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Preliminary draft

Public Expenditures on Education, Human Capital and Growth in Canada: An OLG Model Analysis

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Abstract

This paper uses a computable overlapping-generations model (OLG) to investigate the dynamic effects of public investment in human capital in the Canadian context of population ageing. The decisions of time allocation between learning, working and leisure activity are endogenously determined in the model and react differently to tax policy changes. Learning time and public expenditures on education both improve human capital accumulation and effective labour supply. The simulation results indicate that a tax-financed increase in public spending on education may have significant crowding-out effects in the short run. In the long run, however, higher education incentives may increase the rate of human capital accumulation which in turn could mitigate the negative effects of population ageing. Furthermore, economic and welfare effects analysis shows that the impact depends on the distortions implied by alternative tax instruments and the productivity of public expenditures on education.

JEL Classification: C13, D58, J22, J24, O51
Keywords: Public expenditure, education, human capital, general equilibrium model, overlapping generations, Canada.

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1. Introduction

Since the emergence of the new growth theory in the 1980s, investments in education and human capital accumulation have been identified as a key determinant of long-run growth. In Canada, in addition to provincial investments in education, the federal government has been playing an important role in fostering post-secondary education (PSE). However, from 1995 to 2002, Canada's share of gross domestic product (GDP) being devoted to education has declined by more than one percentage point. This decline is attributable to a retrenchment of government expenditures, which has more than offset a rising contribution from the private sector. Recent empirical studies suggest that countries not too far away from the technological frontier should invest primarily in higher education in order to enhance productivity and economic growth.

In this context, the present study aims to assess the long-run effects of tax-financed increases in the consolidated government expenditures on PSE.[1] It uses a life-cycle overlapping-generations model – which takes into account future demographic changes – where learning time and investment in formal education both improve human capital formation and effective labour supply.

The simulation results indicate that tax-financed increases in public spending on education may have significant crowding-out effects in the short run. In the long run, however, higher education incentives – through lower costs and improved education quality – may increase the rate of human capital accumulation which in turn could mitigate the negative impact of population ageing in terms of per capita income. Furthermore, economic and welfare effects analysis shows that the impact depends on the distortions implied by alternative tax instruments and the productivity of public expenditures on education.

[1] We assume that the budget equilibrium is maintained over the whole simulation horizon through endogenous changes in the level of taxes or other expenditures.

The remainder of this paper proceeds as follows. The second section presents an overview of the issue of public funding of higher education in Canada. The third section reviews briefly the literature on dynamic general equilibrium studies analysing the impact of tax policy, and presents the characteristics of the model used in this research. The simulation scenarios and the results are discussed in section four. The last section concludes.

2. Overview of the Issues

According to the OECD (Education at a Glance, 2006), for the year 2004, 84% of Canadian adults aged 25 to 64 have attained at least upper secondary education. This proportion is greater than the OECD countries' average (67 %) but less than in the U.S. where this proportion is about 88%. When it comes to the percentage of population that has attained a tertiary education, Canada has the highest level among OECD countries, where 45% of adults aged 25 to 64 hold a tertiary degree. This high level is mainly due to a higher participation in vocational education (22%) with respect to OECD countries.

Canada's federal and provincial governments both play a key role in fostering education through transfer payments, research funding and student financial assistance. However, we note from Table 1 that Canada's share of GDP being devoted to education has been decreasing over the last decade and has been below that of the U.S. in 2001 and 2002. In addition, there has been a shift away from reliance on public funding of education in Canada. Since 1995, the contribution of the private sector has doubled, to reach 22% in 2002. The larger contribution from the private sector is partly explained by higher tuition fees. Between 1994 and 2005, the average tuition fee increased from $2,535 to $3,863 across Canada.[2] On the contrary, total expenditures on education, as a percentage of GDP, in the U.S. have remained fairly steady over time, and from 1995 to 2002 the contribution from the public sector has increased by 0.3 percentage points.

[2] The figures are for undergraduate tuition fees according to the Report of the Pan-Canadian Education Indicators Program, Statistics Canada, 2005.

Table 1. Contributions of the public and private sectors to education – Canada and the U.S. (percent of GDP)

		1995	1998	1999	2000	2001	2002
Canada	Public*	6.2	5.5	5.3	5.1	4.9	4.6
	Private**	0.8	0.7	1.3	1.2	1.3	1.3
	Total	7.0	6.2	6.6	6.4	6.1	5.9
United States	Public	5.0	4.8	4.9	4.8	5.1	5.3
	Private	2.2	1.6	1.6	2.2	2.3	1.9
	Total	7.2	6.4	6.5	7.0	7.3	7.2

Source: Education at a Glance 1998-2005, OECD.
* Including public subsidies to households attributable for educational institutions, as well as direct expenditure on educational institutions from international sources.
** Net of public subsidies attributable for educational institutions.

Furthermore, although Canada has the highest post-secondary attainment rate among OECD countries, it has lower proportions of Masters' and PhD graduates relative to its main trade partner, the U.S.[3] Recent empirical studies suggest that countries not too far away from the technological frontier, should invest primarily in higher education in order to enhance innovation, productivity and economic growth (Sapir et al. 2004 and Aghion et al. 2005 and Vandenbussche et al. 2006).[4]

For instance, using U.S. data, Aghion et al. (2005) suggest that investment in 'high brow' education is more growth enhancing for states that are close to the technological frontier and 'low brow' education has more beneficial effect on growth in states that are far from the frontier.[5] Besides, even if two states have the same total stock and the same distance from the technological frontier, their different human capital composition (primary, secondary, tertiary) will result in different growth rates. In the same vein, using a sample of 19 OECD countries, Vandenbussche et al. (2006) argue that skilled human capital, which is useful for innovating, has a stronger effect on economic growth as countries get closer to the technological frontier.[6]

[3] See Canadian Council on Learning (2006).
[4] Previous empirical studies of OECD countries suggesting that education and human capital have a positive impact on growth include, among others, Mankiw et al. (1992), de la Fuente and Doménech (2000, 2001), Bassanini and Scarpetta (2001a, 2001b). For a literature survey see Temple (2000).
[5] The measure of proximity to the frontier is based on personal income per worker. Thus, the state with the maximum labour productivity is considered as the technical frontier.
[6] The proximity to the technological frontier is measured by the ratio of a country's total factor productivity (TFP) to the technological frontier, in this case, the TFP in the U.S.

On the other hand, Bowlus and Robinson (2004) estimate the relative contributions of PSE to human capital stocks in Canada and the U.S. for the period 1975 to 2000. Their results suggest that due to the larger fraction of university educated in the U.S., U.S. post-secondary schooling may add substantially more efficiency units of human capital to those making the investment than it occurs in Canada. The authors claim that growing differences in the university sector may have played an important role in explaining the widening gap in living standards between the two countries since the 1990s.

In most countries, government plays an important role in human capital formation by providing funds for formal schooling and research. The existence of social benefits of education that are not captured by private agents supports the role for government education policy. Moreover, the empirical evidence supporting the hypothesis that investments in higher education and skills are more growth-enhancing strengthens the case for additional public expenditures on education. But expanding public investment in human capital and skills raises the question of funding sources such as taxes or changes in the composition of public spending. To address this issue, we use a computable general equilibrium (CGE) model in order to assess the dynamic effects of tax-financed increases in public expenditures on PSE in the Canadian context of population ageing. Particularly, we examine to what extent the benefits from higher education incentives could offset the distortionary effects of taxation.

3. Methodology

Since the emergence of the new growth theory in the 1980s, investments in education and human capital accumulation have been identified as a key determinant of long-run growth (Lucas, 1988). Based on the pioneering general equilibrium models developed by Auerbach et al. (1983) and Auerbach and Kotlikoff (1987), a life-cycle overlapping-generations model with endogenous human capital accumulation is deemed as an appropriate tool to examine how public policy could affect economic growth through the channel of human capital formation. The rationale supporting this assertion is that human

capital-related public policies could affect households' decision with respect to learning effort and work, which may have an impact on a country's welfare and economic growth. A representative paper in this field is Davies and Whalley (1989). The authors suggest that different types of tax distortions could have opposite effects on economic growth if human capital is explicitly incorporated into an OLG framework.

Following Davies and Whalley (1989), there has been an extensive research focusing on the impact of different tax instruments on human capital formation and growth.[7] On the other hand, a number of studies have formalized the link between government education spending and growth by building growth models where public education expenditures directly influence human capital accumulation. However, few of them used an applied OLG model to examine the potential growth and welfare effects of increasing public education expenditure. Examples of studies include the seminal work of Glomm and Ravikumar (1992). The authors study the influence of public and private financing of education on long-run growth and inequality. Using an endogenous growth model with heterogeneous agents, the results suggest that public education reduces income inequality more quickly than private education. However, per capita income is greater with more private funding of education unless the initial income inequality is sufficiently large.

More recently, Blankenau et al. (2004) analyse the growth effects of public education expenditure under various tax policies and draw the conclusion that different public policy regimes may have non-monotonic effect on human capital accumulation and economic growth. With non-distortionary taxes, economic growth is enhanced by a moderate level of increase in public education spending. However, a large increment to education expenditure may reduce growth because of the crowding-out effect on both physical and human capital accumulation. Under a consumption tax framework, growth

[7] Studies on the impact of alternative tax instruments on human capital accumulation and economic growth include Trostel (1993), Perroni (1995), Mérette (1997) and Lau (2000). Heckman et al. (1998a) and Taber (2002) focus on the effects of the progressivity of income taxation on educational attainment. They suggest that, for the U.S. case, progressive labour income taxes, in combination with a proportional capital income tax, have a large short-run but a small long-run negative effect on human capital accumulation.

is increasing with public education expenditures. Nevertheless, if government revenue comes from income tax on labour and capital, the growth effect of public education expenditure is ambiguous.[8]

Using an endogenous growth OLG model, Voyvoda and Yeldan (2005) examine the macroeconomic effects of the International Monetary Fund (IMF) austerity programme and taxation alternatives to finance increased public expenditure on education. Their results show that allocating more funds for human capital accumulation through wealth income taxation generates superior outcomes in terms of growth rate and welfare gains compared with financing through wage income taxation.

Furthermore, as population ageing becomes a challenging issue for many industrial countries, many recent studies also incorporate population ageing into an OLG model with endogenous human capital.[9] In this paper we contribute to this literature by analysing the effects of an increase in public education expenditure in Canada, using an OLG model with endogenous human capital and population ageing. The next section presents the structure of the general equilibrium model used for this purpose.

3.1 Overlapping Generations Model

The analysis uses a life-cycle OLG model of a small closed economy. The economy is populated by rational households earning their income by providing their human capital to the production sector and by receiving interest on accumulated assets and transfers. The production sector hires effective labour and rents capital up to their marginal product to produce and sell a single good. The public sector is represented by a

[8] Blankenau et al. (2006) also suggest that the increase in public expenditure on education enhances growth as long as a government chooses the proper financing sources.

[9] Docquier and Michel (1999) show that in many industrial countries an optimal public policy could be to increase government education expenditure when the baby-boom generation is still in the labour market. Fougère et al. (2006) use an endogenous time allocation model to examine the impact of population ageing in Canada. Their results indicate that young generations anticipate future increases in wages and tend to invest more in human capital which may lower the cost of population ageing.

national government which levies taxes on consumption and on factors of production and issues one-period bonds to finance its spending.

Human Capital Accumulation

The dynamic general equilibrium OLG model used in this paper draws on Fougère et al. (2006) with an extension of the learning technology to account for productive public expenditures on education. The specification of human capital accumulation is similar to that adopted by Glomm and Ravikumar (1992, 1997). In what follows, the subscript *t* stands for time period and the subscript *g* stands for the age group. Human capital evolves according to

$$h_{g+1,t+1} = \frac{h_{g,t}}{1+\delta_h} + \beta \cdot h_{g,t} \cdot z_{g,t}^{\gamma} \cdot GE_{g,t}^{\mu} \quad , \delta > 0;\ \beta > 0;\ 0 < \gamma < 1;\ 0 < \mu < 1 \tag{1}$$

δ_h is the human capital depreciation rate; γ represents the elasticity of human capital with respect to the education effort and β is a scale parameter reflecting the efficiency of the education system. The human capital production technology is linear with respect to $h_{g,t}$ but strictly concave with respect to the fraction of time allocated to the schooling activity $z_{g,t}$ and to the expenditures on education $GE_{g,t}$.[10] Investments in education may be considered as a quality indicator of the education system. The assumption that education input is an argument of the production function of human capital is in line with the empirical evidence that supports a positive correlation between public education expenditure, human capital formation and growth in developed countries (Blankenau et al. 2006).

Household Behaviour

The dynamics of the population are represented by 15 finitely-lived Canadian households structured in an Allais-Samuelson overlapping-generations setting. At any

[10] The distribution of public expenditures by age group is based on Fougère and Mérette (2000).

period of time a new generation enters the workforce at the age of 17, retires at the age of 65 and lives until the age of 76. Each period of the model corresponds to 4 years. The population growth rate is exogenous.

In each period the representative individual is endowed with one unit of time which can be allocated towards learning $(z_{g,t})$, working $(LS_{g,t})$, or to leisure activity $(\ell_{g,t})$. Time allocated to education corresponds to human capital investment effort.

$$z_{g,t} + LS_{g,t} + \ell_{g,t} = 1 \tag{2}$$

The household preferences are represented by an isoelastic time-separable utility function similar to that in Auerbach and Kolikoff (1987) which takes the following form:

$$U_t = \sum_{g=1}^{15} \left(\frac{1}{1+\rho} \right)^{g-1} \frac{u\left[C_{g,t+g-1}, \ell_{g,t+g-1} \right]^{1-\sigma}}{1-\sigma} \tag{3}$$

where $C_{g,t}$ is consumption of an individual of age group g at time t. ρ and σ are respectively the pure rate of time preference and the inverse of the inter-temporal elasticity of substitution. The instantaneous preferences are represented by a constant elasticity of substitution (CES) utility function:

$$u\left[c_{g,t}, \ell_{g,t} \right] = \left[C_{g,t}^{1-\theta} + \phi_g \ell_{g,t}^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{4}$$

θ is the inverse of the intra-temporal elasticity of substitution between consumption and leisure, and ϕ_g is the leisure preference parameter.

The accumulation of assets by the representative agent is a function of savings and evolves according to:

$$\begin{aligned} FA_{g+1,t+1} - FA_{g,t} = {} & r_t FA_{g,t} \cdot (1-\tau_t^k) \\ & + (1-\tau_t^w - cr_t) \cdot w_t h_{g,t} LS_{g,t} + (1-\tau_t^w) \cdot \left(Tr_{g,t} + Pens_{g,t} + OAS_{g,t} \right) + GIS_{g,t} \\ & - (1+\tau_t^c) \cdot C_{g,t} \end{aligned} \tag{5}$$

where $FA_{g,t}$ denotes the financial assets accumulated by generation g at time t, cr_t the public pension contribution rate and r_t the interest rate. τ_t^w, τ_t^k and τ_t^c represent respectively the effective tax rates on labour income, capital income and consumption expenditures. Tr represents government transfers excluding public pensions, OAS is Old Age Security, GIS includes Guaranteed Income Supplement and Spouse's Allowance (SPA**)**. $Pens$ is Canada and Quebec Pension Plans' (CPP/QPP) benefits. CPP/QPP benefits are a fraction of lifetime labour earnings, which is determined by the pension replacement rate $PensR$:

$$Pens_{g,t} = PensR \cdot \sum_g w_t h_{g,t} L_{g,t} \tag{6}$$

The optimization problem of the representative household is to maximize its inter-temporal utility (3) subject to the accumulation of human capital (1), to a lifetime budget constraint derived from Equation (5), and to the time constraint described by Equation (2) . Optimal consumption and leisure profiles are found by maximizing with respect to $C_{g,t}$ and $\ell_{g,t}$ and optimal investment in education is derived by maximising with respect to $z_{g,t}$ and $h_{g,t}$.

Producer Behaviour

The production sector is represented by a national firm which hires effective labour (L_t) and rents physical capital (K_t) to produce and sell a single good in a perfectly competitive market. Its production technology is represented by a Cobb-Douglas production function:

$$Q_t = A K_t^{\alpha} L_t^{1-\alpha} \tag{7}$$

where α is the share of capital in value added, and A a scale parameter. Since adjustment costs in investment are not taken into account, there is no inter-temporal optimisation problem for production and profit maximization requires the equality between marginal productivity and the rate of return of each factor of production:

$$r_t + \delta_k = \alpha A K_t^{\alpha-1} L_t^{1-\alpha} \tag{8}$$

$$w_t = (1-\alpha) A K_t^{\alpha} L_t^{-\alpha} \tag{9}$$

r_t, w_t and δ_k denote respectively the rate of return to capital, the wage rate and the depreciation rate of physical capital. In addition, labour demand is a composite factor of three skills levels (high, medium and low skilled-workers) represented by a constant elasticity of substitution (CES) function.[11] Consequently, the demand for labour per skill equals:

$$L_{s,t} = A_s \cdot \left(\frac{w_t}{w_{s,t}} \right)^{\varepsilon} \cdot L_t \tag{10}$$

where $L_{s,t}$ is the effective labour force by skill level s, $w_{s,t}$ the wage rate per skill level, A_s a scale parameter and ε the elasticity of substitution between skill levels of labour. Given Equation (10), the wage rate per unit of effective labour w_t is a function of the wage rate per unit of effective labour of skill level *s*:

$$w_t = \left(A_s \sum_s w_{s,t}^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}} \tag{11}$$

In addition, without adjustment costs, future investments (Inv_t) are determined by foregone consumption and the evolution of physical capital stock, rented by the production sector, is described by the following law of motion:

$$K_{t+1} = (1-\delta_k) K_t + Inv_t \tag{12}$$

The Government Sector

The national government issues one-period bonds to finance its spending and the interest on public debt and to satisfy the budget constraint. It levies taxes on labour income, capital income, taxable transfers, and consumption expenditures. It spends on public expenditures GO_t, health care $GH_{g,t}$, education $GE_{g,t}$ and interest payments on

[11] In the rest of the presentation the subscript denoting skill level is omitted to ease notation.

public debt. It also provides transfers to residents through the presence of social transfers. The national government budget constraint is defined as:

$$\begin{aligned} GB_{t+1} - GB_t = {} & r_t GB_t \\ & + \sum_g Pop_{g,t}(Tr_{g,t} + OAS_{g,t} + GIS_{g,t}) + \sum_g (GH_{g,t} + GE_{g,t}) + GO_t \\ & - \sum_g \begin{Bmatrix} Pop_{g,t} \cdot \left[\tau_t^w \cdot (w_t h_{g,t} L_{g,t} + Tr_{g,t} + OAS_{g,t} + Pens_{g,t}) \right] \\ + \tau_t^c \cdot C_{g,t} + \tau_t^k \cdot r_t FA_{g,t} \end{Bmatrix} \end{aligned} \tag{13}$$

Equation (13) describes the variation of the stock of public debt $GB_{t+1} - GB_t$ which is equal to the government deficit. The three remaining expressions on the right-hand side are interest payments on the public debt, total transfer payments (Tr, OAS and GIS), which evolve with demographic changes, total expenditures on public services, and government revenues from taxes levied on labour income (plus taxable transfers), consumption and capital income.

We assume an intermediary entity for the CPP/QPP pension plans which is represented by the following equation:

$$\sum_{g=13}^{15} Pop_{g,t}\, Pens_{g,t} = cr_t \cdot \sum_{g=1}^{15} Pop_{g,t} w_t h_{g,t} L_{g,t} \tag{14}$$

The left-hand side is pension benefits to be paid to the retired generations (g =13-15) and the right-hand side is workers' contributions. Equation (14) represents a pay-as-you-go (PAYG) pension system where the contribution rate is endogenously determined to satisfy the budget constraint of the intermediary.

Market Equilibrium Conditions

The model assumes perfectly competitive markets and perfect foresight agents. The equilibrium condition for markets of goods states that total output must be equal to total demand:

$$Q_t = \sum_g (Pop_{g,t} C_{g,t}) + Inv_t + \sum_g (GH_{g,t} + GE_{g,t}) + GO_t \quad (15)$$

The stock of effective labour supply is the number of workers $Pop_{g,t}$ times their corresponding human capital stock and individual labour supply:

$$L_t = \sum_g (Pop_{g,t}\, h_g\, LS_g) \quad (16)$$

Bonds and physical capital ownerships are considered perfectly substitutes. Hence total supply of assets must equal total demand:

$$\sum_g Pop_{g,t}\, FA_{g,t} = K_t + GB_t \quad (17)$$

3.2 Calibration of the Model

Parameterization

The values for the behavioural parameters draw on various sources (Table 2). The value of the intra-temporal elasticity of substitution between consumption and leisure is based on Auerbach and et al. (1983) and Auerbach and Kotlikoff (1987). Regarding the inter-temporal elasticity of substitution, estimates for this parameter used in applied general equilibrium literature, lie between 0.1 and 1. We choose a value a value of 0.9 for the base run scenario. The elasticity of substitution between more and less skilled workers is taken from the estimates of Ciccone and Peri (2005).

The elasticity of time input in the human capital technology is similar to that used by Lau (2000), Fougère et al. (2006), and to the estimate of Heckman et al. (1998b). The base-run value for the elasticity of public spending input in human capital is based on the estimation of Blankenau et al. (2006). The simulation results are sensitive to the value of this elasticity, which reflects the efficiency of public expenditures on education. Thus, a lower value (0.12), reported in Glomm and Ravikumar (1998) as well as Card and Krueger (1992), is used in the sensitivity tests analysed below. Finally, the production parameters used in the model are standard in the literature.

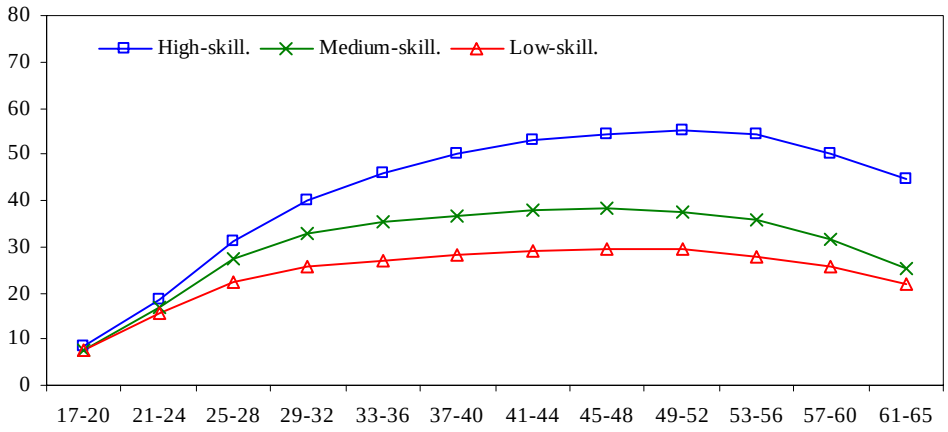
Table 2. Behavioural and public policy parameters

Parameter	Notation	Value
Consumer preferences		
Inter-temporal elasticity of substitution	$1/\sigma$	0.90
Intra-temporal elasticity of substitution	$1/\theta$	0.80
Production technology		
Production share of physical capital	α	0.30
Elasticity of substitution for labour demand	ε	1.50
Depreciation rate of physical capital	δ_k	0.05 (per year)
Interest rate	r	0.04 (per year)
Human capital technology		
Elasticity of time input	γ	0.70
Elasticity of public spending input	μ	0.18
Public policy		
Pension replacement rate	*PensR*	0.20
Government expenditures/GDP		0.37
Labour income tax rate	τ^w	0.31
Capital income tax rate	τ^k	0.38
Consumption tax rate	τ^c	0.10

Earning Profiles

The calibration of the life-cycle earnings profiles' in the initial steady state is based on information from the 2001 Census. Figure 1 presents the distribution of earnings by skill level (see Appendix) and by age. The earning profile for high-skilled workers is higher and 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. It peaks earlier and declines at age 49-52.

Figure 1. Earnings profiles by skill level (Thousands of CAD)

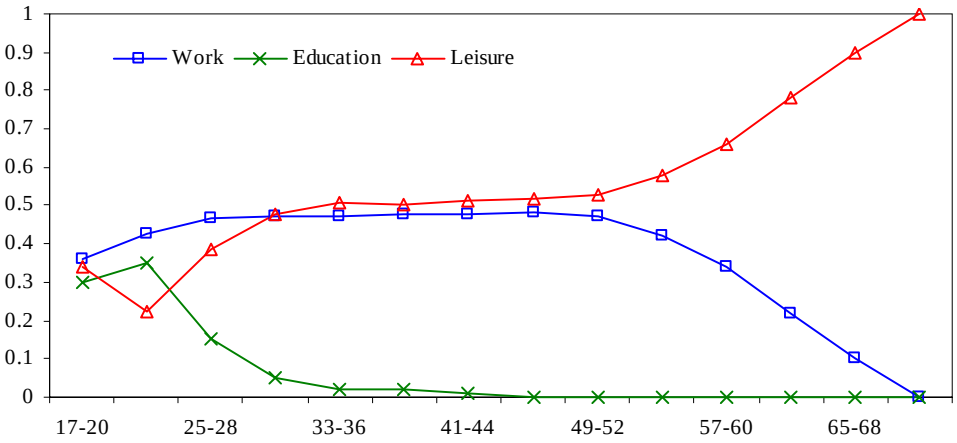


Time Allocation over the Life Cycle

Data on time allocated to employment is derived from HRSDC-PRCD labour force participation rate model, while time allocated to human capital formation is derived from the 1998 General Social Survey on Time Use.

Figure 2 presents the distribution of time allocation for the high-skilled workers by age group in the initial steady state. 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 lower leisure time. Time allocated to education falls at age 25-28, accounting for individuals who undertake Master's and Doctorate degrees and tends to zero thereafter. Time spent in employment gradually increases when young and stabilises at age group 29-32 until 49-52. After the age 49-52, the preference for leisure increases, while working time decreases until complete withdrawal from the labour market.

Figure 2. Time allocation of high-skilled workers



4. Analysis

4.1 Simulation Scenarios

In this section we perform different simulations, discuss their impact on time allocation over the life cycle and analyse their implications for the economic activity and welfare in the long run. Moreover, since the main objective of this study is to isolate the effects of the increase in public expenditures on education, the shock of population ageing is incorporated in the base run scenario as well as in the rest of the scenarios described herein.

In all the simulation scenarios, the increase in public education expenditure benefits equally all individuals belonging to age group 17-20 (g1), 21-24 (g2) and 25-28 (g3). The increase in public expenditures on education can be seen as an increase in student financial assistance or as a quality-enhancing measure such as an increase in faculty size or an improvement of the research infrastructure. In order to maintain the budget equilibrium as in the initial steady state, we assume that the increase in public education expenditure is financed through endogenous changes in taxes or in other expenditures. The following simulations are implemented from 2006 and onwards:

- **Scenario 1**: permanent increase by 1% of GDP in public education expenditure financed through a *Lump-sum tax*;
- **Scenario 2**: permanent increase by 1% of GDP in public education expenditure financed through *Personal income tax*;
- **Scenario 3**: permanent increase by 1% of GDP in public education expenditure financed through restrained *Other public expenditures* growth.

As mentioned previously, the model results are sensitive to the value of the elasticity of public expenditure input in the human capital production function (see Equation(1)). Hence we run another set of simulations with a lower value for this elasticity, which implies a lower productivity of public expenditures. Also, we perform the same set of simulations with a lower value for the intra-temporal elasticity of substitution between

consumption and leisure (0.6). This latter sensitivity test implies a reduced preference for leisure with respect to consumption.

4.2 Results

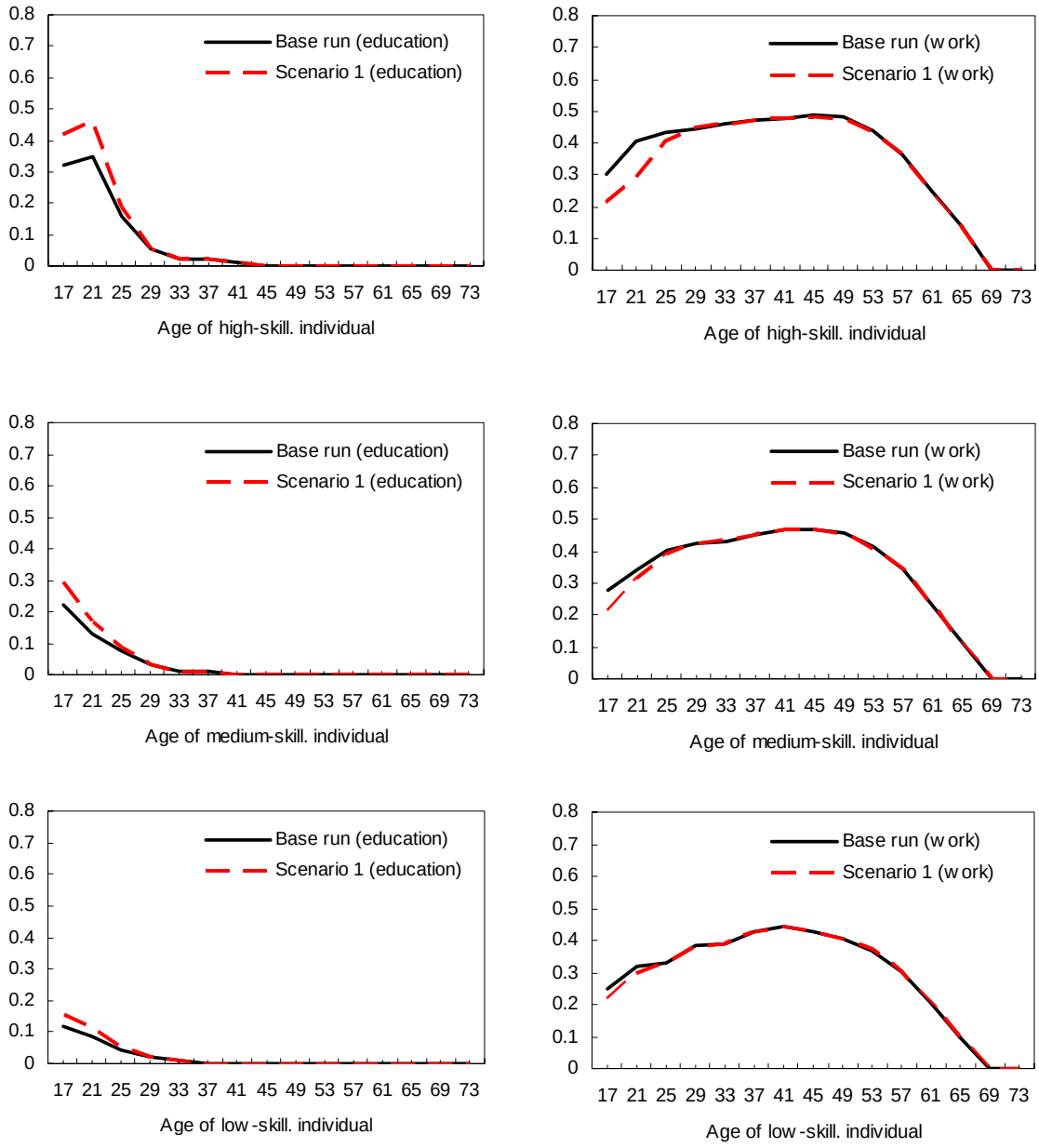
In static CGE models, counterfactual analysis is made with respect to the base run that is represented by the initial equilibrium, usually represented by a social accounting matrix. However, in dynamic models the analysis should be done with respect to the initial growth path. In our case both the initial and the counterfactual growth paths include the ageing shock.[12]

Before analysing the results we should mention that the optimal conditions obtained from the resolution of households problem imply that time allocated to education is an increasing function of future wages and public expenditures on education, and a decreasing function of the interest rate and the current wage rate, which represents the opportunity cost. On the other hand, leisure demand reacts negatively to future increases in the wage rate and positively to increases in interest rate. We pay attention to these elements in our policy analysis.

The results of all the simulation are described in Tables 3-6 and Figures 3-6. Table 3 presents the aggregate results and Table 4 the impact on the labour market. Tables 5 and 6 present the results of the sensitivity tests. In what follows the figures are in percent deviation from the base run. The short run corresponds to the year when the reform is implemented, 2006, and the long run corresponds to year 2102 when the model reaches a new steady state in which all the variables remain constant.

[12] For a detailed discussion of the impact of population ageing in Canada, see Fougère et al. (2006). According to the authors, population ageing will rise pressures on the labour market and reduce long-run GDP per capita.

Figure 3. Impact on time allocation over the life cycle by skill level (Cohort 2006)[13]



Source: Simulation results.
Note: The vertical axis represents total time endowment which is equal to one unit.

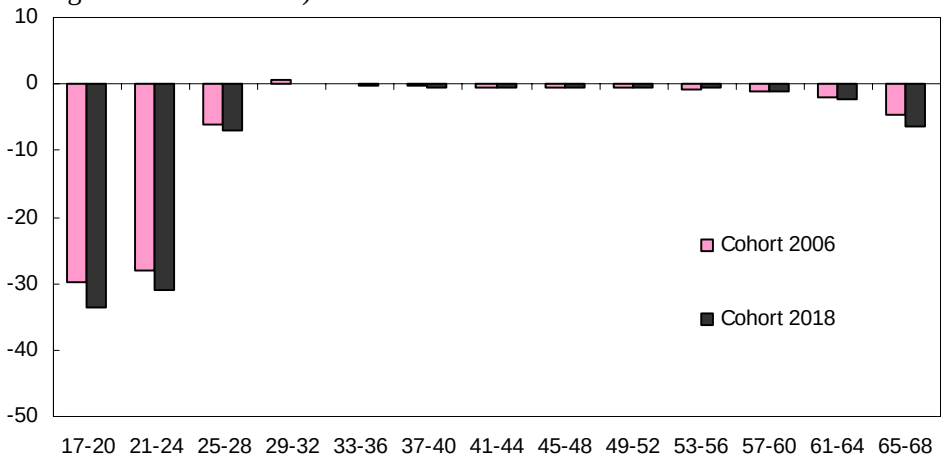
[13] Cohort 1998, 2002 and future cohorts react similarly to the reform. Previous cohorts, who entered the work force before 1998, do not benefit from the funds being devoted to education but have anticipated the raise in taxes and have increased their labour supply when younger (in the past) and will reduce it after the implementation of the shock. However, this is not very relevant for the current analysis.

The Lump-Sum Tax (Scenario 1)

In the present scenario, the lump-sum tax paid by each generation is proportional to its weight in total population. This implies the modification of the period-to-period budget constraints represented by Equation (5) and Equation (13).

Figure 3 indicates that the rise in public expenditures on education, which can be seen as higher education incentives, raises the amount of time allocated to education of all the individuals belonging to age group 17-20, 21-24 and 25-28 of the 2006 cohort. The stronger increase for the high-skilled individual of age 21-24 is explained by the fact that at this age initially individuals allocate more time to education. These changes should be regarded as an improved access to higher education – through lower costs or increased student financial assistance – at the national level.[14]

Figure 4. Scenario 1 – Time allocated to work by cohort of high-skilled individuals
(Percent change from the base run)



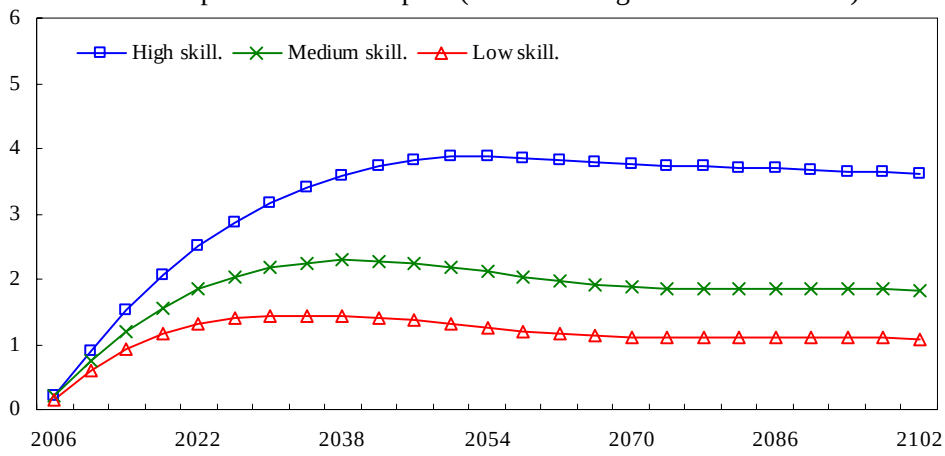
Source: Simulation results.
Note: Cohort 2006 enters the labour force at age 17 in 2006 and starts retirement at age 65 in 2054, and cohort 2018 starts retirement at age 65 in 2066.

[14] Note that rather than upgrading skill levels, the increase in time allocated to education improves the quality of the labour force and enhances effective labour supply.

Recall that in each period the individual is endowed with one unit of time which can be allocated towards working, learning or leisure activity. Consequently, we note that the participation in the labour market declines for all levels of qualification. Labour supply decreases sharply at young ages and the change is more pronounced for high-skilled individuals. Moreover, the life-cycle hump-shaped earning profile (Figure 1) also indicates that, at older ages, leisure is cheaper in terms of foregone earnings. Hence, we note from Figure 4 that labour supply of cohorts of high-skilled individuals decreases slightly at older age, translating into a slight increase in leisure demand. We also note that the shock is larger for future cohorts. This is explained by the stronger decline in wages in the long run (Table 3), which makes leisure cheaper for future generations and reduces further their labour supply. The pattern is almost the same for the medium and low-skilled individuals, but with a lower reduction in time allocated to work.

Overall, the reform leads to a rise in productivity of all levels of qualifications as they are all affected by the increase in public education expenditure. The increase in time spent on education will result in more human capital accumulation, especially for the high-skilled individuals who spend more time on education and expect higher earnings. As expected, we observe from Figure 5 that the largest increase in human capital, along the new steady-state path, is for the high-skilled workers (3.6 %).

Figure 5. Scenario 1 – Impact on human capital (Percent change from the base run)



Source: Simulation results.

At the aggregate level, labour supply decreases by 0.8% and 1%, in the short run and the long run respectively (Table 3). Equation (16) states that effective labour supply is equal to the number of workers (quantity) times their corresponding human capital stock (quality) and individual labour supply (intensity). The results in Table 3 suggest that the short-run negative impact on effective labour supply (-0.1%) is driven by two factors. First, the increase in time spent on education which is accompanied by a decline in labour activity. Second, the decrease in previous cohorts' participation in the labour market, as tax keeps on rising to maintain budget equilibrium. However, in the long run these two negative effects are offset by the rise in human capital stock over time, and we note that effective labour supply increases by 1.4%.

Table 3. Impact on key economic indicators (Percent change from the base run)

		Scenario 1	**Scenario 2**	**Scenario 3**
		Lump-sum tax	*Pers. income tax*	*Other pub. exp.*
GDP per capita	*SR*	0.1	-0.2	-0.4
	LR	1.0	0.1	0.4
Labour supply	*SR*	-0.8	-1.2	-1.0
	LR	-1.0	-1.6	-1.7
Effective labour supply	*SR*	-0.1	-0.8	-0.4
	LR	1.4	0.4	0.5
Investment	*SR*	-1.5	-2.6	-1.1
	LR	-0.1	-1.1	0.1
Physical capital intensity	*SR*	0.6	1.8	0.3
	LR	-1.2	-1.2	-0.3
Interest rate	*SR*	-0.1	-0.3	-0.1
	LR	0.2	0.2	0.1
Wage rate	*SR*	0.2	0.5	0.1
	LR	-0.4	-0.4	-0.1
Consumption	*SR*	-0.4	-0.6	-0.1
	LR	-0.4	-1.8	0.4
Aggregate welfare measure		*-0.36*	*-0.58*	*0.31*
*Leisure contribution**		*-0.09*	*0.13*	*0.19*

Source: Simulation results.
Note: SR and LR denote respectively the short run (2006) and the long run (2102).
* The difference between aggregate welfare and leisure contribution is equal to consumption contribution.

As mentioned before, without adjustment costs, investment is only determined by foregone consumption. Although, the lump-sum tax is regarded as a less distortionary way of raising taxes, the results suggest that it crowds-out investment in physical capital by reducing disposable savings in the economy. The negative impact on investment is

nonetheless less pronounced in the long run (-0.1%) than in the short run (-1.5%). To some extent, this is due to the stronger effective labour supply and higher labour income which mitigate the decrease in savings in the long run (see Table 4). In addition to demographic changes, the impact on production is determined by the changes in effective labour supply and investment in physical capital. The results show that the reform has positive impacts on GDP per capita, which registers a rise by 1% in the long run.[15]

As previously-mentioned, leisure demand reacts negatively to future increases in the wage rate and positively to increases in the interest rate. In the long run, the excess supply of labour reduces the wage rate (-0.4%), and the drop in the physical capital intensity rises the interest rate (0.2%). These two effects explain mainly the slight increase in leisure time and the decrease in time allocated to work particularly for older generations (see Figure 4).

On the other hand, because of the lump-sum tax, consumption of goods and services decreases in both the short and long runs. This is consistent with the impact on aggregate welfare (Table 3).[16] Given an initial utility level, the aggregate welfare change – for all the generations over the whole simulation horizon – measures the amount of transfers required for the individual to attain the same level of satisfaction after the implementation of the reform. The welfare measure has two components. The consumption of goods and leisure activity (Equation (3)). A negative value indicates that the households are worse off. Conversely, a positive value indicates that the households are better off. The negative impact on aggregate welfare (-0.36%) may be explained by the fact that potential impact of higher human capital accumulation on the economic growth rate is not considered.[17]

[15] The short-run positive impact on GDP per capita may seem surprising at first sight; however, this is partly due to a jump up of capital stock in the short run before decreasing afterwards. This is in line with the perfect foresight assumption: agents react before the implementation of the shock.

[16] Ho and Jorgenson (1999) show that as the U.S. population becomes older, higher government spending on education has negative impact on welfare. They suggest that the reform is welfare-enhancing on condition that this policy is accompanied by higher enrolment rate.

[17] This could be incorporated through a mechanism of knowledge transmission between generations in an endogenous growth framework. These developments are beyond the scope of this study, and are left for future research.

Besides, the consumption component of welfare measure is sensitive to taxation instruments and other ways of raising funds may also change the outcomes.

Table 4. Impact on the labour market (Percent change from the base run)

			Scenario 1 *Lump-sum tax*	**Scenario 2** *Pers. income tax*	**Scenario 3** *Other pub. exp.*
High skill.	Wage rate	*SR*	0.4	0.9	0.4
		LR	-1.2	-1.0	-0.7
	Effective labour supply	*SR*	-0.4	-1.3	-0.9
		LR	2.6	1.4	1.4
	Net labour income	*SR*	-0.2	-1.7	-0.6
		LR	1.0	-2.3	0.8
Medium skill.	Wage rate	*SR*	0.2	0.7	0.1
		LR	-0.3	-0.4	-0.1
	Effective labour supply	*SR*	-0.1	-1.0	-0.5
		LR	1.3	0.4	0.5
	Net labour income	*SR*	-0.1	-1.6	-0.5
		LR	0.7	-2.5	0.5
Low skill.	Wage rate	*SR*	0.0	0.6	0.1
		LR	-0.5	-0.1	0.2
	Effective labour supply	*SR*	0.1	-0.9	-0.4
		LR	1.5	0.0	0.1
	Net labour income	*SR*	0.0	-1.5	-0.5
		LR	0.8	-2.7	0.4

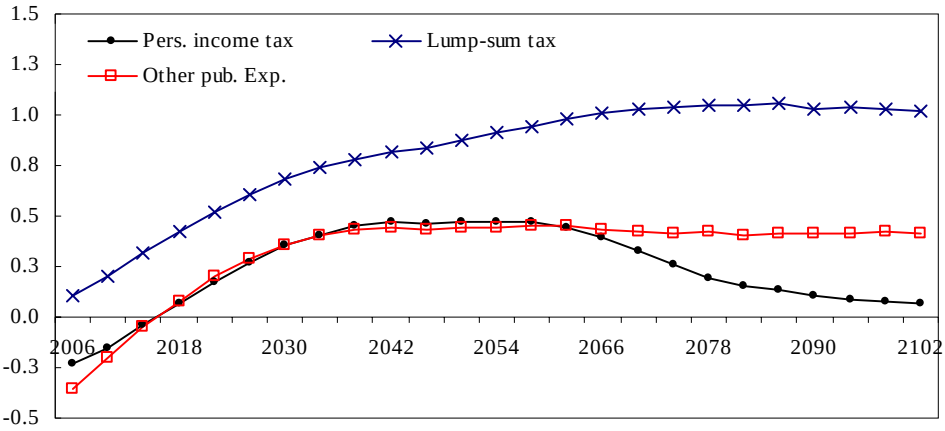
Source: Simulation results.
Notes: SR and LR denote respectively the short run (2006) and the long run (2102). The net labour income does not take into account the lump-sum tax.

Finally, the reform benefits all households, in terms of labour income, and the gains are larger for the high-skilled individuals who register, in the long run, the highest increase in their effective labour supply (2.6%) and net labour income (1%). Moreover, the gains in terms of labour income among low-skilled individuals are higher than among medium-skilled individuals (Table 4). This is due to a smaller fall in time allocated to work of low-skilled workers, as they devote less time to education.

The Personal Income Tax (Scenarios 2)

In this section we examine alternative ways of raising taxes to finance the increase in public expenditures on education and discuss the different results with respect to the main scenario analysed previously (Scenario 1). The comparison of the impact on GDP per capita of the various scenarios is depicted in Figure 6.

Figure 6. Impact on GDP per capita (Percent change from the base run)



Source: Simulation results.

The rise in personal income tax in Scenario 2 reduces the incentive to work by lowering the effective price of leisure and increasing its demand. Consequently, households' earned income falls leading to a reduction in disposable savings for new investments in physical capital. The results presented in Table 3 indicate that the participation in the labour market of all the generations decreases more in Scenario 2 than in Scenario 1. Therefore the long-run positive impact on effective labour supply is less pronounced in the Scenario 2 (0.4%) than in Scenario 1 (1.4%). As expected, the reduction in earned income (Table 4) and saving leads to a significant decline in investment in both the short and long runs. Hence, GDP per capita falls in the short run (-0.2%) and increases only by 0.1% in the long run. Furthermore, Table 3 shows that the long-run impacts on physical capital intensity, wages and the interest rate are roughly equal to those under the lump-sum tax, however the drop in consumption is larger, which

is explained not only by the decline in income, but also by the substitution towards leisure. As a result, welfare decreases more (-0.58%) than in Scenario 1 (-0.36%).

Restrained Growth in Expenditures (Scenario 3)

In Scenario 3, the additional investments in post-secondary education are funded through restrained growth in other public expenditures. Despite the fact that public expenditures are not internalised by agents, it seems interesting to examine the changes in the outcomes under this assumption. We note that the positive long-run effects, in terms of GDP per capita, are higher than those in Scenario 2. This is mainly due to a stronger increase in effective labour supply and to the positive impact on investment in the long run.

However, the long-run impacts on effective labour supply and GDP per capita are smaller than with the lump sum tax. This is the result of the positive impact on income (Table 3) and the increased preference for leisure which leads to a stronger decrease in labour supply. Moreover, contrary to previous scenarios, which involved income taxation, the change in the composition in public expenditures leads to a long-run increase in consumption (0.4%) as well as to an improvement in total welfare (0.31%). Lastly, Table 4 indicates that the gains in terms of net labour income are – again – increasing with the level of qualification.

Sensitivity Analysis

To test the robustness of the results, we run another set of simulations with a lower value for the elasticity of public expenditure input in the human capital production function, which implies a lower efficiency of public expenditures.[18] The results reported in Table 5 suggest that the outcomes are similar to those reported in Table 3, although less pronounced. GDP per capita increases less for all scenarios except for Scenario 2. In this latter scenario, the distortionary effect of personal income tax dominates the benefits

[18] In this case a recalibration procedure is implemented to the efficiency parameter in Equation (1) in order to maintain unchanged the stock of human capital and the earning profiles.

from higher human capital, resulting in a decline in GDP per capita in both the short and long runs. This confirms that we can not drain indefinitely resources from the economic productive sectors to fund expenditures.

Table 5. Impact on key economic indicators – lower elasticity of public spending input
(Percent change from the base run)

		Scenario 1	**Scenario 2**	**Scenario 3**
		Lump-sum tax	*Pers. income tax*	*Other pub. exp.*
GDP per capita	*SR*	0.2	-0.1	-0.2
	LR	0.9	-0.1	0.3
Labour supply	*SR*	-0.4	-0.8	-0.7
	LR	-0.3	-0.9	-1.1
Effective labour supply	*SR*	0.1	-0.6	-0.3
	LR	1.2	0.2	0.3
Investment	*SR*	-0.9	-2.0	-0.7
	LR	-0.2	-1.3	0.1
Physical capital intensity	*SR*	0.5	1.6	0.2
	LR	-1.2	-1.2	-0.2
Interest rate	*SR*	-0.1	-0.3	0.0
	LR	0.2	0.2	0.0
Wage rate	*SR*	0.1	0.5	0.1
	LR	-0.3	-0.3	0.0
Consumption	*SR*	-0.3	-0.5	-0.1
	LR	-0.6	-2.1	0.2
Aggregate welfare measure		*-0.54*	*-0.76*	*0.20*
Leisure contribution		*-0.18*	*0.05*	*0.12*

Source: Simulation results.
Note: SR and LR denote respectively the short run (2006) and the long run (2102).

Moreover, we perform the same set of simulations with a lower value for the intra-temporal elasticity of substitution between consumption and leisure. This latter sensitivity test implies a reduced preference for leisure with respect to consumption. Therefore, with respect to Table 3, the results in Table 6 show that labour supply decreases less, effective labour supply increases more and that GDP per capita registers higher levels in the long run. Finally, the reduced preference for leisure activity lowers its contribution to aggregate welfare change, particularly in Scenario 2.

Table 6. Impact on key economic indicators – lower intra-temporal elasticity of substitution. (Percent change from the base run)

		Scenario 1 *Lump-sum tax*	**Scenario 2** *Pers. income tax*	**Scenario 3** *Other pub. exp.*
GDP per capita	*SR*	0.1	-0.2	-0.4
	LR	1.0	0.4	0.4
Labour supply	*SR*	-0.8	-1.1	-1.0
	LR	-1.0	-1.3	-1.7
Effective labour supply	*SR*	-0.1	-0.7	-0.5
	LR	1.4	0.7	0.5
Investment	*SR*	-1.4	-2.5	-1.0
	LR	0.0	-0.7	0.4
Physical capital intensity	*SR*	0.6	1.8	0.3
	LR	-1.2	-1.2	-0.3
Interest rate	*SR*	-0.1	-0.3	-0.1
	LR	0.2	0.2	0.0
Wage rate	*SR*	0.2	0.5	0.1
	LR	-0.4	-0.4	-0.1
Consumption	*SR*	-0.4	-0.6	-0.1
	LR	-0.4	-1.3	0.4
Aggregate welfare measure		*-0.37*	*-0.49*	*0.33*
Leisure contribution		*-0.11*	*0.07*	*0.19*

Source: Simulation results.
Note: SR and LR denote respectively the short run (2006) and the long run (2102).

5. Conclusion

From 1995 to 2002, Canada's share of GDP being devoted to education by the public and private sectors has declined by more than one percentage point. This decline is attributable to a retrenchment of government expenditures, which has more than offset a rising contribution from the private sector. Recent empirical studies suggest that countries with advanced technologies, such as Canada, should invest primarily in higher education in order to enhance innovation, productivity and economic growth. This raises questions regarding the optimal level of government expenditures on education as well as the financing sources. To explore these issues the present study uses a computable overlapping-generations model to assess the dynamic effects of increasing government expenditure on PSE in the Canadian context of population ageing.

The simulation results indicate that tax-financed increases in public expenditures on education may have significant crowding-out effects in the short run, by lowering saving

and investment in physical capital. In particular, the increase in personal income taxes provides a disincentive to work, which reduces labour supply and GDP per capita. In the long run, however, higher education incentives may increase human capital accumulation which in turn could mitigate some of the negative effects of population ageing. The shock results in a higher level of effective labour supply and raises the long-run level of GDP per capita. However, the gains are dampened by the adverse effects of higher taxes. Under both the lump-sum and the personal income taxes scenarios, the rise in GDP does not necessarily translate into an increase in consumption. Lifetime welfare is affected negatively, and the contribution of leisure does not offset the value of lost consumption.

These results are consistent with the findings of other quantitative studies suggesting that growth and welfare maximization are not totally equivalent goals when the crowding-out effect on consumption is relatively high (see e.g. Greiner, 2007 and Angelopoulos et al., 2007). Angelopoulos et al. (2007) analyse the effects of increasing public education expenditure in the U.S. using a growth model with human capital externalities. The authors find that the welfare-maximizing share of education expenditure in total output is 8.5%, much higher than the historical average share of about 5.5%, which would lead to an increase of 4% in lifetime welfare. Their results suggest that accounting for social benefits of education in an endogenous growth model may lead to higher gains.

An important limitation of this study is that the potential impact of higher human capital accumulation on the economic growth rate in Canada is not considered. Thus the results presented in this paper should be considered as lower bounds for the potential gains from investments in human capital. Sustainable long-run economic growth could provide more resources to fund the human capital sector without stronger increases in taxes. Fougère and Mérette (2000) suggest that more investment in human capital could significantly stimulate economic growth and mitigate the negative impact of population ageing in a knowledge-based economy like Canada. Bouzahzah et al. (2002) find that compared to the exogenous model, an endogenous growth model only plays important

role in affecting economic growth when policy reforms could significantly affect private incentives to accumulate human capital. These developments are left for future research.

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Appendix

Classification of Skill Levels – National Occupational Classification (NOC), 2001.

High Skilled
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 Skilled
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 skilled
Skill level C and Skill level D

Note: The NOC is available at http://www23.hrdc-drhc.gc.ca/2001/e/generic/publications.shtml