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

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Summary

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.

Key words: Ageing, overlapping generations model, time allocation, human capital, labour supply

JEL classification: D58, J22, J24

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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 describes the technical structure of the model used for the analysis and Section 6 the calibration procedure. Section 7 presents the main simulation results. Finally, Section 8 raises some policy implications and concludes.

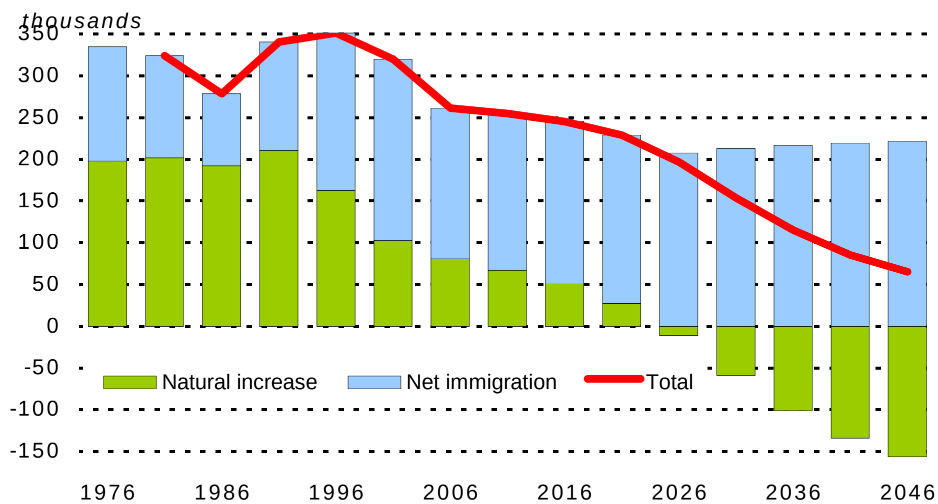
2. Some Stylised Facts on Canada's Demographic Changes

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

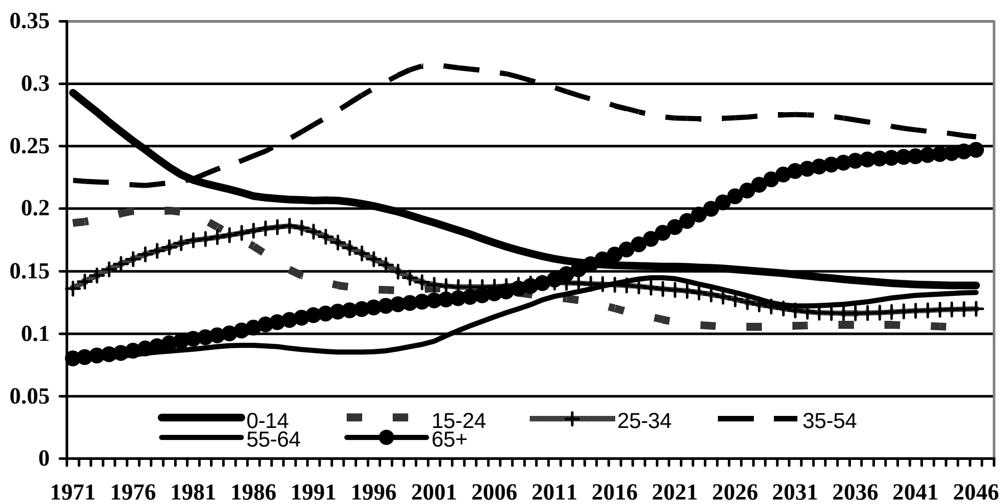


Source: Statistics Canada, Census 1976-2001; HRSDC-PRCD, 2002-2046 (COPS Reference 2004)

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.

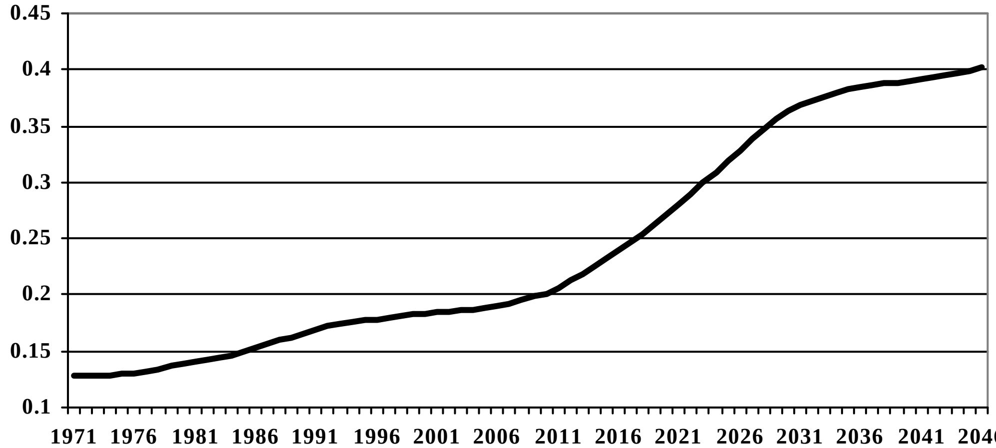
Chart 2
Population Share by Age Group in Canada



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 influencial 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.

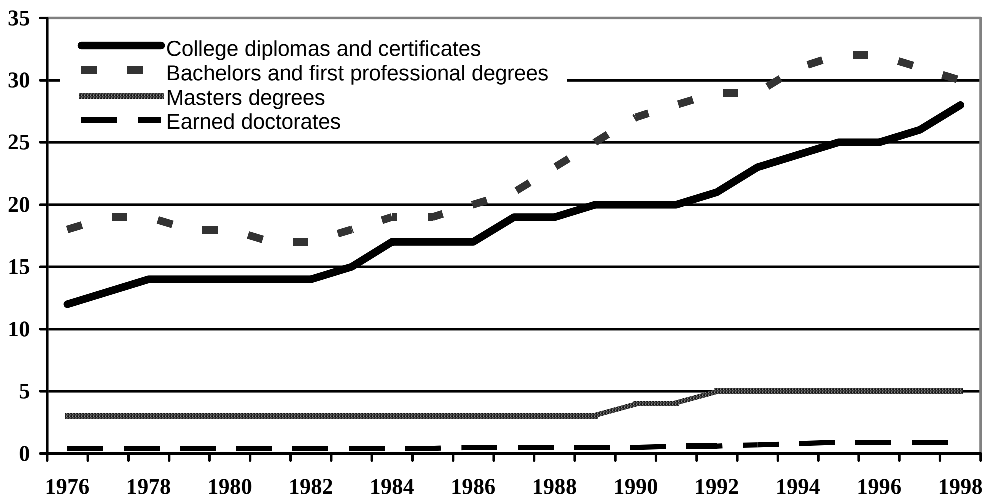
As can be seen from the empirical literature, with improvement in data quality and in methodologies, recent findings provide stronger evidence of a positive relationship between human capital and economic growth. These recent findings also suggest that human capital is an important determinant of economic growth.

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 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 could change 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 hand, 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. This therefore calls for a quantitative investigation.

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



Source: University Student Information System, Statistics Canada

A number of studies have recently explored the issue and provide evaluation of 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.

Finally, some studies have estimated the stock of human capital and used partial analysis framework to examine the relationship between changes in demographics and changes in the stock of human capital. Building on previous work from Laroche and Mérette (2000), Laroche, Mérette and Lan (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.

An interesting finding from Laroche et al. (2005) results is that alternative projection of the human capital stock in the future is very dependant on assumptions regarding the rate of return to education. Also, since the return to human capital could be greatly influenced by changes in factor returns in the future, ignoring the role of human capital in the context of ageing population could be misleading.

5. The Model

Our analysis is based on a dynamic general equilibrium model with an overlapping generations (OLG) structure. The model is calibrated to represent the Canadian economy. We here provide a technical description of the model.

5.1 The Production Sector

A representative firm produces a single good. Its technology is Cobb-Douglas. With Y_t being output at time *t*, K_t the capital stock, L_t the effective labour force, and *A* a total factor productivity factor, we thus have:

(1) $$Y_t = AK_t^{\alpha} L_t^{1-\alpha}$$

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

(2) $$rent_t = \alpha A \left(\frac{K_t}{L_t} \right)^{\alpha - 1}$$

(3) $$w_t = (1-\alpha) A \left(\frac{K_t}{L_t} \right)^{\alpha}$$

where $rent_t$ is the rental rate of capital and w_t the wage rate per unit of effective labour.

5.2 Investment and Asset Returns

The capital stock K_t is accumulated with exponential depreciation:

(4) $$K_{t+1} = Inv_t + (1-\delta_K) K_t$$

where Inv_t is flow investment at time *t* and δ_K is the constant depreciation rate. Return on capital reflects rental and depreciation:

(5) $$1 + r_t = (1 + rent_t - \delta_K)$$

5.3 Households Behaviour

The Canadian population is composed of 15 representative households structured in an Allais-Samuelson overlapping generations structure. Consequently, at each period of time, 15 generations live side by side. At any period *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 76. A period in this model therefore 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 population growth rate and immigration are both exogenous. The number of individuals in generation *g* living at time *t* is $Pop_{g,t}$.

Individuals optimise a CES type inter-temporal utility function of consumption and leisure subject to lifetime income and time constraint. The household's optimisation problem consists of choosing the consumption and savings pattern over the lifecycle, as well as the time allocation between working, education and leisure. Time spent in education is investment in human capital. Human capital accumulation raises both effective labour supply and the quality of leisure. The inter-temporal utility function for an individual born at the beginning of period *T* takes the following form:

(6) $$U_T = \frac{1}{1-\sigma}\sum_{g=1}^{15}\left(\frac{1}{1+\rho}\right)^g (C_{g,T+g-1}^{1-\theta} + \phi_g LA_{g,T+g-1}^{1-\theta})^{\frac{1-\sigma}{1-\theta}}, \quad 0<\theta<\infty, 0<\sigma<\infty$$

where $C_{g,t}$ and $LA_{g,t}$ are respectively consumption of goods and leisure by an individual of age group *g* at time *t*; ρ is the pure rate of time preference; σ is the inverse of the inter-temporal elasticity of substitution; θ is the inverse of the intra-temporal elasticity of substitution between consumption and leisure and ϕ_g measures the relative weight of leisure activities in household preferences. Our specification of leisure follows Becker (1965) and Heckman (1976), and is meant to capture both the quantity of the time allocated and its quality: $LA_{g,t} = l_{g,t} h_{g,t}$, where $l_{g,t}$ is leisure time and $h_{g,t}$ the human capital accumulated by the individual at that date.

Human capital production is individualized, and its technology is assumed linear in h but strictly concave with respect to time devoted to education and training. The specification chosen is similar to that of Lucas (1988, 1990) and takes the following form:

$$(7) \qquad h_{g+1,t+1} = \left[\frac{1}{1+\delta_h} + \beta z_{g,t}^{\gamma} \right] h_{g,t}^{\psi} + Exp_{g,t} \qquad \beta > 0 \ , \ 0 < \gamma < 1 \ , \delta_h > 0, \ \psi > 0 \, ,$$

where $z_{g,t}$ is the fraction of time allocated to the production of human capital, $Exp_{g,t}$ an experience variable that exogenously evolves with age (with inverse-U shape), δ_h the human capital depreciation rate and β a production parameter. The parameters γ and ψ respectively measure the contribution of time allocated to education and human capital already acquired, to the production of human capital.[7]

Each household is endowed with one unit of time per period of life that is allocated between leisure ($l_{g,t}$), human capital production ($z_{g,t}$) and labour market participation ($Lpar_{g,t}$) so that:

$$(8) \qquad l_{g,t} + z_{g,t} + Lpar_{g,t} = 1$$

The representative household maximizes equation (7) subject to (8), (9) and to its assets accumulation constraint:

$$(9) \qquad \begin{aligned} & a_{g+1,t+1} + (1+\tau_t^c) C_{g,t} = \left(1 + r_t (1-\tau_t^k)\right) a_{g,t} + w_t h_{g,t} Lpar_{g,t} (1 - \tau_t^w - cr_t) + GIS_{g,t} \\ & + \left(OAS_{g,t} + Pens_{g,t} + Tr_{g,t}\right)(1-\tau_t^w) \end{aligned}$$

[7] The human capital function implies that physical capital plays no role. In our view, since the proportion of young adults is projected to continue declining over the next decades, we believe there is no accessibility issue with respect to education at the moment. We may in fact experience an excess supply of schooling facilities.

where $a_{g,t}$ represents total assets accumulated by g at time t, τ_t^c, τ_t^k and τ_t^w are the effective tax rates respectively on consumption, capital and labour incomes, and cr_t is the contribution rate to public pension. Government transfers in Canada take different forms: $GIS_{g,t}$ includes Guaranteed Income Supplement and Spouse's Allowance (SPA**),** $OAS_{g,t}$ is Old Age Security, $Pens_{g,t}$ represents Canada and Quebec Pension Plans' (CPP/QPP) benefits, and $Tr_{g,t}$ collects all other public transfers to households.[8] The CPP/QPP benefits are proportional to lifetime labour earnings:

(10) $$Pens_{gg,t} = PensR \sum_g w_t h_{g,t} Lpar_{g,t} \text{ , } g = 1 \text{ to } 12,\ gg = 13 \text{ to } 15.$$

where $PensR$ is the replacement rate assumed to remain unchanged.

5.4 The Government Sector

The national government taxes capital and labour incomes, as well as some transfers, together with private consumption expenditures. It spends on goods and services (e.g. health care, education), operates transfer payments to households, and pays interest on its debt. Public budget is balanced by issuing bonds. Formally, the government budget constraint writes as:

(11) $$\begin{aligned} &Bond_{t+1} - Bond_t + \sum_g Pop_{g,t}\left[\tau_t^k r_t a_{g,t} + \tau_t^w \left(w_t h_{g,t} Lpar_{g,t} + Tr_{g,t} + OAS_{g,t}\right) + \tau_t^c C_{g,t}\right] \\ &= Gov_t + \sum_g Pop_{g,t}\left[Tr_{g,t} + OAS_{g,t} + GIS_{g,t}\right] + r_t Bond_t \end{aligned}$$

CPP/QPP pension plans are separated from public budget and assumed to be self-financed at every period by workers' contributions at endogenous rate cr_t:

(12) $$\sum_{gg} (Pop_{gg,t} Pens_{gg,t}) = cr_t \sum_g Pop_{g,t} w_t h_{g,t} Lpar_{g,t} \text{ , } g = 1 \text{ to } 12,\ gg = 13 \text{ to } 15.$$

[8] *Tr, OAS and GIS* in the model are calibrated as a proportion of GDP.

where the left-hand side is pension benefits to be paid and the right-hand side is workers' contributions (the system therefore is pay-as-you-go).

5.5 Equilibrium Conditions

Market equilibrium for goods requires that:

$$(13) \quad Y_t = \sum_g Pop_{g,t} C_{g,t} + Inv_t + Gov_t \,.$$

Effective labour supplied is the amount of time worked by each generation multiplied by its specific quality index, summed over all generations; full employment requires that:

$$(14) \quad L_t = \sum_g Pop_{g,t} h_g Lpar_g \,, \ \text{g = 1 to 13.}$$ [9]

Bonds and physical capital being perfect substitutes, total asset accumulation by households should satisfy:

$$(15) \quad \sum_g Pop_{g,t} a_{g,t} = K_t + Bond_t$$

which completes the model.

6. Calibration Procedure and Parameters

Since the simulation results depend greatly on the parameter values of the behavioural functions, the calibration procedure is an important and delicate task. The CGE model must first generate an initial equilibrium in a dynamic framework, to replicate the stylised facts present in the data. The initial equilibrium is in fact a steady state that repeats every period with a population structure assumed to remain unchanged. A demographic shift is then imposed to the steady state to capture the composition of the population in 2002 and the demographic projection up to 2046. Since the population composition of 2002 is the result of changes in the birth rate and life expectancy that occurred in the past, it is necessary to begin

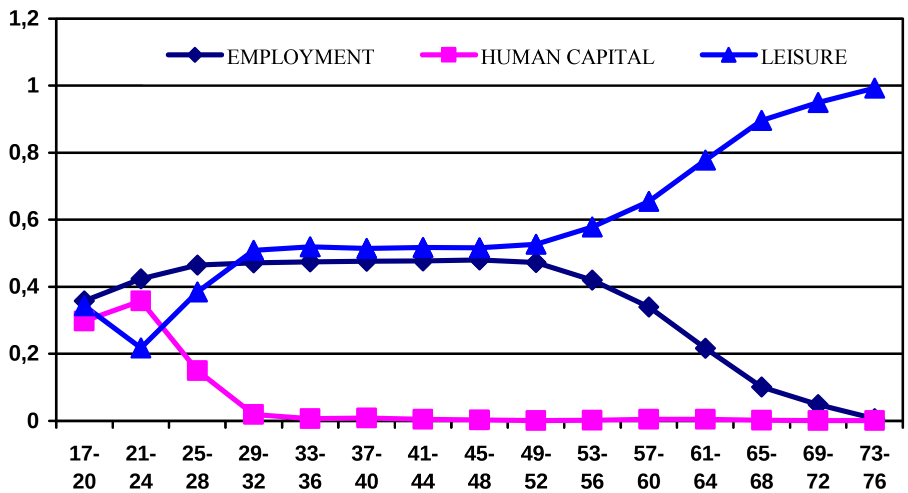
[9] Please note that although the model assumes that the representative agent receives public pension benefits at the age of 65 (g = 13 to 15), they can work until the age of 69 (g = 1 to 13).

the demographic shock in 1946. Changes in the birth rate are used to calibrate the old-age dependency ratio observed and projected up to 2046. After 2046, we assume that the birth rate gradually returns to its natural replacement level.

6.1 Time Allocation

Chart 5 presents the distribution of time allocation by age group in the initial steady state. Data on time allocated to employment is derived from HRSDC-PRCD labour force participation rate model, while time allocated to human capital is derived from the 1998 General Social Survey (GSS) on Time Use from Statistics Canada. The GSS is also used to calibrate the parameters of the human capital function so that the aggregate stock of human capital is consistent with Laroche, Mérette and Lan (2005).

Chart 5
Time Allocation in the Initial Steady State



As shown in Chart 5, when young, individuals 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 leisure. Time allocated to education falls at age 25-28, accounting for 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 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.

6.2 Behavioural Parameters

Table 3 reports key behavioural and government program parameter values. The value of the inter-temporal elasticity of substitution is 1.0 and the value of the intra-temporal elasticity of substitution between consumption and leisure is 0.8. These values are similar to those used by Auerbach and Kotlikoff (1987), Perroni (1995), Altig *et al.* (1997), Kotlikoff *et al.* (1999) and Baylor (2005). The CPP/QPP pension replacement rate is 0.3. The elasticity of human capital technology is set equal to 0.7 and is taken from Heckman (1975), Perroni (1995) and Fougère and Mérette (1999, 2000). Also, Heckman *et al.* (1998), who provide an empirical estimate of the parameter values for the United States, found a value of 0.9[10].

Table 3
Behavioural and Government Program Parameters

Inter-temporal elasticity of substitution	1.0
Intra-temporal elasticity of substitution	0.8
Ratio of CPP/QPP pension replacement rate	0.3
Elasticity of human capital technology	0.7
Elast. of human capital already acquired to the production of human capital	1.0
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

7. 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

[10] However, Heckman *et al.* (1998) also found an elasticity of human capital already acquired to the production of human capital to be significantly less than 1 at 0.9. Therefore, they find that γ and ψ would sum to 1.8, a slightly higher value than 1.7, the sum of both parameters in this paper.

(see Table 4). Chart 6 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.

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 6). 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.

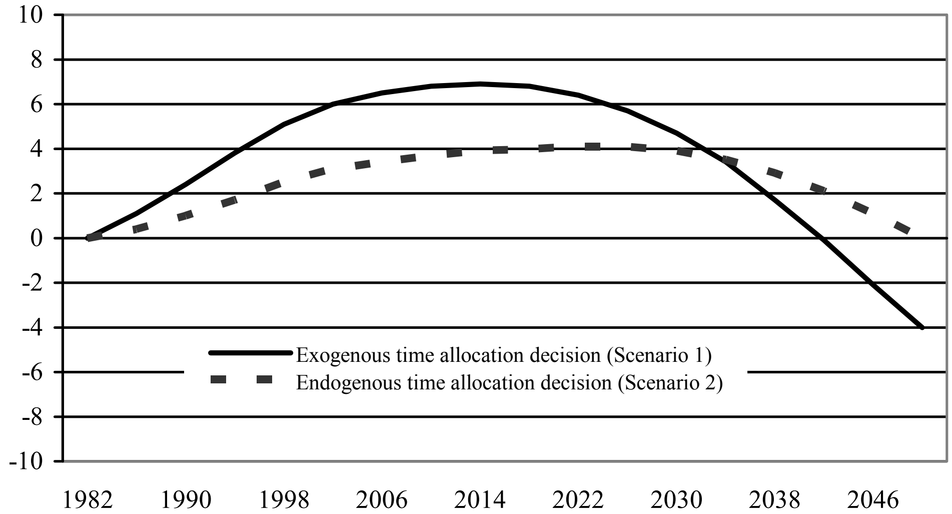
Table 4
Impact of Population Ageing on Key Macroeconomic Indicators under Exogenous and Endogenous Time Allocation Decisions

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.

Chart 6
Impact of Population Ageing on Real GDP per Capita
Endogenous vs. Exogenous Time Allocation Decision Scenarios



Since the labour supply increase is more moderate initially in Scenario 2, the overall impact on national savings is more negative than in Scenario 1 until 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 7 provides an overview of the dynamic change in labour supply behaviour by cohort during the working life. For illustrative purposes, we examine 5 cohorts who enter the labour market in 1974, 1986, 1998, 2010 and 2018, respectively. As is shown, for cohort 1974, time allocated to work rises steadily from age 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 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 8 presents the evolution of time allocated to education between 1978 and 2050 for 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 7
Impact of Population Ageing on Time Allocated to Work by Cohort

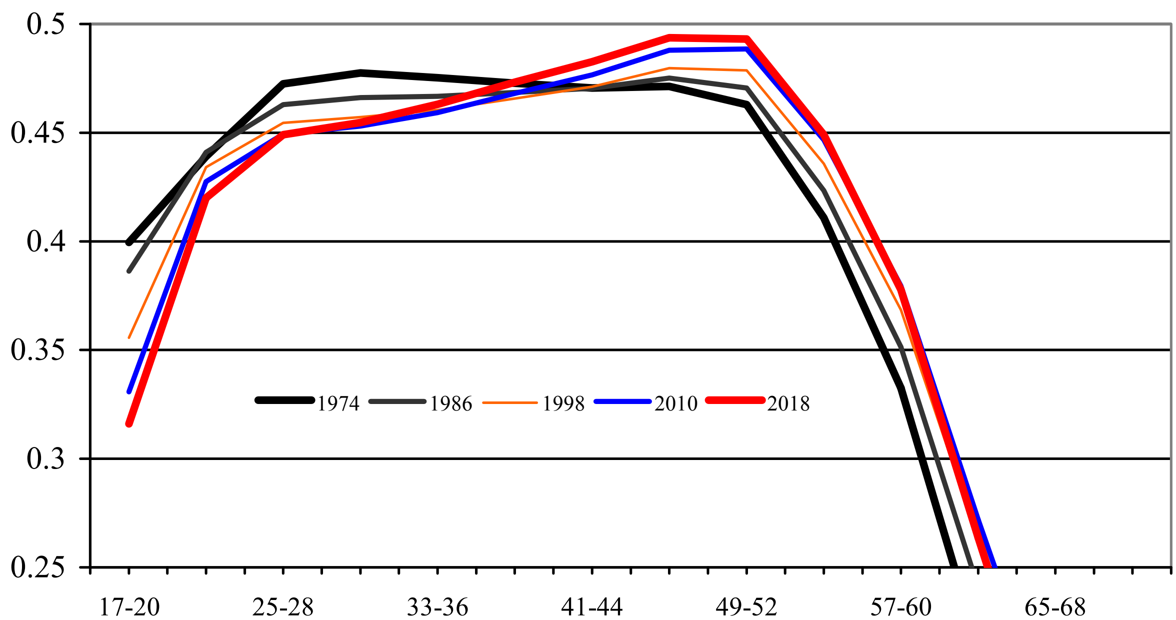
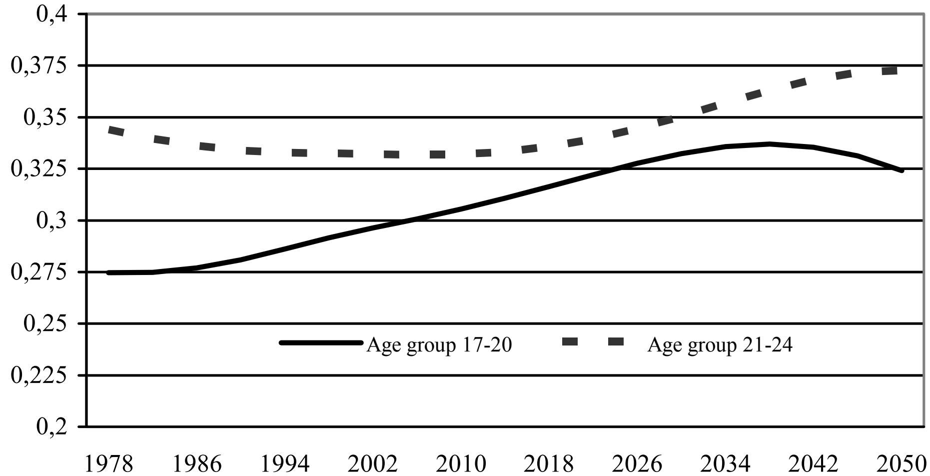


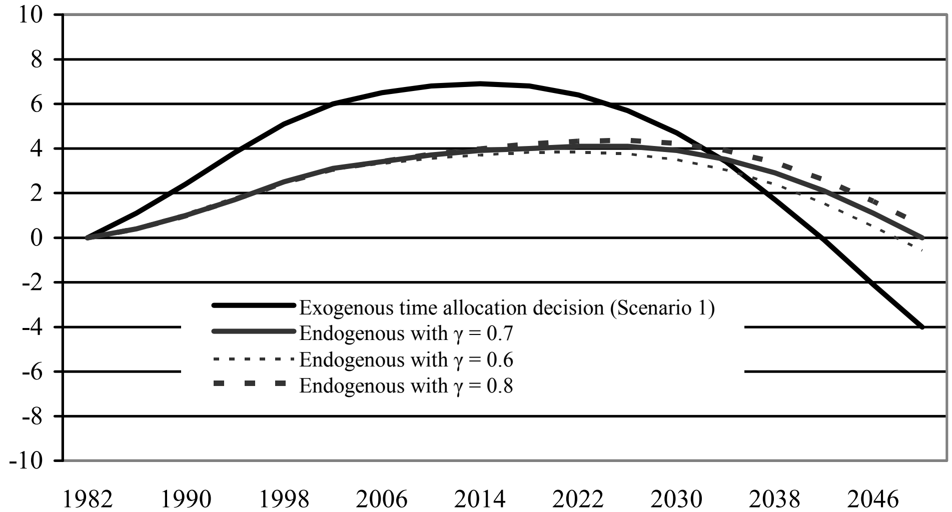
Chart 8
Time allocated to Education for Age Groups 17-20 and 21-24



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.

Finally, to test the robustness of our results, we provide sensitivity analyses with alternative parameter values for the elasticity of human capital technology, the intra-temporal and inter-temporal elasticity of substitution. More specifically, the impact of the demographic shock is simulated again with these parameter values modified by ± 0.1. Charts 9.1 to 9.3 provide the impact of the shock on real GDP per capita under these alternative parameter values.

Chart 9.1
Impact of Population Ageing on Real GDP per Capita
Under Alternative Elasticity of Human Capital Technology



As can be seen in Chart 9.1, until 2018, a 0.1 point difference in the elasticity of human capital production has a marginal impact on real GDP per capita. After 2018, the difference gradually increases. A higher (smaller) elasticity of human capital production shows a higher (lower) real GDP per capita in the long run. The real GDP per capita difference ranges from ±0.15 percentage points in 2018 to ±0.5 percentage points in 2050. Accordingly, as indicated in Chart 9.2, a lower (higher) inter-temporal elasticity of substitution generates a higher (lower) real GDP per capita, although the difference is rather small until 2014. The real GDP per capita difference reaches ±0.45 percentage points in 2050. Finally, a change in the intra-temporal elasticity of substitution has a marginal impact on the results (see Chart 9.3). The real GDP per capita difference ranges from ±0.1 percentage points in 2022 to ±0.2 percentage points in 2050.

Chart 9.2
Impact of Population Ageing on Real GDP per Capita
Under Alternative Inter-temporal Elasticity of Substitution

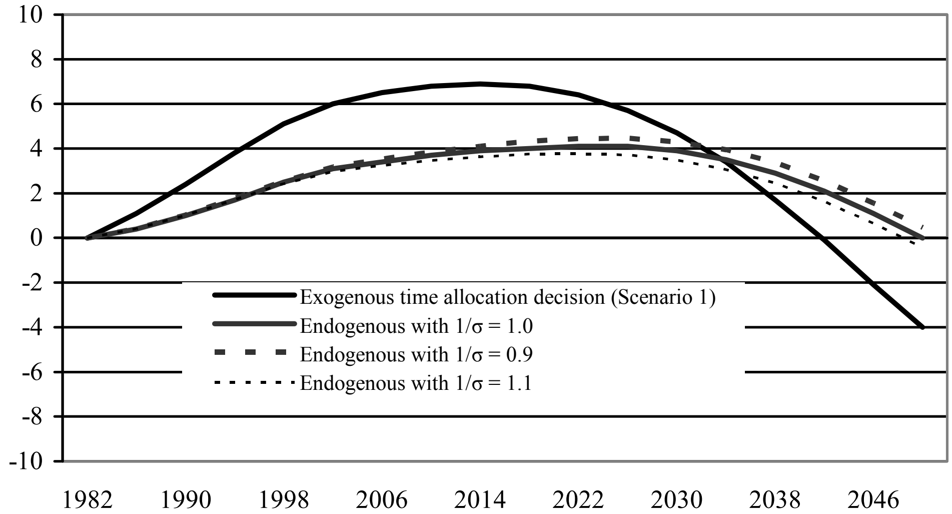
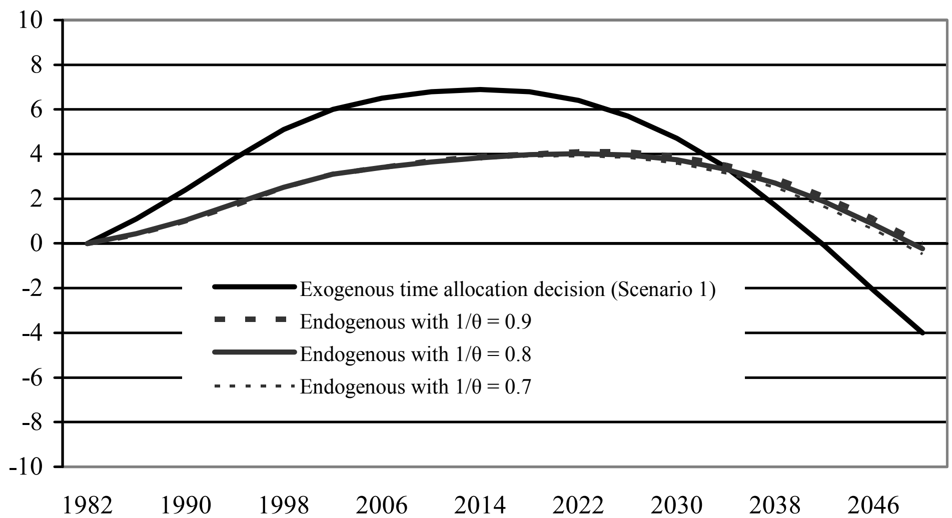


Chart 9.3
Impact of Population Ageing on Real GDP per Capita
Under Alternative Intra-temporal Elasticity of Substitution



8. Conclusion and Policy Implications

In this paper, we have explored the transitional and long-term impact of population ageing on labour supply and human capital investment in Canada. More specifically, we have examined to what extent the demographic shock observed since the 1960s and 1970s can explain the behaviour of labour supply and human capital investment during the 1980s and 1990s. We have also evaluated the long-term impact of more educated cohorts of workers on productive capacity. The analysis is made using a dynamic CGE overlapping generations model.

Our results provide an explanation to the significant rise in the level of education over the past 25 years. Beginning in the 1980s and 1990s, population ageing induces new incentives for young individuals with rational expectations to invest more in education at young age and supply better skilled labour later during their life.

Secondly, 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 from 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. Hence, accumulation of human capital is a powerful smoothing mechanism: neglecting this is bound to lead to substantial overestimation of the economic costs of ageing.

Thirdly, 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.[11] 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.

It is important to stress that all this is conditional on agents being rational and endowed with perfect foresight. There is a risk that young individuals are less rational and/or more myopic then assumed here, so that they could underestimate future earnings, assuming them to remain close to those of current older workers. The government has here an important role to play, in order 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

[11] 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.

make the right choice, the economic cost of population ageing could be modest. If not, the cost will be much greater and lead to much slower growth in living standards for future generations.

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