Skills Research Initiative
Initiative de recherche sur les compétences

Population Ageing, Time Allocation and Human Capital: a General Equilibrium Analysis for Canada

Maxime Fougère (Human Resources and Social Development Canada)
Simon Harvey (Human Resources and Social Development Canada)
Jean Mercenier (Université Cergy-Pontoise)
Marcel Mérette (University of Ottawa)

Working Paper 2006 A-10

Human Resources and Social Development Canada/Ressources humaines et Développement social Canada
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A. Labour Market and Skills Implications of Population Aging;
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;
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Courriel : mepa.apme@ic.gc.ca

Abstract

This study explores the long-term impact of population ageing on labour supply and human capital investment in Canada, as well as the induced effects on productive capacity. The analysis is conducted with a dynamic computable overlapping generations model where in the spirit of Becker (1965) and Heckman (1976), leisure has a quality-time feature and labour supply and human capital investment decisions are endogenous. The role of human capital in the growth process is based on the framework used by Mankiw, Romer and Weil (1992). The paper indicates that population ageing creates more opportunities for young individuals to invest in human capital and supply more skilled labour at middle age. Consequently, the reduction in labour supply of young adults initially lowers productive capacity and exacerbates the economic costs of population ageing. However, current and future middle-age cohorts are more skilled and work more, which eventually raises productive capacity and significantly lowers the cost of population ageing. Finally, these results suggest that the recent increase in the participation rate of older workers might be the beginning of a new trend that will amplify over the next decades.

Résumé

Cette étude se penche sur l'impact à long terme du vieillissement démographique au Canada sur l'offre de travail et l'investissement en capital humain, ainsi que les effets induits sur la capacité productive de l'économie. L'analyse est effectuée à l'aide d'un modèle calculable dynamique à générations imbriquées, où dans l'esprit de Becker (1965) et Heckman (1976), le loisir comprend un élément de qualité et les décisions d'offre de travail et d'investissement en capital humain sont endogènes. La contribution du capital humain dans le processus de croissance est modélisée selon le cadre proposé par Mankiw, Romer et Weil (1992). L'étude indique que le vieillissement démographique crée plus d'opportunités pour les individus d'investir en éducation à un jeune âge et d'accroître par la suite leur offre de main-d'œuvre qualifiée. En conséquence, en passant plus de temps à l'école, la baisse de l'offre de travail des jeunes adultes réduit tout d'abord la capacité productive et accentue les coûts économiques du vieillissement. Toutefois, les cohortes présentes et futures d'âge moyen sont plus qualifiées et travaillent plus, ce qui éventuellement augmente la capacité productive et diminue sensiblement les coûts du vieillissement démographique. Finalement, les résultats de simulation laissent entendre que la hausse récente du taux d'activité des travailleurs âgés est le début d'une nouvelle tendance qui va aller en s'accentuant au cours des prochaines décennies.

1. Introduction

With the decline in the fertility rate, increase in life-expectancy and ageing of the baby boom generation, the growth in labour force population is slowing in Canada and most OECD countries. According to recent demographic projections and despite immigration, the Canadian elderly dependency ratio (ratio of population 65+ as a proportion of the 15-64 population) is expected to at least double between 2000 and 2050. From one individual aged 65+ for five worker-age individuals in 2000, this ratio will rise to 2/5 in 2050.

The slowing in labour force growth being inevitable, the long-term consequences on growth in productive capacity could be substantial if it is not compensated by a significant rise in productivity.[1] The increase in relative scarcity of labour caused by population ageing could also lead to a reduction in national savings, an increase in physical capital intensity, an increase in real wages and a reduction in world interest rates.[2] However, most studies so far have ignored the effect of population ageing on time allocation, more specifically on time spent at work and in human capital formation.[3] This paper argues that since population ageing is expected to lead to significant changes in production factor returns, these effects and their potential impact on productive capacity could be important.

Several factors can be considered to compensate for the decline in labour force growth. First, since the return to human capital is the discounted sum of future wage revenues, future young cohorts might be inclined to invest more in education. Second, a greater participation of middle-age and older workers may arise as a consequence of the increase in real wage pressures. Third, current cohorts of young adults are better educated than older cohorts

[1] For example, Fougère *et al.* (2005) find that without policy changes, population ageing could lead to an average growth reduction of 0.4 percentage points in real GDP per capita over the period 2015-2050.

[2] See, for example Borsch-Supan et al. (2002), Équipe Ingenue (2001), Hviding and Mérette (1998) and Auerbach *et al.* (1989) for international studies. Alternatively, Ferh *et al.* (2004) argue that population ageing will lead to a reduction in the capital-labour ratio.

[3] Although, Fougère and Mérette (1999, 2000a) and Sadahiro and Shimasawa (2003) look at the relationship between population ageing and human capital in a Lucas-type endogenous growth model, they assume that leisure time remains exogenous. Moreover, they do not relax the endogenous growth assumption to test the robustness of their results under a Mankiw, Romer and Weil (1992) framework.

(young women in particular). These combined factors would lead to a rise in the quality of the workforce, in productivity and to an increase in hours worked.

This paper uses a dynamic applied general equilibrium model with overlapping generations and endogenous time-allocation decisions to explore the relationship between population ageing, human capital and labour supply. Two simulation experiments are undertaken. The first simulation performed examines the long-term economic and labour market impact of population ageing in Canada by assuming that time-allocation decisions are exogenous. The second simulation applies the same demographic shock, but this time with endogenous time-allocation decisions.

The difference between the two scenarios will isolate the contribution of endogenous labour supply and human capital investment decisions on productive capacity in the context of demographic changes. More specifically, the second simulation will explore to what extent the demographic shock observed since the 1960s and 1970s could explain the stylised facts on labour supply and human capital investment by cohort during the 1980s and 1990s and evaluate the long-term impact of more educated cohorts of workers on productive capacity.

The paper is structured as follow. Section 2 provides a few stylised facts on historical and projected future demographic changes. Section 3 presents an overview on the relationship between human capital and growth. Section 4 discusses the possible relationship between population ageing and human capital. Section 5 provides a description of the model used for the analysis and calibration procedure. Section 6 presents the main results. Section 7 raises some policy implications and concludes.

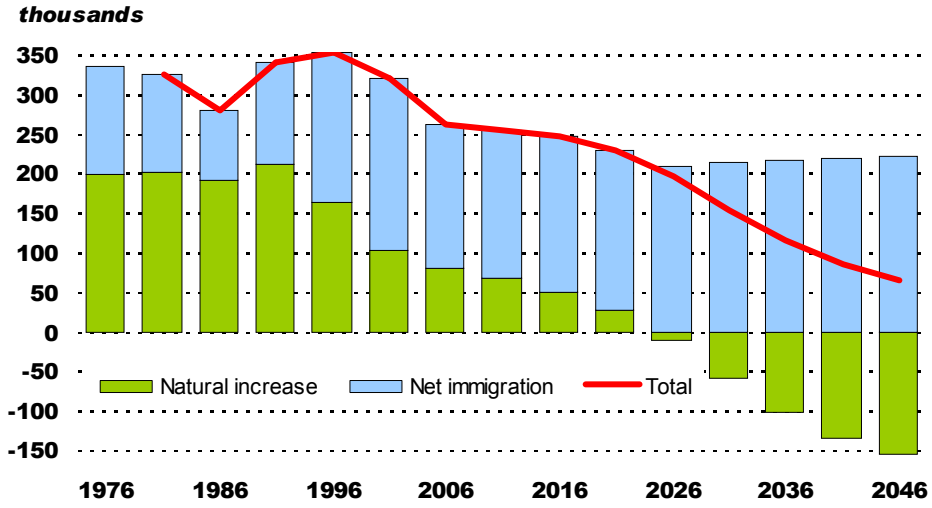
2. Some Stylised Facts on Canada's Demographic Changes

As indicated in introduction, over the next decades, population and labour force growth are expected to slow significantly. In addition, the age-composition of the population will change substantially. This section presents an overview of historical and projected demographic changes, according to HRSDC demographic projections using MEDS.[4]

[4] See Models of economic-demographic system (MEDS), Research Institute for Quantitative Studies in Economics.

Chart 1 presents historical and projected population growth in Canada. As can be shown, over the period 1976 to 2000, the annual population increase has averaged about 325 thousands. Until 1991, the natural increase in the population accounted for about 2/3 of the population increase, the rest coming from net immigration. Over the past ten years, although the population increase has remained constant, the substantial reduction in the fertility rate led to a reduction in the natural increase of the population, which was compensated by an increase in the composition of immigration in population growth. According to a recent demographic projection, the natural increase in the population will continue to slow and eventually turn negative. By 2026, the net population increase will essentially come from immigration.

Chart 1
Historical and Projected Population Growth in Canada



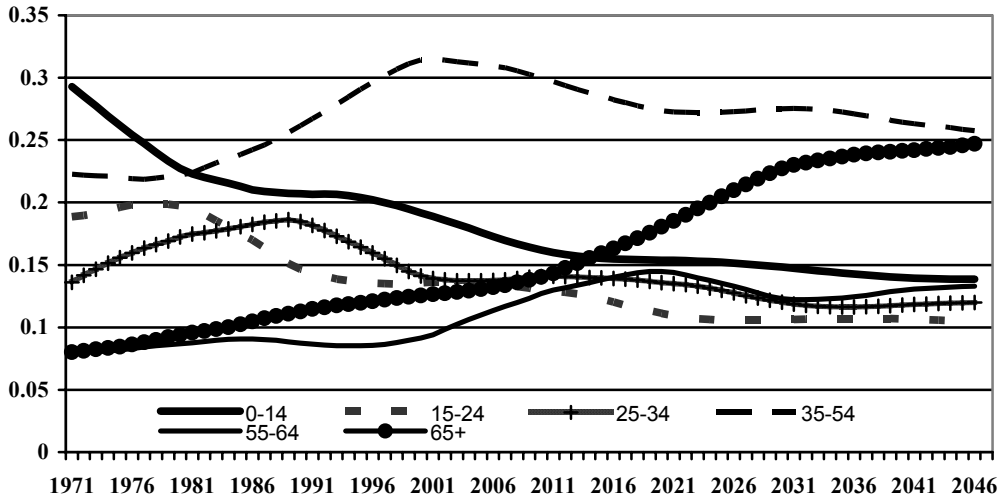
Source: Statistics Canada, Census 1976-2001; HRSDC-PRCD, 2002-2046 (COPS Reference 2004)

The age-composition of the population is also expected to change substantially over the next decades. As shown in Chart 2, the proportion of the younger population (0-14) is expected to continue to fall over the next decades from 18.9% in 2001 to 13.8% in 2046, while the proportion in age group 15-24 will fall more moderately from 13.6% to 10.4% over the same period, after a more significant decline since the early 1980s. In comparison, the proportion of the prime-age population (25-34) will decline at an even more moderate pace, from 13.9% to 12% over the period 2001 to 2046. In contrast, the proportion of the middle-

age population (35-54) has increased substantially over the past two decades, which illustrates the effect of the demographic shock from the baby boom generation on the population structure. According to the demographic projection, the proportion of the middle-age population is beginning to decline. From the 31.5% peak in 2001, the proportion of this age group will fall to 25.7% of the population in 2046.

Following the effect of the baby boom cohorts, the proportion of the 55-64 age group is projected to increase from 9.4% in 2001 to 14.5% in 2020. This will be followed by a moderate decline in the longer term to 13.3% by 2046. Finally, to illustrate the demographics of population ageing, the older age group (65+) is expected to increase at a rapid pace during the next 25 years, from 12.6% in 2001 to 22.7% in 2030, then grow more moderately between 2030 and 2046 and reach 24.7% by 2046.

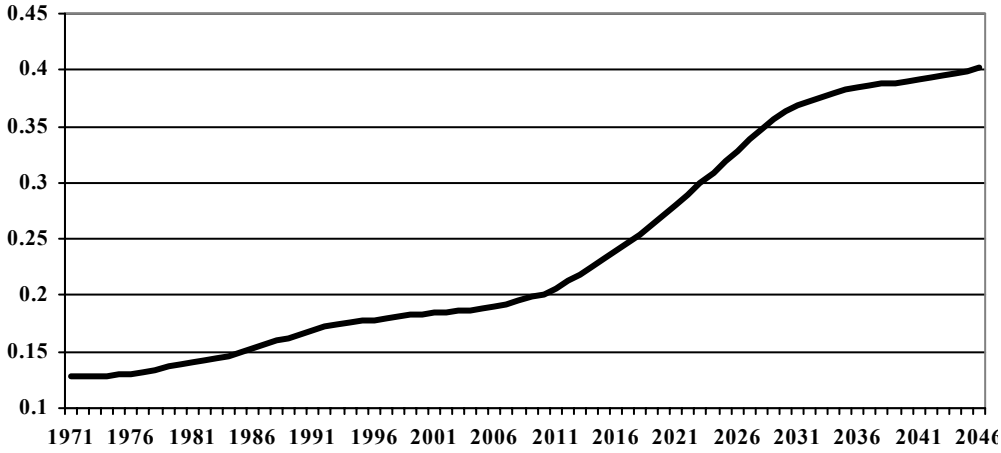
Chart 2
Population Share by Age Group in Canada



Source: Statistics Canada, 1971-2001; HRSDC-PRCD, 2002-2046 (COPS Reference 2004)

Chart 3 now presents the historical and projected old-age dependency ratio (population 65+ as a ratio of the population 15-64). As can be seen from the chart, over the period 1971 to 2001, the old-age dependency ratio increased from 0.13 to 0.185. Over the next decades, it is expected to continue rising, first at an increasing rate, until about 2031, and at a slower pace for the remaining projection period. Between 2001 and 2046, this represents a 216% increase in the old-age dependency ratio.

Chart 3
Projected Elderly Dependency Ratio in Canada



Source: Statistics Canada, 1976-2001; HRSDC-PRCD, 2002-2046 (COPS Reference 2004)

3. The Role of Human Capital in Economic Growth

The role of human capital formation in the growth process has been extensively analysed in the literature.[5] According to the theoretical literature, human capital would affect economic growth in two ways. First, human capital directly participates in production as a productive factor and the accumulation of capital directly generates output growth. This is the so-called level effect. Second, human capital can contribute to raising technical progress through increased innovation, diffusion and adoption of new technologies. From this indirect channel, human capital influences growth through increases in productivity.

The level effect of human capital on economic growth has been examined through the convergence analysis as proposed by Barro and Sala-i-Martin (1992). In their influential paper, Mankiw, Romer and Weil (1992) (henceforth MRW) extend the basic Solow model of economic growth by accounting for the accumulation of human capital to better explain cross-country differences in living standards. By running simple cross-country regressions, they find evidence of a direct effect of human capital on economic growth.

[5] See, for example, Lucas (1988), Romer (1989) and Mankiw, Romer and Weil (1992).

Following MRW, several papers have examined the relation between human capital and growth by modifying some aspects of the analysis. Overall the empirical literature has come up with mixed results. For example, Islam (1995), Hanushek and Kimko (2000) and Barro (2001) either find a negative or insignificant relationship between human capital and growth. Among the studies that find a significant positive relationship between human capital and growth, Fuente and Doménech (2000) argue that poor data quality may explain the mitigated results found in the literature. By improving the data quality from Barro and Lee (1996) and Nehru *et al.* (1995), they find positive, more robust and theoretically plausible results using a variety of growth specifications. Bassanini and Scarpeta (2001) also provide evidence that investment in human capital has been an important engine of growth in Canada and most OECD countries over the past decades. Freige-Seren (2001) uses a dynamic system that describes the behaviour of the economy to examine how human capital affects growth, by considering the simultaneity or reverse impact of growth on human capital accumulation. He provides evidence about the level effect of education on economic growth. Finally, Coulombe *et al.* (2004) find a strong empirical relationship between human capital and economic growth across OECD countries by using a measure of human capital based on literacy scores.

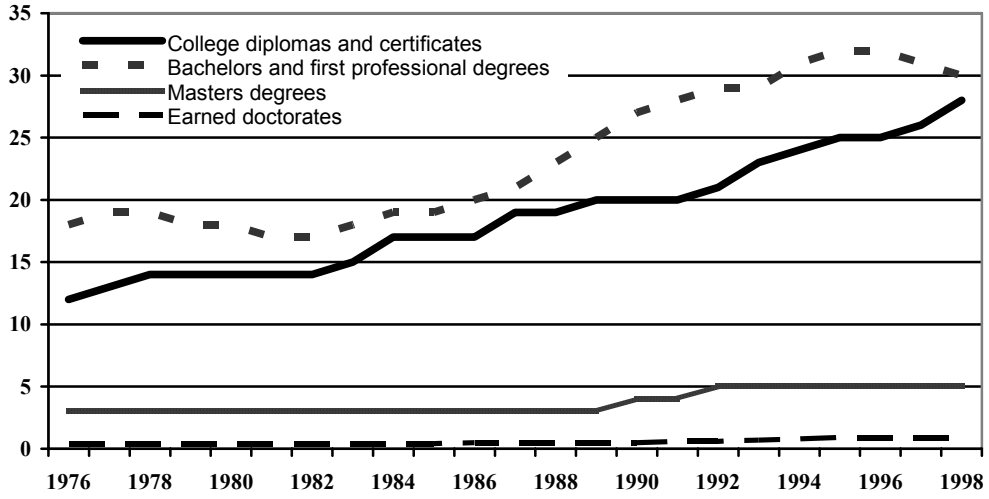
4. Population Ageing and the Accumulation of Human Capital

It is well know that the education component of human capital has grown substantially in Canada over the past decades. For example, the percentage of the population aged 25-29 with post-secondary education has risen from 43.8% in 1990 to 62.8% in 2003 (source: Labour Force Survey). When we decompose graduation rates by education level (see Chart 4), we can see that graduation rates for bachelors, college diplomas and certificates have increased almost steadily over the past two decades, while graduation rates for masters and doctorates has remained flat throughout the period, except for an increase in masters degree during the 1988-1992 period.

However, with population ageing, the contribution of human capital to growth is uncertain in the future. On the one hand, as the baby boom generation ages, the older workforce is expected to raise the experience component of human capital. On the other, the

net contribution of education to the growth in human capital is indeterminate because key determining factors may play in opposite directions. First, the younger population will continue to represent a smaller proportion of the workforce, which may reduce the contribution of education to human capital. Second, the increase in relative scarcity of workers may raise real wages and the return to human capital. Third, the rise in the stock of human capital associated to experience may flatten the lifecycle earnings profile, and hence reduce the net return to education.

Chart 4
Graduation Rates
(Relative to Population at Typical Graduation Age)



Source: University Student Information System, Statistics Canada

A number of studies have recently looked at the contribution of human capital to growth in the context of an ageing population. Fougère and Mérette (1999, 2000a) (henceforth FM99 and FM00) provide simulation results with an overlapping generations endogenous growth model, where growth is generated by the accumulation of physical and human capital. FM99 examine seven OECD countries and FM00 use a more detailed model for Canada. Their results indicate that population ageing could create more opportunities for future generations to invest in human capital, which in turn would stimulate economic growth and significantly reduce the negative apprehended reduction in real GDP per capita.

Using a model structure of endogenous growth similar to FM99, Sadahiro and Shimasawa (2003) examine the long-term consequences of population ageing in Japan. Among their key findings, they find that younger individuals have a greater incentive to allocate their time into education in the phase of declining population growth and that the endogenously determined growth in human capital offsets the negative labour force growth rate on economic growth.

Building on previous work from Laroche and Mérette (2000), Laroche, Mérette and Yan (2005) present an updated measure of Canada's human capital stock for the period 1971 to 2000, which accounts for completion of education levels and years of working experience. They also provide a projection until 2041, accounting for changes in demographics and on alternative assumptions about the return to education in the future. Under the assumption that the rate of return to education and experience remains at its 2001 level, their results indicate that human capital will grow at a slower pace in the future, compared to the last decades. Under the alternative assumption that the positive trend in the rate of return to education and experience observed during the period 1971-2001 continues, human capital grows at a faster rate than during the past 30 years.

5. The Model

The analysis is based on a dynamic general equilibrium model with an overlapping generations (OLG) structure (the detailed technical description of the model is available upon request). The model is calibrated to represent the Canadian economy.

5.1 General Description

At each period of time, there are 15 age groups of adult individuals by skill level and immigration status, structured in an Allais-Samuelson overlapping generations framework. Each individual maximizes an intertemporal utility function with consumption and leisure as arguments subject to two accumulation conditions: wealth and human capital. At any age, each individual allocates a specific proportion of its time endowment toward leisure, work and human capital formation. Each individual also allocates its disposable income in consumption and savings. Savings can be allocated between domestic physical capital ownership titles or government bonds.

The role of human capital in the growth process is based on the framework used by Mankiw, Romer and Weil (1992). This implies that human capital has a direct effect on productive capacity but no indirect one through technical progress and innovation. The cost of investing in human capital is the current wage. Investment returns in education and training are a stream of net revenue from future labour supply. Since the return to human capital is the discounted sum of future wage revenues, it is rational to invest in human capital when young and work a little and invest in physical capital when middle age and older.

The government collects taxes on labour income, capital income and consumption expenditures. Government spending is divided into three components: health, education and other government expenditures including interest payments on the public debt. The government distributes social transfers to individuals. The public pension system is modeled as a two-tier pension program. The first-tier, the Old Age Security (OAS) system, which also includes the Guaranteed Income Supplement (GIS) is modeled as a national transfer program to the elderly and is financed through general taxes from the national government. The second-tier, the Canada/Quebec Pension Plan (CQPP) is a comprehensive contributory pension plan.

The representative firm produces a unique goods. Its production technology is represented by a Cobb-Douglas function. The firm hires labour by skill and rents physical capital. Labour is a composite factor of 3 skill levels (high, medium and low-skill) represented by a constant elasticity of substitution function. The investment technology is represented by a constant elasticity of substitution (CES) function.

The model assumes perfectly competitive markets and agents with perfect foresight. Bonds and physical capital ownerships are considered perfect substitutes. Hence total supply of assets must equal total demand.

5.2 Distribution of workers by skill

The model distinguishes between 3 different labour qualification levels by immigration status – high-skill, medium-skill and low-skill workers and a 4th category of working-age individuals who are unattached to the labour market or inactive. Lifetime

earnings profiles depend on the qualification, labour market participation, human capital investment and the nationality status of the individual. As shown in Chart 5, the distribution of earnings in the initial steady state also differs substantially by skill and age. Those with higher skill earn more because they are more productive. The age-earnings profile for high-skilled workers also has a steeper slope. The earnings level stabilises around age 49-52 and begins to decline after age 56. In comparison, the age-earnings profile for medium and low-skilled workers is much lower across all ages, peaks earlier and declines at age 49-52.

Chart 5
Earnings by Skill Level and Age

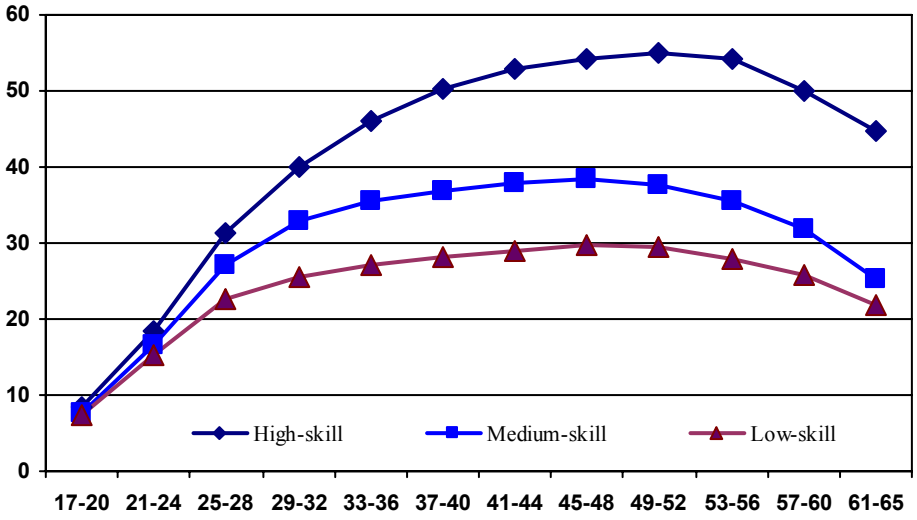


Table 1 describes the classification of skill levels in the model. The occupational composition of high-skilled workers used in the model is the same as the definition of highly qualified workers used in Laroche (2000) and OECD (2000). Using the National Occupation Classification (NOC) Matrix, high-skilled 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 occupations 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 2 reports the distribution of recent immigrants (been in Canada for 5 years or less), other immigrants (been in Canada for more than 5 years) and non-immigrant workers by skill levels as calibrated in the initial steady state and based on the 2001 Census. The distribution of non-immigrant workers by skills has been fairly stable in Canada over the past 10 years. For recent immigrants, the proportion of skilled immigrants has changed radically over the 1990s. According to the 2001 Census, 26.7% (24%) of non-immigrants (recent immigrants) are high-skilled workers, 22.2% (13%) medium-skilled and 29.3% (28%) low-skilled. In addition, 21.9% (35%) are unattached individuals. Finally, the skill distribution of immigrants who have been in Canada for more than 5 years is calibrated on the 1996 Census. For immigrants who came to Canada earlier, 15.6% are high-skilled, 13.6% are medium-skilled, 30.2% are low-skilled and 40.6% are unattached to the labour market. The skill-distribution of future immigrants is assumed to remain the same as in the 2001 Census.

Table 1
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 2
Skill Share of Permanent Residents and Non-Immigrant Workforce

Skill level	High	Medium	Low	Unattached
Non-immigrants	0.267	0.222	0.293	0.219
Recent immigrants	0.240	0.130	0.280	0.350
Other immigrants	0.156	0.136	0.302	0.406

5.3 Time Allocation

Charts 6 to 8 present the distribution of time allocation by age group for high-skilled, medium-skilled and low-skilled workers in the initial steady state. Data on time allocated to employment by skill is derived from HRSDC-PRCD labour force participation rate model, while time allocated to human capital is derived from the 1998 General Social Survey on Time use.

As shown in Chart 6, high-skilled workers, when young, allocate a significant proportion of their time to college and university education. Time allocated to education peaks at age 21-24 to account for time spent in undergraduate and some graduate university education. This is mainly at the expense of lower leisure time. Time allocated to education falls at age 25-28, accounting for high-skilled individuals who undertake Master's and Doctorate degrees and tends to zero thereafter. It can also be seen that although workers may spend some of their time in adult training, in aggregate time spent in training during a year remains negligible. Time spent in employment for high-skilled workers gradually increases when young and stabilises at age group 29-32 until 49-52. After 49-52, the preference for leisure increases, working time decreases and eventually turns to zero.

When we compare the age-distribution of time allocation of high-skilled with medium-skilled workers (Chart 7), we can see that medium-skilled when young spend less time on education, slightly fewer time on employment and enjoy more leisure. Finally, compared to high- and medium-skilled workers, low-skilled workers spend less time on

education and employment and more time on leisure (Chart 8). Time spent in employment also diminishes earlier (age 45-48). Overall, the data reflect the fact that high-skilled workers are expected to have longer careers than medium and low-skilled workers.

Chart 6
Time Allocation for High-Skilled Workers

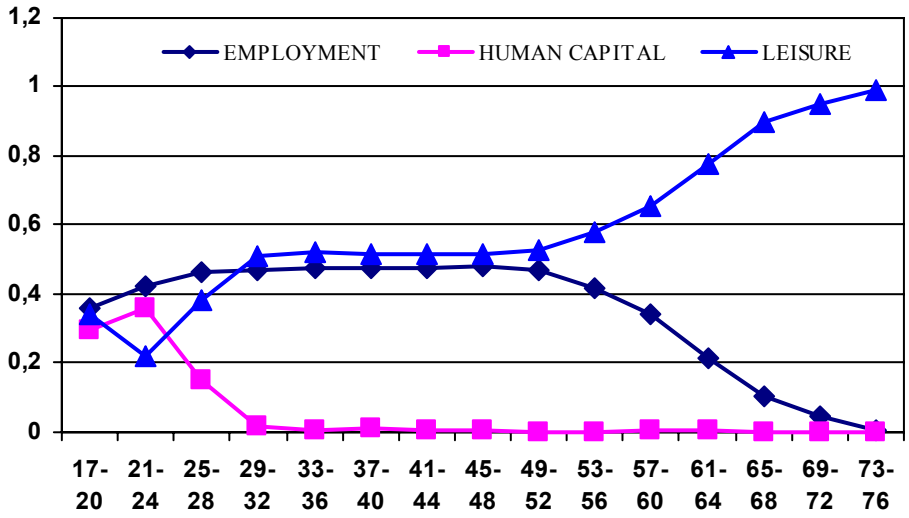
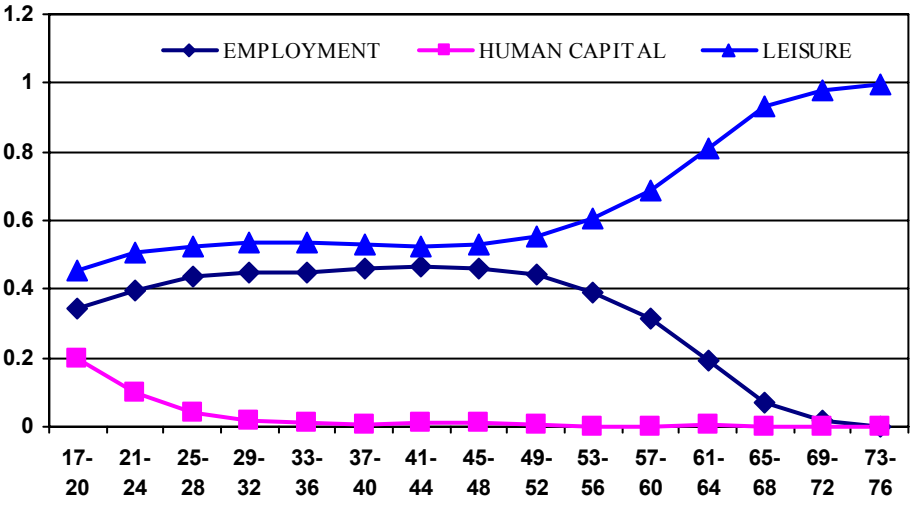


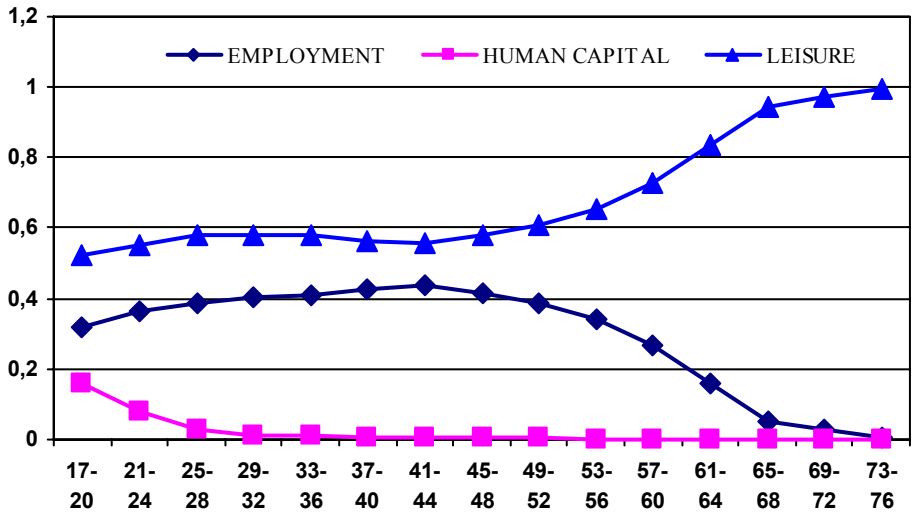
Chart 7
Time Allocation for Medium-Skilled Workers



5.4 Calibration

The computable general equilibrium model compares two states of the economy, a steady state scenario and one with population aging, according to the demographic scenario generated with the demographic model. Since the model is dynamic, changes in the birth rate, beginning in 1946, are used to replicate the elderly dependency ratio until 2046, as projected in the demographic model. We then assume that the birth rate returns to its natural replacement level in the long run.

Chart 8
Time Allocation for Low-Skilled Workers



5.5 Behavioural Parameters

Table 3 reports key behavioural and government program parameter values. The value of the inter-temporal elasticity of substitution is 0.25 and the value of the intra-temporal elasticity of substitution between consumption and leisure is 0.8. These values are taken from Auerbach and Kotliikoff (1987). The CPP/QPP pension replacement rate is 0.3. The elasticity of human capital technology is equal to 0.7 and is taken from Fougère and Mérette (1999, 2000a).

Table 3

Behavioural and Government Program Parameters

Inter-temporal elasticity of substitution	0.25
Intra-temporal elasticity of substitution	0.8
Ratio of CPP/QPP pension replacement rate	0.3
Elasticity of human capital technology	0.7
Production share of capital	0.3
Rate of interest	0.038
Depreciation rate of capital	0.051
Public health care spending/GDP	0.076
Public education spending/GDP	0.059
Government debt/GDP	0.76
Labour income tax rate	0.325
Capital income tax rate	0.489
Consumption tax rate	0.196

5. Simulation results

To undertake a retrospective and prospective analysis of the economic and labour market impact of population ageing, the simulation results are presented from 1982 to 2050 (see Table 4). Chart 9 also presents the impact of the demographic shock on real GDP per capita for Scenarios 1 and 2.

As indicated earlier, Scenario 1 assumes that time-allocation decisions are exogenous to the model. Therefore, changes in the return to work and to invest in human capital do not affect individuals' labour supply and education decisions. According to the results of Scenario 1, following the massive labour supply shift during the 1970 and 1980s associated with the entry of the baby boom generation into the labour market, productive capacity increases substantially relative to the steady state with no population ageing. Real GDP per capita increases substantially during the 1980s, 1990s and 2000s. Eventually, as the baby boom generation gradually transits towards retirement, the impact on productive capacity stabilises and real GDP per capita begins to fall by 2014. Finally, between 2014 and 2050, real GDP per capita falls by about 10%, corresponding to a 0.4 percentage point annual growth reduction.

This result is similar to Fougère *et al.* (2005), Fougère and Mérette (2000b) and Hviding and Mérette (1998) who use OLG models and assume that labour supply and human capital investment decisions are exogenous. Baylor (2005) also comes up with similar results, although the OLG model he uses assumes endogenous labour supply but exogenous human capital investment decisions.

The demographic shock leads to a moderate increase in national savings during the 1980s and 1990s, and to a substantial reduction thereafter, as the baby boom generation transits towards retirement. The demographic shock also leads to capital deepening and to a substantial increase in real wages after 2002 to compensate for the relative scarcity of workers. Between 1982 and 2002, real wage changes are moderate.

Table 4
Impact of Population Ageing on Key Macroeconomic Indicators under Exogenous and Endogenous Time Allocation Decisions
Percent deviations with respect to initial steady state

	1986	1990	1994	1998	2002	2006	2010	2014	2018	2022	2026	2030	2034	2038	2042	2046	2050
Real GDP per capita																	
Scen1	1.1	2.4	3.8	5.1	6.0	6.5	6.8	6.9	6.8	6.4	5.7	4.7	3.4	1.7	-0.1	-2.1	-4.0
Scen2	0.4	1.0	1.7	2.5	3.1	3.4	3.7	3.9	4.0	4.1	4.1	3.9	3.5	2.9	2.1	1.1	0.0
Capital-labour ratio																	
Scen 1	-0.9	-0.9	0.2	2.3	5.3	8.9	12.6	16.5	20.6	24.9	29.2	33.5	37.5	40.8	43.1	43.8	42.8
Scen 2	-0.6	-0.7	-0.2	0.9	2.5	4.4	6.4	8.4	10.5	12.8	15.1	17.3	19.5	21.3	22.7	23.5	23.3
National savings rate																	
Scen1	0.6	1.0	1.4	1.5	1.3	0.6	0.0	-0.9	-1.7	-2.7	-3.7	-4.8	-6.0	-7.1	-8.3	-9.3	-10.2
Scen2	0.3	0.5	0.6	0.6	0.3	-0.5	-1.2	-2.0	-2.8	-3.7	-4.6	-5.4	-6.3	-7.1	-7.9	-8.6	-9.2
Labour supply*																	
Scen1	4.6	9.1	13.2	16.7	19.2	20.7	20.9	19.8	17.3	13.5	8.7	3.1	-2.8	-8.9	-14.7	-20.2	-25.1
Scen2	4.0	7.9	11.5	14.6	16.9	18.5	18.9	18.2	16.2	13.1	9.1	4.3	-0.8	-6.2	-11.5	-16.6	-21.4
Effective labour supply*																	
Scen1	5.3	10.5	15.4	19.5	22.7	24.6	25.3	24.5	22.3	18.7	13.8	8.0	1.5	-5.3	-12.0	-18.4	-24.1
Scen2	4.5	8.9	13.2	17.1	20.2	22.5	23.7	23.7	22.3	19.8	16.0	11.3	5.9	0.1	-5.9	-11.8	-17.3
Real wage rate																	
Scen1	-0.3	-0.3	0.0	0.7	1.6	2.6	3.6	4.7	5.8	6.9	8.0	9.0	10.0	10.8	11.3	11.5	11.3
Scen2	-0.2	-0.2	-0.1	0.3	0.7	1.3	1.9	2.4	3.0	3.6	4.3	4.9	5.5	6.0	6.3	6.5	6.5

*Labour supply accounts for changes in total hours worked, while effective labour supply also includes a measure of quality in the workforce.

When we turn to Scenario 2, the analysis indicates that young individuals with perfect foresight and rational expectations well anticipate the rise in the education premium in the future due to population ageing. As a result, they invest more in education at young age to supply more skilled labour at middle age. Consequently, by spending more time in education,

the reduction in the labour supply of young adults initially lowers productive capacity. However, as future cohorts of middle-age workers are more skilled and work more, the productivity gains and additional supply of skilled workers eventually reduce the cost of ageing on productive capacity (see Chart 9). Consequently, the long term impact of population ageing is smoother over the period 1982 to 2050 and the cost in term of output loss appears more manageable. Between 2015 and 2050, real GDP per capita falls by about 4%, compared to 10% in Scenario 1.

Since the labour supply increase is more moderate initially in Scenario 2, the overall impact on national savings is more negative than in Scenario 1until about 2038. Also, given that labour supply is endogenous in Scenario 2, the effect of population ageing on real wage pressures is smaller than in Scenario 1 since both wages and hours adjust (labour supply curve has a positive slope). In Scenario 1, labour market equilibrium comes exclusively from real wage changes (vertical supply curve).

Chart 9
Impact of Population Ageing on Real GDP per Capita
Endogenous vs. Exogenous Time Allocation Decision Scenarios

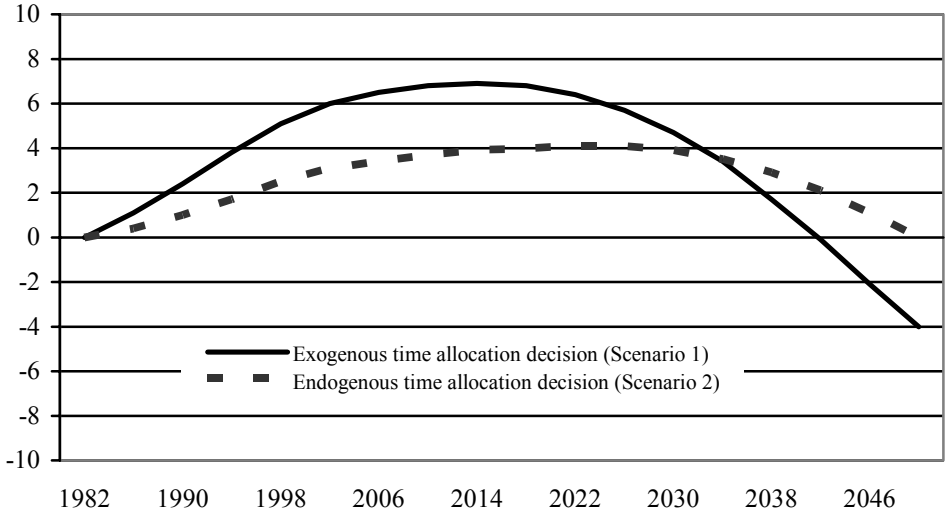
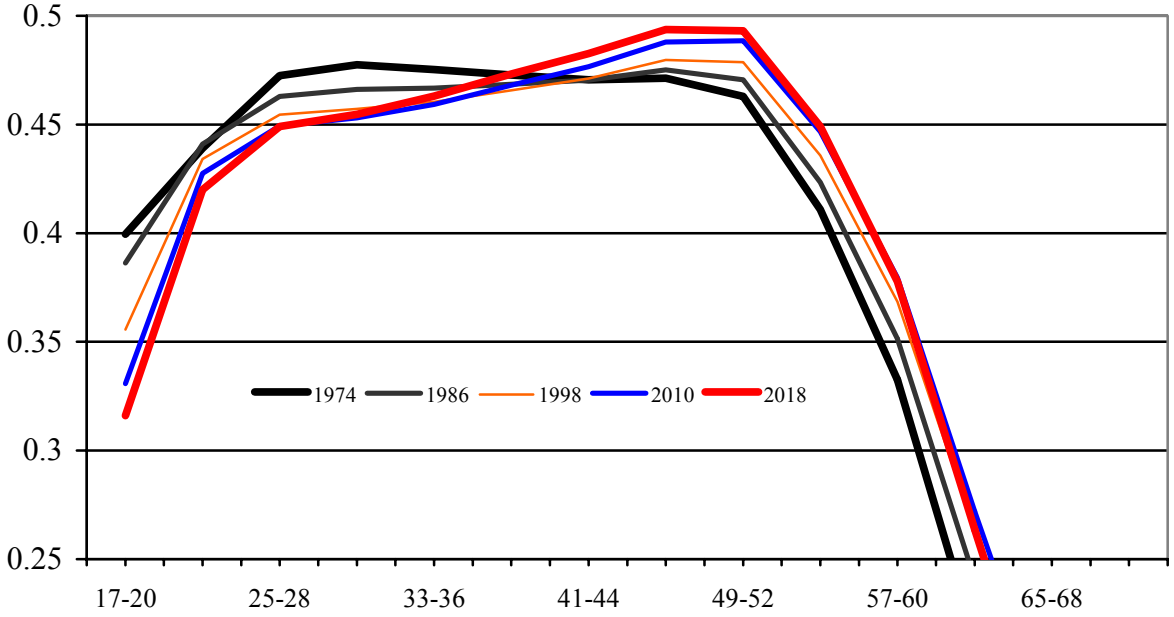


Chart 10 provides an overview of the dynamic change in labour supply behaviour by cohort during the working life for high-skilled workers. For illustrative purposes, we examine 5 cohorts who enter the labour market in 1974, 1986, 1998, 2010 and 2018, respectively. As can be shown, for cohort 1974, time allocated to work rises steadily from age groups 17-20 to 25-28, stabilises between 25-28 and 45-48 and declines more rapidly during pre-retirement years as the preference for leisure rises. However, for future cohorts, the labour supply behaviour changes gradually, with a substantial reduction in time allocated to work for age groups 17-20 to 37-40, which is mainly compensated by an increase in time allocated to education. At middle age (41-44), the labour supply increases and time allocated to work becomes greater than that of previous cohorts. Also, since these individuals have invested more time in human capital, they are more qualified and productive. Finally, as they get older, they work longer than previous cohorts. For example, for age groups 57-60, 61-64 and 65-68, time allocated to work increases by 14%, 23.5% and 46.7%, respectively between cohort 1974 and cohort 2018.

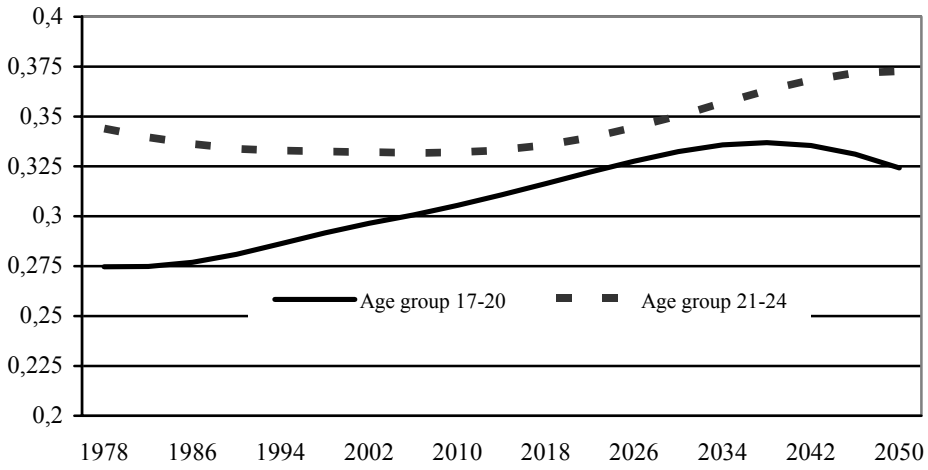
Chart 11 presents the evolution of time allocated to education between 1978 and 2050 for high-skilled workers in age groups 17-20 and 21-24. Time allocated to education for age group 17-20 more likely corresponds to college and undergraduate university education, while time allocated to education for age group 21-24 captures a greater proportion of post-graduates (Master's degrees and Doctorates). As can be shown, the model indicates that population ageing provides more incentives to invest in education for age group 17-20, beginning in the early-1980s, as time spent in education increases, while time spent in education for age group 21-24 remains unchanged over history. This result generated by the model is consistent with the stylised facts (see Chart 4).

Chart 10
Impact of Population Ageing on Time Allocated to Work by Cohort
(High-Skilled Workers)



The model also indicates that time allocated to education increases for age group 17-20 over the period 2002-2038 and declines thereafter. In comparison, time allocated to education for age group 21-24 remains unchanged until 2010 and then increases during the 2010-2050 period. Time allocated to education for medium and low-skilled workers follows a similar pattern but in much smaller magnitude than for high-skilled workers (see Charts 12 and 13).

Chart 11
Time allocated to Education for Age Groups 17-20 and 21-24
(High-skilled workers)



Time allocated to Education for Age Groups 17-20 and 21-24

Chart 12
(Medium Skilled Workers)

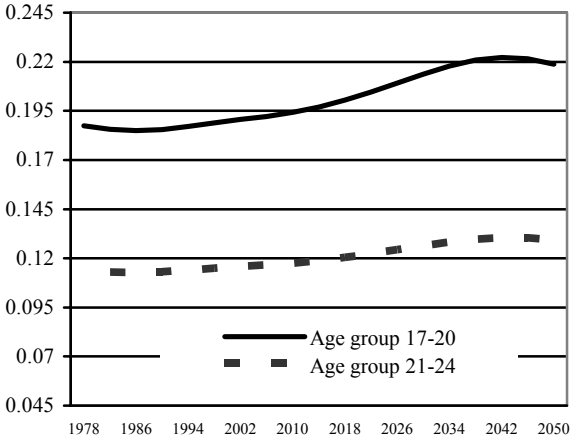
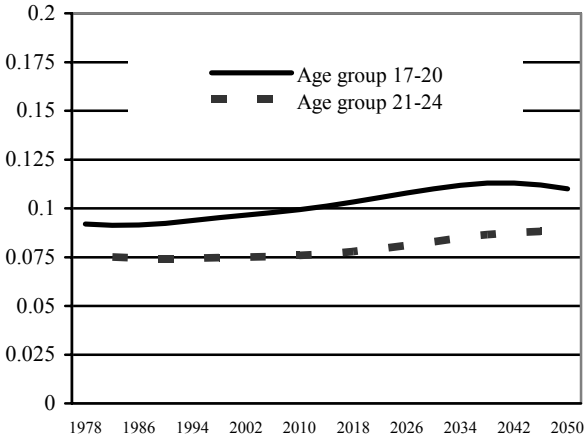


Chart 13
(Low-Skilled Workers)



6. Conclusion and Policy Implications

This study explores the long-term impact of population ageing on labour supply and human capital investment in Canada. More specifically, the study examines to what extent the demographic shock observed since the 1960s and 1970s could explain the behaviour on labour supply and human capital investment during the 1980s and 1990s. It also evaluates the long-term impact of more educated cohorts of workers on productive capacity. The analysis is conducted with a dynamic CGE overlapping generations model.

The results first provide a possible explanation to the significant rise in the level of education over the past 25 years. Beginning in the 1980s and 1990s, population ageing created opportunities for young individuals with perfect foresight and rational expectations to invest more in education at young age and supply more skilled labour later at middle age.

Second, by spending more time in education, the reduction in labour supply of young adults initially lowers productive capacity and exacerbates the economic costs of population ageing. According to the model, we are currently bearing the cost of population ageing through lower labour supply for young adults. However, current and future cohorts of middle-age workers are more skilled and work more, which eventually will raise productive capacity and significantly lower the economic cost of population ageing.

Third, over the past few years, we have observed a significant increase in the participation rate of older workers. Some may argue that the effect is temporary and reflects the recent reduction in stock market performance on the retirement behaviour.[6] The results from this paper suggest instead that the recent increase in the participation rate of older workers might be the beginning of a new trend from more educated workers that will amplify over the next few decades.

Finally, as indicated earlier, agents are assumed to be rational in the model and to well anticipate the consequences of population ageing. This implies that their time allocation is always optimal. However, if young individuals are myopic, they would rather expect future

[6] It must be noted that Coile and Levine (2004) find no evidence for the U.S. that changes in the stock market drive aggregate trends in labour supply for older workers.

earnings to equal the earnings of current older workers. Young individuals would then underestimate the returns to invest in human capital and enter into the labour market earlier instead of spending more time in school. This implies that governments have an important role to play to ensure that current young and future cohorts have complete information before they make a choice between higher education and the job market. If they make the right choice, the economic cost of population ageing will be quite manageable. If not, the cost will be much greater and lead to much slower growth in living standards for future generations.

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