the table, this change in the composition of immigration is large enough to have a positive impact on the overall quality of the labour force. Effective units of high-skilled workers are 0.8% higher in 2010 and 2.9% in 2050. This contributes to a 1.1% increase in total effective labour supply by 2050. The supply of medium and low-skilled

labour contribute somewhat negatively to the labour market over the simulation period relative to Scenario 1 (-0.2% and -0.8% respectively by 2050), which offsets some of the gains obtained by high-skilled workers. Finally, the number of unattached is reduced by 2.1% by 2050.

As real income rises and firms need to better equip their new skilled workforce, the shock stimulates savings and investment. Real investment rises by about 1.1% in 2030 relative to Scenario 1. It also leads to an increase in physical capital intensity - the capital-labour ratio increases by 1.3% by 2042. The combination of a more qualified labour force and the increase in physical capital intensity raises labour productivity and real GDP per-capita relative to Scenario 1. Compared to Scenario 1, labour productivity is 0.8% and 1.8% higher in 2022 and 2050, respectively, while real GDP per capita is 1.1% and 2.5% higher, over the same period. Overall, maintaining this immigration target over the long run would reduce the negative impact of ageing on real GDP per-capita by about a quarter.

Table 9
Simulated Long run Impact of the Recent Change in the Skill Share of Recent Immigrants
Scenario 2 versus Scenario 1
(Percent Difference Relative to Scenario 1)

	1998	**2010**	**2022**	**2030**	**2042**	**2050**
Real GDP per capita	0.1	0.5	1.1	1.5	2.1	2.4
Real GDP per worker	0.0	0.4	0.8	1.1	1.6	1.8
Real investment	0.3	0.8	1.3	1.1	1.0	-2.1
Capital-labour ratio	-0.2	-0.1	0.3	0.7	1.3	1.2
Effective units of labour	0.1	0.3	0.5	0.6	0.9	1.1
high-skilled	0.2	0.8	1.4	1.8	2.5	2.9
medium-skilled	0.0	-0.1	-0.1	-0.2	-0.2	-0.2
low-skilled	-0.1	-0.2	-0.3	-0.5	-0.7	-0.8
Unattached (p.p. change in share)	0.0	-0.1	-0.2	-0.3	-0.4	-0.5
Real wages	-0.1	-0.1	-0.1	0.0	0.1	0.1
high-skilled	-0.2	-0.6	-0.9	-1.1	-1.4	-1.7
medium-skilled	0.0	0.1	0.2	0.4	0.7	0.7
low-skilled	0.0	0.2	0.5	0.7	1.1	1.2

The change in the skill composition of immigrants also has implications on real wages by skill. Although, the overall impact on aggregate real wages is small, the rise in the supply of high-skilled leads to a reduction in their wage, which falls from 0.6% in 2010 to 1.7% by 2050 relative to Scenario 1. On the other hand, real wages for medium and low-skilled workers rise somewhat over the simulation period. The results indicate that the long run impact of a rise in the proportion of high-skilled immigrants reduces the skill premium and likely contributes to a reduction in earnings inequality between high and low-income workers.

In Scenarios 3 and 4, the proportion of recent immigrants increases by 0.25% of the population each year. In the former, the skill composition remains the same as in 1998, while in Scenario 4 additional flows of new immigrants are high-skilled. Tables 9 and 10 compare Scenarios 3 and 4 (as deviations from the base line) for selected economic and labour market indicators.

Chart 6
Real per-capita GDP Impact of Population Ageing According to Alternative Immigration Policies
% Shock-minus-control impact
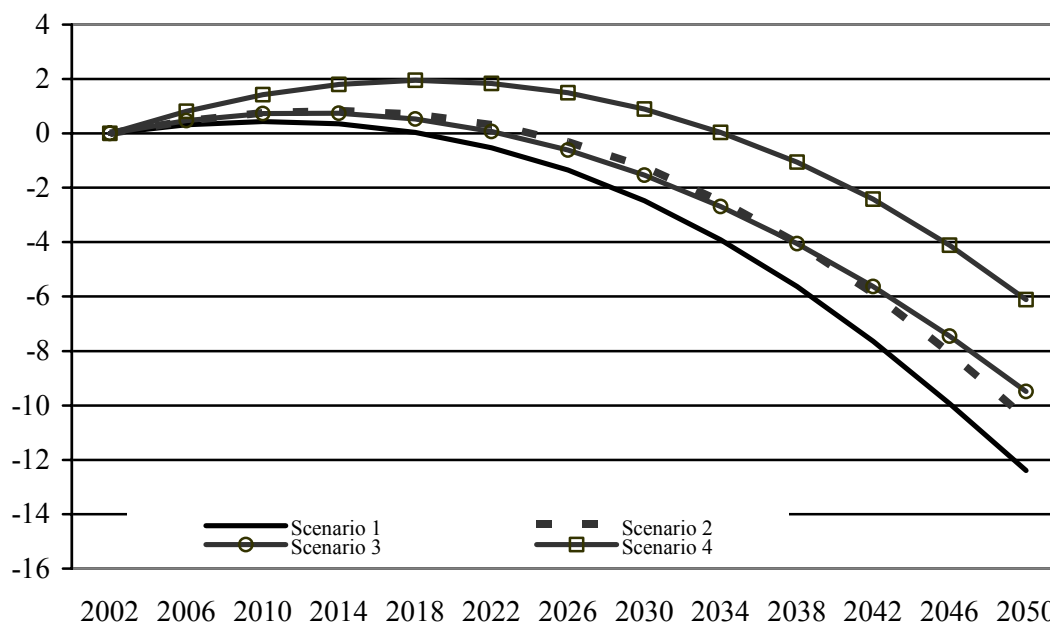
As can be seen, attracting more high-skilled immigrants generates substantially more benefits than raising the proportion of immigrants across all skills (including unattached

individuals). In Scenario 3, the main economic benefits come from the demographic effect of slowing the rise in the elderly dependency ratio by attracting more young immigrants to the labour force. However, the impact on labour productivity is negligible. In comparison, the policy simulation in Scenario 4 generates more economic benefits for two reasons. First, we attract more strongly attached immigrant workers to the labour market. Second, we raise the quality and productivity of the labour force.

Table 10
Alternative Scenarios Relative to Scenario 1
% Shock minus Control
(National Level)

	1998	2010	2022	2030	2042	2050
Real GDP per capita						
Scen3_Proportional	0.1	0.5	0.8	1.2	2.4	3.6
Scen4_High-skilled	0.3	1.8	3.2	4.3	6.5	8.0
Real GDP per worker						
Scen3_Proportional	0.1	0.3	0.3	0.1	0.0	-0.2
Scen4_High-skilled	0.2	1.2	2.0	2.4	3.0	3.0
Investment						
Scen3_Proportional	0.5	1.7	3.7	6.3	12.9	17.4
Scen4_High-skilled	1.5	5.0	9.2	13.3	20.3	19.9
Capital-labour ratio						
Scen3_Proportional	-0.1	0.1	0.3	0.2	-0.2	-1.0
Scen4_High-skilled	-0.5	0.0	1.2	2.0	2.6	1.7
Effective units of labour						
Scen3_Proportional	0.1	0.3	1.0	2.1	5.3	8.8
Scen4_High-skilled	0.3	1.0	2.2	3.6	7.2	10.9
Unattached (p.p. change in share)						
Scen3_Proportional	0.0	-0.1	-0.2	-0.3	-0.5	-0.5
Scen4_High-skilled	-0.1	-0.4	-0.7	-0.9	-1.2	-1.4
Total real wages						
Scen3_Proportional	-0.1	-0.1	-0.1	-0.1	-0.3	-0.5
Scen4_High-skilled	-0.2	-0.3	-0.1	0.1	0.3	0.0

In Scenario 4, the proportion of high-skilled immigrant workers increases substantially overtime. This leads to a higher positive impact on effective labour supply. Relative to Scenario 1, total effective labour increases by 2.2% in 2022, compared to 1% in Scenario 3 and by 10.9% in 2050 compared to 8.8% in Scenario 3. In addition, the rise in effective labour stimulates investment as firms raise their desired stock of physical capital to equip their new flow of highly

skilled workers. Consequently, real investment rises more substantially in Scenario 4 than in Scenario 3 and physical capital intensity increases. Finally, the combination of a greater increase in effective units of labour and in the capital-labour ratio lead to a positive impact on labour productivity and to a more substantial effect on real GDP per-capita in Scenario 4 compared to Scenario 3. Relative to Scenario 1, real per-capita GDP is 3.2% higher in 2022 and 8% in 2050, compared to 0.8% and 3.6% for Scenario 3, respectively. This implies that Scenario 4 is far more effective than Scenario 3 to reduce the real output loss due to population ageing.

Table 11
Labour Market Impact by Skills
Percent change relative to Scenario 1

Scen3_Proportional	1998	2010	2022	2030	2042	2050
Effective units of labour						
Total	0.1	0.3	1.0	2.1	5.3	8.8
High-skilled	0.2	0.8	1.9	3.2	6.8	10.7
Medium-skilled	0.0	0.0	0.4	1.3	4.2	7.4
Low-skilled	-0.1	-0.2	0.2	1.1	3.8	7.0
Real Wages by Skill						
Total	-0.1	-0.1	-0.1	-0.1	-0.3	-0.5
High-skilled	-0.2	-0.5	-0.8	-1.1	-1.6	-2.2
Medium-skilled	0.0	0.2	0.4	0.4	0.4	0.1
Low-skilled	0.0	0.3	0.6	0.7	0.8	0.6
Skill Premium						
High versus medium-skill	-0.2	-0.7	-1.2	-1.5	-2.0	-2.3
High versus low-skill	-0.2	-0.8	-1.4	-1.8	-2.4	-2.8
Medium versus low-skill	0.0	-0.1	-0.2	-0.3	-0.4	-0.5
Scen4_High-skilled						
Effective units of labour						
Total	0.3	1.0	2.2	3.6	7.2	10.9
High-skilled	0.8	3.0	5.5	7.8	12.8	17.6
Medium-skilled	-0.1	-0.4	-0.3	0.4	3.0	6.0
Low-skilled	-0.2	-0.8	-0.8	-0.2	2.1	5.0
Real Wages by Skill						
Total	-0.2	-0.3	-0.1	0.1	0.3	0.0
High-skilled	-0.7	-2.0	-2.9	-3.4	-4.4	-5.5
Medium-skilled	0.0	0.7	1.5	2.0	2.4	2.0
Low-skilled	0.1	1.1	2.1	2.7	3.3	3.0
Skill Premium						
High versus medium-skill	-0.8	-2.8	-4.6	-5.6	-7.1	-8.0
High versus low-skill	-0.8	-3.1	-5.1	-6.3	-8.0	-9.1
Medium versus low-skill	-0.1	-0.3	-0.5	-0.7	-0.9	-1.0

Relative to Scenario 1, total real wages decline only marginally in both Scenarios 3 and 4. There are, however, substantial movements in real wages across skills. In Scenario 4, real wages fall by 2.9% in 2022 and 5.5% in 2050 for highly-skilled workers. The real wage decline for highly-skilled workers is explained by the positive labour supply shock from immigration. This is also followed by real wage increase for medium and low-skilled workers ranging from 2.4 to 3.3% by 2042. Real wage movements follow similar trends in Scenario 3, but in much smaller magnitude. The skill premium is also reduced substantially in the long run. Finally, looking at the impact of the immigration shock on relative wages, the skill premium between high and low-skilled workers falls by more than 9% by 2050, compared to 8% decline between high and medium skilled. This is about 4 times greater than the reduction in the skill premium in Scenario 3. These results are consistent with Borjas (2005) who finds that an increase in the supply of high-skilled immigrants (doctorate degree) reduces the earnings of competing workers.

6. Policy Implications and Conclusion

According to this paper, without policy intervention, the anticipated negative labour supply shock due to population ageing could lead to an average annual growth decline of 0.4% in real GDP per-capita over the period 1015-2050. This may appear small, although the cumulative real output loss would turn out to be quite large after a few decades (11% by 2050). In this context, raising labour force growth and the proportion of high-skilled workers through immigration is seen as a way to help reduce skill pressures and to mitigate the negative consequences of workforce ageing.

As shown in the simulations, immigration is more effective if it is well targeted towards high-skilled (highly productive) immigrant workers, conditional on their adaptability to the Canadian labour market and recognition of their credentials. In addition, raising the proportion of high-skilled immigrants by 0.25% of the population could significantly offset the expected negative impact of ageing on the economy and the labour market through an increase in labour productivity. Alternatively, immigration could lead to only small economic gains if immigrants are not well targeted. For example, attracting a large proportion of immigrants with a weak attachment to the labour market and low productivity may end up being worse off.

Another implication of attracting more high-skilled immigrants to Canada is that it may reduce earnings inequality. For example, if we compare Canadian and U.S. immigration policies over the past few decades, the U.S. have attracted more low-skilled immigrants compared to Canada. This would suggest that respective immigration policies have contributed to raise earnings inequality in the U.S., by putting downward pressure to low-skilled wages and reduce earnings inequality in Canada by reducing high-skilled wages. One drawback for Canada is that by reducing the skill premium, targeting high-skilled immigrants may also reduce the return to investment in human capital.

The model used in this paper assumes that labour supply and human capital investment decisions are exogenous. Therefore, one limitation is that the model does not account for the likely impact of relative wage changes across skills on labour supply decisions and on incentives to invest in human capital. For example, it is possible that the positive shock on the supply of high-skilled workers will be partly compensated by a reduction in the domestic supply of high-skilled workers or a corresponding increase in the domestic supply of low or medium-skilled workers. In addition, by reducing the skill premium, future school leavers may be less inclined to invest in higher education. This could in turn partly offset the gain in human capital coming from immigration and reduce the net benefits in the long run. These questions need to be examined in future work using the same applied model extended to incorporate endogenous labour supply and human capital investment decisions.

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