The Impact of an Aging Population on Occupations: The Role of Immigration and Public Expenditure on Education

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I. Introduction

A common view among policymakers is that population aging represents a crisis for industrialized countries. In 1994, the World Bank referred to the population aging challenge as a "crisis". Two major demographic factors explain why policymakers and some economists worry.

The first one is the increase in life expectancy that accompanies the continuously downward trend in the birth rate. The proportion of elderly with respect to total population in OECD countries is projected to double between 1995 and 2050 (from 11.3 in 1990 to 24.5 percent in 2050). Meanwhile the population growth rate has decreased from 1.5 percent in the early 1980s to the current rate of 1.25 percent and is projected to fall steadily to 0.5 percent by 2050[1].

The second factor is the upcoming retirement of baby boomers. Baby boomers were born in the prosperity of the post-war years between 1946 and 1960, and now form a large group of future retirees. The increased population of seniors is headed to create economic and fiscal stresses beginning in the second decade of the 21st century.

Demographic changes will certainly alter labour supply, private and public saving rates, and the growth of national income and consumption. How these variables, and to what extent, will react to population aging will depend on behavioural adjustments made by households, producers, investors and governments.

Most of the related studies in the literature have concentrated on the macroeconomic effects of population aging. After reviewing most of the macroeconomic issues induced by population aging, this paper focuses more attention on microeconomic issues, specifically, the inter-regional, inter-sectoral and occupational effects that will arise from the shift in consumption demands due to population aging. The consumption behaviour

[1] From United Nations population projections:
http://www.iiasa.ac.at/Research/LUC/Papers/gkh1/alltab.htm

of individuals changes with age, as obligations and demands change over the lifetime. As a result, the composition of demand for goods and services is expected to alter significantly with population aging. The changes will affect the production of many sectors, bring changes to the occupational characteristics of labour demand, and lastly, modify the relative economic performance of the regions. Furthermore, we discuss the education and immigration effect on labour market under the circumstances of aging.

Facilitated by the related achievements of Mercenier and Mérette (2002)[2], this paper builds a computable general equilibrium model and simulates the inter-regional, inter-sectoral, and occupational effects of population aging, taking into consideration the consumption preferences of different age groups with respect to different sectoral goods. The model is calibrated on Canadian data. The main interest of the paper is to identify and evaluate the reformation of final demands due to forthcoming demographic changes and its potential consequences on the composition (by qualification and profession) of the labour market. What is more, the model supplies a measure of the labour market imbalances that may accompany population aging in the case of Canada. The paper will use the model to focus on education and immigration effects on the future labour market when population ages.

II. Macroeconomic issues

Policymakers worry because pensions and old age health insurance are largely funded out of public budgets. Consequently, increases in the percentage of the retired population must eventually cause sharp increases in the fraction of government budgets devoted to old age voters. A significant rise in the level of public spending is to be expected.

With respect to the challenge of the population aging, the opinion is divided into two clear camps. The pessimistic view claims that the demographic change will push major inevitable adjustments on the fiscal side such as higher taxes or debt. Population aging

[2] *Will Population aging increase inequality across regions in Canada* 2002

means working people have to support a growing proportion of inactive individuals and hence a decline in public and private savings must be expected. This impact is strengthened by the fact that the length of time spent in retirement is growing as people are living longer and are retiring earlier. Fiscal adjustments such as higher taxes and public debt will result in a decrease in the national savings rate relative to the investment rate. This will require larger net foreign borrowing and result in wider trade and current account deficits. For the current young and future generations, the pessimistic scenario suggests a likely slowdown in economic growth and a decline in living standard. Intergenerational inequity will be huge since the young and future generations will have to bear the economic burden of providing for aging baby boomers and at the same time to provide for themselves when they retire.

On the other hand, some optimistic economists think the concerns with the population aging effects frequently ignore some important offsetting factors. Consequently, the negative impacts of population aging are exaggerated, according to Denton and Spencer (2000)[3], Emery and Rongve (1999), and Mérette (2002)[4]. The optimistic analysis emphasises that numerous market and institutional feedback mechanisms in the economy could offset many of the pessimistic scenarios predicted. Mérette (2002) analyzes the reasons why the negative economic consequence of population aging is highly misleading because it treats aging within the narrow perspective of government budgets. Mérette stresses two important considerations. First, a rising wage-rental ratio should stimulate investment in human capital, with the result that the post-baby-boom generation can enjoy more attractive labour market opportunities. Second, Mérette also draws attention to the existence of tax-sheltered private savings plans in the case of Canada. When baby boomers are currently working and contributing to these plans, they represent a drain on government revenues. In the future, when baby boomers are retired and withdrawing funds form these accounts. These programs will become net revenue raisers. This turnaround will limit the level to which governments will have to raise taxes on the post-baby-boom generation while they are working. Denton and Spencer (1999) add that

[3] SEDAP: *Population Aging and its Economic Costs: A Survey of the Issues and Evidence March 1999*
[4] Choices IRPP Economic Growth Vol.8 : *The Bright side: A positive view on the economics of aging* March 2002

while population aging will put pressure on some categories of government expenditure it will reduce the pressure on others.

Projection of the dependency ratios

The dependency ratio is the ratio of the combined child population (aged 0 to 14) and elderly population (aged 65 and over) to the working age population (aged 15 to 64)[5]. It describes how many retired citizens, children, and non-working adults there are for each one hundred workers. The dependency ratio is a simple indicator often used to analyze the burden on the economy of the inactive share of the population. By definition, a population is divided into economically active and economically inactive groups since the young and the elderly are the groups least able to provide for themselves economically. The total dependency ratio is the sum of elderly dependency ratio and youth dependency ratio. The population aging problem means that the elderly dependency ratio will rise in the future. It is believed that a change in the total dependency ratio with the population aging ultimately affects such factors as consumption patterns, saving propensity, and macroeconomic performance in general.

Foot (1987[6]) claims that a rising elderly dependency ratio would eventually result in an increase in government spending, and then an increase in public budget deficits. However, Denton and Spencer (1999) note that the overall dependency ratio that will occur when baby boomers are retired will not reach the level observed when the baby boom was young in the 1950s. Even though health-care costs for old dependents are higher than education costs for young dependents, western economies may not have to cope with any bigger challenge than what was faced earlier. When Spencer (1999) pooled his results with Foot's, he drew a general conclusion that dependency ratios were very low in the 1990s and that they are likely to change little for another 15 or 20 years. The pooling also indicates that they will rise substantially thereafter as the proportion of elderly people in the population rises.

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[5] From Statistics Canada: www.statcan.ca/english/freepub/82-221-XIE/01201/community/community.htm#pop

[6] *Population aging and government deficits in Canada* 1987 David K. Foot

Government expenditure

The prospect of retirement in the next decade for the current middle age baby boomers cohort has given rise to major concerns about the government's financial ability to cope with this significant demographic shift. Specifically, the ability of governments to meet the large anticipated additions to health care, pension, and other costs associated with the increase in the older population is under question.

Denton and Spencer (1999) call for a balanced assessment of costs which requires an attention to be given to all publicly provided services—not only those used in large measure by the elderly such as health care, but also those linked to other age groups such as education, employment insurance, and correctional services. A balanced assessment requires also that privately provided goods and services be considered. They project that the government expenditures necessary to maintain social security and health care at current per capita levels will rise slowly in the coming decades. But these increases will be offset elsewhere in the budgetary framework, especially in education. In any case, it will be important for governments to pay more attention to the reallocation within budgets to accommodate the rising demand of some types of goods and services coupled with the falling demand of others. Mérette (2002) estimates that education spending will decline by an equivalent of one percent of GDP in the next 50 years, while the other types of spending will fall only modestly by 0.3 percent.

The productive capacity of the economy

It is important to recognize that demographic change affects not only the nation's productive capacity but also the ways in which the national product is used. As economies become more knowledge-based rather than resource-based, people pay more attention to human capital investment. The theory of human capital is based on the assumption that in a perfectly competitive market, the wage of workers equals the marginal revenue product. According to the theory, the cost of investing in human capital is the current wage whereas the benefits are future wages. As the wage-rental ratio is

expected to rise with population aging, the net benefits from investing in human capital are expected to increase. Economic growth may improve from these investments according to Mérette (2002). Moreover, as the labour force growth is expected to be slow, optimists such as Habakkuk (1962)[7] believe that technical innovations are greatest when labour growth is scarce, because technical progress is labour saving.

National savings

Saving enhances society's ability to produce and consume in the future, but it requires the sacrifice of current consumption. And it is one of the key differences in the logics of pessimism and optimism. The trend toward longer life spans and longer periods of retirement, in addition to projections suggesting that the share of the elderly is growing, imply that more savings will be necessary over the next several decades to maintain the growth in living standards.

Among the various theories about saving's determinants, the life-cycle theory is important in the context of an aging population. It predicts that people will save in order to translate their fluctuating levels of income into smooth paths of consumption. Because earnings tend to rise first and then fall over a lifetime, smooth consumption implies that households borrow when young, save when middle-aged, and spend savings, or "dissave," when old. The pure version of the theory assumes that people consume all their wealth by death and that people have unlimited access to capital markets at a single interest rate paid by borrowers or received by savers. Given these assumptions, the pure life-cycle theory implies pronounced differences in annual saving rates by age, with consumption fluctuating with changes in permanent income but not transitory income.

Population aging will also profoundly affect future public savings through the major government transfer programs, especially the health programs, which disproportionately benefit the elderly. Part of government consumption, such as expenditures on public

[7] From Ruttan *Sources Of Technical Change* Feb. 2001
http://www.apec.umn.edu/faculty/vruttan/TECHCHGE.pdf

education, disproportionately goes to the young, who will become a smaller share of the population. This will reduce government spending in the future.

Given that national saving is the sum of private and public saving, the effects of demographic change on national saving are driven by the age-related patterns of private saving rates and the age-related patterns in government transfers. Bettendorf and Knaap (2001) argue that if aging is caused by lower fertility, the fraction of the population that saves is expected to go down, depressing the overall saving rate. Rogers, Toder and Jones (2000[8]) claim that demographic changes have more straightforward effect on public saving and, meanwhile, the decreasing share of children will reduce the growth in public education spending. The effect of changes in the number of children relative to adults reinforces the optimistic story about private saving.

Capital stock

The stock of capital grows as the result of investment. Investment, in turn, is related to the amount of saving, which reflects life-cycle considerations. Briefly put, people are assumed to save an asset during their working years and dissave during retirement. Thus one might expect that at present the baby boom would be in a phase of relatively high accumulation rates, and that high rates of aggregate saving would continue for another decade or so, but then start to fall. Thus Robson (2001[9]) argues that there is the prospect of a decline in the saving rate as the population ages, and hence in the rate of growth of the capital stock, and that would coincide with the slowing rate of labour force growth. That combination could, then, result in a slower rate of growth of the national income and product.

However, the argument does demonstrate how population aging may affect the capacity to produce goods and services as well as the demand or requirements for those goods and

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[8] Rogers, Toder and Jones *Economic Consequences of an aging population* Sept. 2000 http://www.urban.org/retirement/reports/6/retire_6.html

[9] Robson, William B.P. "*Will the Baby Bommers Bust the Health Budget? Demographic Changes and Health Care Financing Reform*" Feb.2001

services. We can also show the saving rate would probably increase with the people's stimulated incentives to invest in education for themselves for their children.

Labour force

A decline in the share of workers in the population means that, if all else remains the same, output per capita and living standards will be lower than they otherwise would have been if the share of workers had remained stable. Toder (1999) suggests that the average earnings and productivity per worker would be increased through the possible increase of labour force participation rates of working-age women, which outweighed the reduction in labour force participation rates of older men over the next two decades. The increase in experience associated with an older workforce will raise average earnings and productivity per worker. General workforce education levels will also increase as less educated workers retire and are replaced by the better-educated workers in later birth cohorts. Johnson (1992) points out that with the demographic change in labour market, the age structure affects macroeconomic performance because workers of different ages are not perfect substitutes for each other.

Mérette (2002) indicates the potentials to offset some of the negative labour force impacts outlined by the pessimists. These factors are improved job market opportunities due to the increased relative scarcity of labour; the increased probability of finding work due to the aging process; a better-educated labour force; and the likelihood of steady rather than declining performance by older workers. The educational attainment of future older workers will be higher than that of present older workers. As a result, the growth in the *effective* labour force may not drop much with population aging with these offsetting factors.

The current accounts and the interest rate

Bettendorf and Knaap (2001) provide several reasons to expect that the supply and demand of capital will be affected by demographics. On the supply side, we know that an important incentive for saving is the life-cycle motive. If it comes about through a longer

lifespan, lengthening retirement, saving should go up during the active period. On the demand side, a large fraction of the savings of the aging Western countries can be used to invest in emerging economies, where the aging problem is less severe (Reisen, 1998). Emerging economies, where per-capita levels of capital are low, offer greater returns and may attract investment from western countries. The simulations in Borsch-Supan *et al.* (2001), assuming perfect capital mobility, seem to support this argument. However, Turner *et al.* (1998) argue that total absorption is impossible: the OECD is too large relative to the emerging economies.

Because of the uncertainty of capital demand and supply, how the interest rate move in the context of aging is not clear. Quantitative methods are needed but the econometric estimations with respect to this issue are difficult. Poterba (1998)[10] finds that such an exercise produces no robust results when applied to the U.S., the U.K. and Canada. He concludes that the fact that an aging population is unlike anything that has been experienced before makes it unsuitable for statistical predictions.

Another method of predicting the interest rate is to use an applied general equilibrium model. By their nature, such models can cope with changes not yet observed in any economy, such as an aging population. Bettendorf and Knaap (2002) use general equilibrium models of different types and investigate a closed economy as well as world-models and their different outcomes with regard to the interest rate. They reach the conclusion that current account is sensitive to different assumptions about population aging, and that the effects of interest rate shocks on the current account can be mainly traced back to their effect on personal and pension saving.

Living standard

Pessimists believe that real GDP will decline with the shrink of the labour market because the young population grows more slowly than the elderly population. They reach that conclusion by assuming that labour force participation rates by age will decrease with population aging. However, we could consider that the improvements in health and

longevity of the elderly may cause workers to retire at older ages so that their expected years in retirement remain constant. Toder and Solanki (1999) assume that participation rates by age will remain constant and obtain a smaller decline in the work force. Still, labour supply is expected to shrink between 2010 and 2040 as baby boomers enter retirement age.

Emery and Rongve (1996)[11] believe that if wages rise enough it may be possible for the next generation to pay the higher payroll taxes necessary to finance the baby-boomers' pension and public health care, and still enjoy higher living standards themselves. Emery and Rongve use a calibrated version of the simplest two-period overlapping generation model to examine this possibility. They find that the post-baby-boom generation's living standard is higher than the steady-state outcome.

In the case of Canada, Mérette (2002) points out two factors that will not only smooth the demographic transition toward a much older population, but will arguably offer opportunities for a better standard of living to young and future generations. The first factor is that people will be stimulated to invest more in education to increase their human capital. The other factor is that Canada is characterized by the accumulation of a large stock of taxable wealth in the form of contributions to tax-deferred retirement savings plans. The programs would become new sources of government revenue at the most critical point in Canada's population aging.

III. Microeconomics issues

Population aging not only brings many macroeconomic effects, but also microeconomic ones. Indeed, we might expect that the population age structure changes would have extensive effects on the demand for goods and services provided by the private sector as well as on those provided by the public sector. The demographical structure change might

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[10] J. M. Poterba *Population Age Structure and Asset Returns: An Empirical Investigation* Oct. 1998

[11] Emery and Rongve *Much Ado About Nothing? Demographic Bulges, The Productivity Puzzle and CPP Reform* Aug. 1996

be expected to cause production to shift to some extents from goods and services associated mainly with children to those associated with people in middle or old age. For example, as the Conference Board of Canada (2002) predicts, over the next five years, the baby-boomers will be moving through their peak spending years, when the focus is on durable goods for themselves and their children, and this group will enter a high-income, high-savings period as they prepare for retirement between 2005-2015.

The change of consumption patterns is likely also to influence various kinds of investment, thereby extending its impacts. Such shifts will take place mostly through market forces: producers will respond by producing more of what consumers want (and are willing to pay for) and less of what they do not want. Moreover the allocation of government spending is subject to the size of the various age groups. This spending sensitivity will noticeably depend on the distribution of these expenditures per age group. Public education expenditure targets the young and health care spending benefits mostly seniors, whereas other transfers rather benefit the middle age. Therefore a shift in the composition of the population as significant as the predicting aging process in Canada may activate considerable macroeconomic and microeconomic effects.

Population aging shifts attention also to immigration issues. Canada's immigration may be an important offsetting factor to alleviate the population aging burdens. Countless empirical evidence shows that immigrants invest more in human capital than the natives and have consequently faster earnings growth. Duleep and Regets[12] (1999) try to explain this feature theoretically and empirically. They point out that the key factor distinguishing immigrants from natives is that the human capital of immigrants may not be fully valued in the destination country (Chiswick, 1979). They used an immigration human capital investment model to predict a high rate of investment and earnings growth for immigrants who have lower opportunity costs of human-capital investment versus natives. Thus, the higher incentives of immigrants' investment could facilitate the

[12] Duleep and Regets *American Economic Review* Immigrants and Human-Capital Investment (1999 vol. 89)

transfer of previously learned skills. Of course, immigrants' investment and occupational change also affect immigrant versus native competition in the labour market.

After considering the future consequences of income taxes paid by immigrants, as well as by their native offspring, Auerbach and Oreopoulos (1999 [13]) evaluate the U.S. fiscal burdens imposed by immigration by using generational accounting methodology. They believe the payments might more than compensate for the increase in government spending. They also reach the conclusion that a change in immigration policy that increases the education or training level of immigrant, does have the potential to reduce the fiscal burdens on future generations.

We now turn to the strong implications of immigration for public finance with population aging present. Young immigrants would lessen the current demographic imbalance and selective immigration could mitigate some of the fiscal burdens associated with the aging of the baby boom generation, and might serve as an alternative to tax hikes or spending cuts for financing future fiscal deficits. Storesletten (2000)[14] uses a calibrated general equilibrium overlapping generations model which accounts for differences between immigrants and natives to show that, in the US case, the inflow of selective immigrants, that is, working-age high and medium-skilled immigrants, can remove the need for tax increases. He thus illustrates the trade-off between higher taxes on the one hand and a larger number of high-skilled immigrants on the other. Storesletten computes the net government gain and believes that if skilled workers immigrate and immediately start paying taxes, the net fiscal effects are likely to be large and positive, even when the gains are traded off against the subsequent costs of retirement.

The purpose of this paper is to concentrate on the microeconomic issues of aging and study more deeply the role of education expenditures and immigration. In particular, we will investigate the inter-regional and inter-sectoral effects of aging on the Canadian economy. To this end, we will use the model of Mercenier- Mérette (2002).

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[13] *The Fiscal Impact of U.S. Immigration: A generational accounting perspective* Auerbach and Oreopoulos (1999)

[14] Journal of Political Economy *Sustaining Fiscal Policy through Immigration* (2000 vol. 108)

IV. The model

A computable general equilibrium model that comprises 6 Canadian regions with 6 different age groups within each, 14 sectors and about 25 different occupations distinguished by profession categories and skill levels is built to analyze the inter-regional consequences of population aging in Canada. The model is calibrated on various sources of Canadian data. We simulate the inter-regional, inter-sectoral, and occupational effects, especially on the labour market by taking into consideration the upcoming structural shift of the Canadian population.

The following model includes producers, households and government and each of them has a different objective. For producers, they maximize their profits by minimizing costs subject to their technology constraints. They have in a first step a demand for general labour. Then, according to a technology that summarises the complementarities and substitutability of different types of occupations, they generate a labour demand by profession and by qualification. Households aim at maximizing their utility subject to a wealth constraint. The economic behaviour of an individual, including consumption behaviour, changes with age. In general, Canadians follow lifecycle behaviour. That is, young Canadians borrow to invest in human capital while middle-age individuals work more to acquire assets to secure future consumption. Finally, the seniors prefer leisure time and consume considerable health care services. Government obtains revenues from labour, consumption and capital taxes. The main obligation of the government is to keep the budget balanced.

Sets and indices

There are I fully endogenous and symmetric Canadian regions indexed by i *or* j and a reduced form residual rest of the world indexed *row* in a subset denoted *RoW*. The set of all regions is denoted II and indexed by ii or jj (ii=1,…,II).

There are S sectors of production indexed by s,ss (s=1,…,S) in each region. Labour is distinguished by qualifications, within different occupations or professions grouped in different types and qualifications. We identify the set of qualifications by *Iqual* (*iqual*=1,…,*Iqual*), the set of occupations by *Iprof*(*iprof*=1,…,*Iprof*), and the set of labour types by *Itype*(*itype*=1,…,*Itype*).[15]

At each point in period (time is indexed t) there are G (g=1,…,N) generations that coexist. We index by gj (gj=1,…,GJ) the working generations, and by gm (gm=GJ+1,…, G) the retired.

Producers of region j at time t

There are two factors of production, which are capital services denoted $K^{dem}_{j,s,t}$ and different types of labour services form different professions with different qualifications, denoted $L^{Qual}_{j,s,itype,iprof,iqual,t}$. Producers use factors of productions and intermediate input goods from sectors ss, the latter in amount $X_{ss,j,s,t}$. Each input is bought at market prices, respectively $\text{Rent}_{j,t}$, $w^{Qual}_{j,itype,iprof,iqual,t}$ and $P^{c}_{j,ss,t}$. Note that factor prices are the same for all sectors but specific to each region: factors are assumed mobile between sectors but immobile between regions.

When producers make the production decision, they minimize the total costs of producing good s in amount $Z_{j,s,t}$, therefore they solve the following problem:

$$\underset{XS_{SS,J,S,T},K^{dem}_{j,s,t},L^{dem}_{j,s,itype,iprof,iqual,t}}{Minimize} \sum_{ss} P^{c}_{j,ss,t} XS_{ss,j,s,t} + \text{Re}nt_{j,t} K^{dem}_{j,s,t} + \sum_{\substack{itype \\ iprof \\ iqual}} w^{Qual}_{j,itype,iprof,iqual,t} L^{Qual}_{j,s,itype,iprof,iqual,t}$$

We use CD(.;Sc,α) for the Cobb-Douglas form, parameterized by the scaling parameter Sc and the expenditure shares α, and CES(.;α,σ) for a constant-elasticity-of-substitution form with share parameters α and substitution elasticity σ.

$Z_{j,s,t}=CD(X_{j,s,t}Q_{j,s,t};Sc^{z}_{j,s,t},\alpha^{Q}_{j,s})$ $\qquad (P_{j,s,t})$

[15] See Appendix 2

$X_{j,s,t}=CES(XS_{ss,j,s,t};\ \alpha^{XS}_{SS,j,s},\sigma^{X}_{j.s})$ $(P^{X}_{j,s,t})$

$Q_{j,s,t}=CD(K^{dem}_{j,s,t},\ L^{dem}_{j,s,t};Sc^{Q}_{j,s,t},\alpha^{K}_{j,s})$ $(P^{Q}_{j,s,t})$

$L^{dem}_{j,s,t}=CES(L^{type}_{j,s,itype,t};\ \alpha^{Ltype}_{j,s,itype},\ \sigma^{Ldem}_{j.s})$ $(wage_{j,s,t})$

$L^{type}_{j,s,t}=CES(L^{Prof}_{j,s,itype,iprof,t};\ \alpha^{Lprof}_{j,s,itype,iprof},\ \sigma^{Ltype}_{j.s,itype})$ $(w^{Type}_{j,s,itype,t})$

$L^{Prof}_{j,s,itype,iprof,t}=CES(L^{Qual}_{j,s,itype,iprof,iqual,t};\ \alpha^{Lqual}_{j,s,itype,iprof,iqual},\ \sigma^{Prof}_{j.s,iprof})$ $(w^{Prof}_{j,s,itype,iprof,t})$

The optimality conditions of the problem are the following:

(1) $Z_{j,s,t}=Sc^{Z}_{j,s,t}\ X^{1-\alpha^{Q}_{j,s}}_{j,s,t}\ Q^{\alpha^{Q}_{j,s}}_{j,s,t}$

(2) $P^{X}_{j,s,t}X_{j,s,t}=(1-\alpha^{Q}_{j,s})P_{j,s,t}Z_{j,s,t}$

(3) $P^{Q}_{j,s,t}Q_{j,s,t}=\alpha^{Q}_{j,s}P_{j,s,t}Z_{j,s,t}$

The production of output $Z_{j,s,t}$ requires therefore to combine, in fixed expenditure shares, intermediate inputs and value added, respectively in amounts $X_{j,s,t}$, $Q_{j,s,t}$, where $Sc^{Z}_{j,s}$ is the scaling parameter and $\alpha^{Q}_{j,s}$ the value added share. Because output is homogeneous of degree one with respect to $X_{j,s,t}$ and $Q_{j,s,t}$, we have $P^{Z}_{j,s,t}Z_{j,s,t}=P^{X}_{J,S,T}X_{j,s,t}+P^{Q}_{j,s,t}Q_{j,s,t}$. The homogeneity also implies that $1-\alpha^{Q}_{j,s}$ is the intermediate input share and $\alpha^{Q}_{j,s}$ in the value-added share of output.

The aggregate intermediate input is a CES mix of market goods in quantities $XS_{ss,j,s,t}$, which is the quantity of goods *ss* demanded by section *s* of region *j*. In the equation below, $\alpha^{XS}_{s,j,s}$ is the expenditure share and $\sigma^{X}_{j,s}$ is the elasticity of substitution between aggregate intermediate good price $P^{X}_{j,s,t}$ and the specified intermediate good price $P^{c}_{j,ss,t}$. When $P^{X}_{j,s,t}=P^{c}_{j,ss,t}$, the parameter $\alpha^{XS}_{s,j,s}$ determines the demand proportion of $XS_{ss,j,s,t}$ to aggregate intermediate goods demand $X_{j,s,t}$. When $P^{c}_{j,s,t}$ declines or/and when $P^{X}_{j,s,t}$ increases, the demand for $XS_{ss,j,s,t}$ increases. To what extent the relative prices

$\left[\frac{P^X_{j,s,t}}{P^c_{j,ss,t}}\right]$ change to modify the demand structure will depend on the elasticity of substitution $\sigma^X_{j,s}$.

(4) $XS_{ss,j,s,t} = \alpha^{XS}_{ss,j,s}\left[\frac{P^X_{j,s,t}}{P^c_{j,ss,t}}\right]^{\sigma^X_{j,s}} X_{j,s,t}$

Given the CES mix structure, the price of the aggregate intermediate input $P^X_{j,s,t}$ has also a CES relationship with respect to the specific intermediate good price.

(5) $P^{X^{1-\sigma^X_{j,s}}}_{j,s,t} = \sum_{ss} \alpha^{XS}_{ss,j,s} P^{c^{1-\sigma^X_{j,s}}}_{j,ss,t}$

The value added is produced using capital $K^{dem}_{j,s,t}$ and aggregate labour services $L^{dem}_{j,s,t}$. The value added technology has a CD form. The rental return to capital, rent and wage rate equal the marginal products of capital and labour, respectively:

(6) $Q_{j,s,t} = Sc^Q_{j,s} K^{dem^{\alpha^K_{j,s}}}_{j,s,t} L^{dem^{1-\alpha^K_{j,s}}}_{j,s,t}$

(7) $Rent_{j,t} K^{dem}_{j,s,t} = \alpha^K_{j,s} P^Q_{j,s,t} Q_{j,s,t}$

(8) $wage_{j,s,t} L^{dem}_{j,s,t} = (1-\alpha^K_{j,s}) P^Q_{j,s,t} Q_{j,s,t}$

The $\sigma^{Ldem}_{j,s}$ is the elasticity of substitution between the wage of a specific labour type $w^{Type}_{j,s,itype,t}$ and the aggregate wage level $wage_{j,s,t}$. When the wage level of this type of labour is equal to the aggregate wage level, the parameter $\alpha^{Ltype}_{J,s,itype}$ determines the labour demand proportion $L^{dem}_{j,s,t}$ to specific type labour demand $L^{Type}_{j,s,itypet}$. The extent to which the relative wage $\left[\frac{wage_{j,s,t}}{w^{Type}_{j,s,itypet}}\right]$ changes labour demand for type *i* occupation depends on the elasticity of substitution $\sigma^{Ldem}_{j,s}$. When $w^{Type}_{j,s,itype,t}$ increases with respect to the aggregate wage ($wage_{j,s,t}$), $L^{Type}_{j,s,itype,t}$ the demand for the corresponding type of labour increases.

(9) $$L^{Type}_{j,s,itype,t} = \alpha^{Ltype}_{j,s,itype}\left[\frac{wage_{j,s,t}}{w^{Type}_{j,s,itype,t}}\right]^{\sigma^{Ldem}_{j,s}} L^{dem}_{j,s,t}$$

Given the CES mixture, the aggregate wage is determined by a CES relationship with respect to the wage of the specific type of occupations:

(10) $$wage^{1-\sigma^{Ldem}_{j,s}}_{j,s,t} = \sum_{itype} \alpha^{Ltype}_{j,s,itype} w^{Type}_{j,s,itype,t}{}^{1-\sigma^{Ldem}_{j,s}}$$

The aggregate labour service is a CES mixture of different types of labour $L^{Type}_{j,s,itype,t}$, each of these types being a different CES combination of professions $L^{Prof}_{j,s,itype,iprof,t}$, which themselves result from a CES combination of different qualifications $L^{Qual}_{j,s,itype,iprof,iqual,t}$. This multilevel CES aggregation structure captures the different nature of labour inputs. Associated with each constraint of the firm's cost minimization problem are shadow prices, which are indicated in brackets.

(11)

$$w^{Type}_{j,s,itype,t}{}^{1-\sigma^{Ltype}_{j,s,itype}} = \sum_{iprof} \alpha^{Lprof}_{j,s,itype,iprof} w^{Prof}_{j,s,itype,iprof,t}{}^{1-\sigma^{Ltype}_{j,s,itype}}$$

(12) $$L^{Prof}_{j,s,itype,iprof,t} = \alpha^{Lprof}_{j,s,itype,iprof}\left[\frac{w^{Type}_{j,s,itype,t}}{w^{Prof}_{j,s,itype,iprof,t}}\right]^{\sigma^{Ltype}_{j,s,itype}} L^{Type}_{j,s,itype,t}$$

(13) $$w^{Prof}_{j,s,itype,iprof,t}{}^{1-\sigma^{Lqual}_{j,s,iqual}} = \sum_{iqual} \alpha^{Lqual}_{j,s,itype,iprof,iqual} w^{Qual}_{j,s,itype,iprof,iqual,t}{}^{1-\sigma^{Lprof}_{j,s,iprof}}$$

(14) $$L^{Qual}_{j,s,itype,iprof,iqual,t} = \alpha^{Lqual}_{j,s,itype,iprof,iqual}\left[\frac{w^{Prof}_{j,s,itype,iprof,t}}{w^{Qual}_{j,s,itype,iprof,iqual,t}}\right]^{\sigma^{Lprof}_{j,s,iprof}} L^{Prof}_{j,s,itype,iprof,t}$$

Household g of region j at time t

An Allais-Samuelson overlapping generations framework which is based on the life-cycle theory of saving behavior characterizes households. Each individual lives six adult

periods of ten years, retiring after five periods. In each period, the oldest generation dies and a new generation enters the labour force, which implies that at any point in time six generations are alive. The working life starts at the age of 15; younger children are assumed to be fully dependent on their parents to which they constitute no extra burden nor provide any felicity. Individuals with perfect foresight retire from the labour market at the age of 64 and die at age 74. In every region, each new generation's problem consists in a first step to maximize an intertemporal utility function of consumption and bequest subject to a lifetime income. The utility function is time-separable and of the constant elasticity of substitution type:

$$(15) \quad U_{j,t} = \frac{1}{1-\theta}\sum_{g=1}^{6}\left(\frac{1}{1+\rho}\right)^{g}\left(Con_{j,g,t+g-1}^{1-\theta} + \beta_g^{\theta} RBeq_{j,g,t+g-1}^{1-\theta}\right) \qquad \theta>0,\ \beta_{g\neq 6}=0,\ \beta_{g=6}>0$$

where $Con_{j,g,t}$ is consumption of an individual living in region j of age group g at time t, ρ the pure rate of time preference, θ the inverse of the intertemporal elasticity of substitution, β_g is a constant parameter and $RBeq_{j,g,t}$ denotes bequests (in real terms). This equation states that the welfare of an individual is a weighted sum of 6 periods of consumption from age group g=1 at period t to age group g=6 at t+5, plus the (positive) utility to bequest for g=6 in period t+5. Leisure does not enter into the utility function since individual's labour supply is assumed to be exogenous.

The bequest specification follows Blinder (1974) and gives rise to intergenerational transfers in addition to public old-age pension benefits. It is noteworthy that this specification of the utility function yields very different results from the alternative of introducing the utility of future generations directly into the utility function of current generations. In the arrangement chosen here, the felicity from bequest is independent of the present value of cash receipts extending beyond the death of the current generation; hence, the timing of government expenses has an effect on the current generation's utility.

Assuming no borrowing constraints and perfect capital markets, the present value of household wealth $W_{j,t}$, is the discounted sum of lifetime labour income $LInc_{j,g,t}$ net of taxes but inclusive of public old-age pensions $Pens_{j,g,t}$ and inheritance $Inh_{j,g,t}$:

$$(16) \quad W_{j,t} = \sum_{g=1}^{6} \left(\frac{1}{1 + R\text{int}_{t+g-1}(1-\tau^{K})} \right)^{t} (LInc_{j,g,t+g-1}(1-\tau^{w}_{j,t+g-1} - CtR_{t+g-1}) + (1-\tau^{w}_{j,t+g-1})\, Inh_{j,g,t+g-1} + Pens_{j,g,t+g-1})$$

Labour income depends on the individual's age-dependent productivity (earnings) profile. In this model the earnings profile is assumed to be identical across regionS. To be more precise, the earnings profile (EP_g) is a quadratic function of age (g) with parametric values chosen to ensure that the maximum is reached between mid-life and retirement:

$$(17) \quad EP_g = \gamma + \lambda g - \psi g^2, \qquad \gamma, \lambda, \psi \geq 0$$

As labour embodies the earnings profile, we can define the labour income of an individual in working age group gj in region j at time t as being the wage times labour supply times the earning profile, in which wage is dependent on different types of labour services from different professions with different qualifications:

$$(18) \quad LInc_{j,gj,t} = \sum_{\substack{itype \\ iprof \\ iqual}} w^{qual}_{j,itype,iprof,iqual,t} L^{\sup}_{j,itype,iprof,iqual,gj,t} EP_{gj}$$

Pension benefits of the retirees are proportional to their lifetime labour earnings. The fraction is determined by the pension replacement rate $PensR$ that applies identically everywhere in Canada. As people work for 5 periods and then retire, pension benefits can be expressed as:

$$(19) \quad Pens_{j,gm,t} = PensR \frac{1}{5} \sum_{gj} LInc_{j,gj,t-5+gj}$$

Differentiating the household utility function with respect to the individual's lifetime budget constraint yields the following first order conditions for consumption and bequests:

$$(20) \qquad Con_{j,g+1,t+g} = \left[\frac{(1+R\text{int}_{t+g}(1-\tau^K))}{1+\rho_j} \frac{P^{Con}_{j,g,t+g-1}}{P^{Con}_{j,g+1,t+g}} \right]^{(1/\theta)} Con_{j,g,t+g-1}$$

$$(21) \qquad RBeq_{j,g,t} = \beta_g Con_{j,g,t}$$

We can see that consumption is increasing over the life cycle when the rate of the capital tax is greater than the pure rate of time preference, all adjusted by the evolution of the consumer price index ($P^{Con}_{j,g,t+g}$).

Bequests are distributed at the end of each generation's lifetime (generation *gn*). Inheritances arising from the oldest age group's bequests which are supposed to be equally distributed to all working generations *gj*:

$$(22) \qquad Inh_{j,gj,t} Pop_{j,gj,t} = \frac{1}{5} P^{Con}_{j,gn,t} RBeq_{j,gn,t} Pop_{j,gn,t}, \quad gj=1,2,...5;\ gn=6$$

Where $Pop_{j,gj,t}$ is the number of people living in region *j* of age group *g* at time *t*. It is divided by 5 because there are five working periods. The inheritance is defined in current prices and the population growth rate is treated as exogenous.

In the second step of the optimization problem, households must allocate their consumption expenditures among the available final good *s*. Again we assume a CES aggregator. Accordingly, the first-order conditions stipulate that region *j* household's consumption of good s of generation g at time t ($ConS_{j,s,g,t}$) is determined by the following equations, where the price of $ConS_{j,s,g,t}$ is $P^c_{j,s,t}$:

$$(23) \qquad P^{Con}_{j,g,t}{}^{1-\sigma^{Con}_{j,g}} = \sum_s \alpha^{ConS}_{j,s,g} P^c_{j,s,t}{}^{1-\sigma^{Con}_{j,G}}$$

$$(24) \qquad ConS_{j,s,g,t} = \alpha_{j,s,g}^{ConS}\left[\frac{P_{j,g,t}^{Con}}{P_{j,s,t}^{c}}\right]^{\sigma_{j,G}^{Con}} Con_{j,g,t}$$

where $\alpha_{j,s,g}^{ConS}$ is a parameter representing the preference of residents of region j for good s, $\sigma_{j,G}^{Con}$ is the consumption elasticity of substitution. When the price of good s in region j $P_{j,s,t}^{c}$ increases, household's consumption of good s of generation g region j at time t ($ConS_{j,s,g,t}$) will decrease. The composition of consumption baskets varies across generations. For example, as the older population consumes more health services than younger ones, the aggregate consumer price index that is dependent on age group varies.

Investors of region j at time t

Households in region j invest in physical capital $Kij_{i,j,g,t}$ and in bonds $Bij_{i,j,g,t}$. Financial markets are efficient and perfectly integrated. In other words, all assets are perfect substitutes and traded on international markets. So households are indifferent in their allocation of savings between physical ownership titles and bonds issued by regional governments. In this model, it is assumed that both asset holdings by local residents are characterized by home bias (captured by calibrated portfolio shares).

Capital goods are built using a CES investment technology that also allows for substitution between different market goods. Therefore, choosing the optimal constituting mix, we have the pattern of regional investment ($InvS_{j,s,t}$) similar to that of regional consumption:

$$(25) \qquad P_{j,t}^{Inv^{1-\sigma_j^{Inv}}} = \sum_s \alpha_{j,s}^{InvS} P_{j,s,t}^{c\ 1-\sigma_j^{Inv}}$$

$$(26) \qquad InvS_{j,s,t} = \alpha_{j,s}^{InvS}\left[\frac{P_{j,t}^{Inv}}{P_{j,s,t}^{c}}\right]^{\sigma_j^{Inv}} Inv_{j,t}$$

Where, $\alpha_{j,s}^{InvS}$ is a parameter of the CES investment technology and α_j^{Inv} is the corresponding elasticity of substitution. When the price of aggregate investment $P_{j,t}^{Inv}$ increases, regional investment on good s will increase.

The regional stock of physical capital at time t +1 is a function of the regional investment at time *t* plus the depreciated value of the regional stock of physical capital at time *t*. When investment $Inv_{j,t}$ increases, the regional stock of physical capital broadens. However, it narrows with the constant depreciation rate $DepR_j$.

$$(27) \qquad Kstock_{j,t+1} = Inv_{j,t} + (1 - DepR_j)Kstock_{j,t}$$

The one period expected rate of return on capital $R\,\mathrm{Re}t_{j,t}$, from a unit of physical capital bought at time t -1, is a function of its expected real rental price minus the depreciation rate, plus the anticipated capital gains. Algebraically, we have the following equation:

$$(28) \qquad R\,\mathrm{Re}t_{j,t} = \frac{\mathrm{Re}nt_{j,t} + (1 - DepR_j)P_{j,t}^{Inv}}{P_{j,t-1}^{Inv}}$$

The government of region j at time t

A regional government gains tax revenues from labour and capital income, as well as consumption expenditure. Its spending includes government consumption $Gov_{j,t}$, and debt interest payments. Government consumption spending is allocated across sectors using a CES aggregator. The share parameter α determines the proportion of regional government spending on good s to total government spending in region j at time t. When the price of good s in region j at time t increases, government spending for good s in region j at time t declines.

$$(29) \qquad P_{j,t}^{Gov^{1-\sigma_j^{Gov}}} = \sum_s \alpha_{j,s}^{GovS} P_{j,s,t}^{c\ 1-\sigma_j^{Gov}}$$

$$(30) \qquad GovS_{j,s,t} = \alpha_{j,s}^{GovS}\left[\frac{P_{j,t}^{Gov}}{P_{j,s,t}^{c}}\right]^{\sigma_j^{Gov}} Gov_{j,t}$$

When tax revenues become short of total government consumption and interest debt payment, the government issues new bonds at time t+1 to satisfy its budget constraint. Accordingly, the budget constraint of the government is:

$$(31)\quad P_{j,t}^{Gov}\, Bond_{j,t+1} + \sum_{g} Pop_{j,g,t}\left\{\tau_{j,t}^{w}\left(LInc_{j,g,t} + Pens_{j,g,t}\right) + \tau_{j,t}^{Con} P_{j,t}^{Con} Con_{j,g} + \right.$$

$$\left. \tau_{j,t}^{K} \sum_{i}\left(\frac{R\text{int}J_{i,t-1}P_{i,t}^{Gov}}{P_{i,t-1}^{Gov}} - 1\right) P_{i,t-1}^{Gov} Bij_{i,j,g,t} + \tau_{j,t}^{K} \sum_{i} (R\,\text{Re}t_{i,t-1} - 1) P_{i,t-1}^{Inv} Kij_{i,j,g,t}\right\}$$

$$= P_{j,t}^{Gov} Gov_{j,t} + \left(\frac{R\text{int}J_{j,t-1}P_{j,t}^{Gov}}{P_{j,t-1}^{Gov}}\right) P_{j,t-1}^{Gov} Bond_{j,t}$$

On the left hand side of the equation, we have the value of new bonds that are issued at time *t+1* and all the government's tax revenues arising at time *t* from labour income, capital returns and consumption expenditure. On the right hand side we have government consumption plus debt interest payments.

Pay-as-you-go pension benefits are financed by contribution rates on wage earnings. With population aging, the contribution rate is expected to rise. But as the program is considered nation-wide, no inter-regional consequences are expected. The pension program is represented by the following equation; the total pension of the retiring population equals the total income of the working population times CtR_t, the national contribution rate for the pay-as-you-go program:

$$(32)\quad \sum_{j} Pop_{j,gn,t} Pens_{j,gn,t} = CtR_t \sum_{j}\sum_{gj} Pop_{j,gj,t} LInc_{j,gj,t}$$

Region j's foreign trade in goods at time t

All agents within region j make use of a composite good indexed s, which is priced at $P_{j,s,t}^{c}$. The aggregate demand for a specific good is divided by adding-up individual demands, including the intermediate good input demand, the consumption of the population, investment and government spending:

$$(33)\quad \sum_{ss} XS_{s,j,ss,t} + \sum_{g} Pop_{j,t,g} ConS_{j,s,g,t} + InvS_{j,s,t} + GovS_{j,s,t}$$

The traditional Armington assumption is used here to allocate this demand between regions. That is, although individual producers are microscopic price takers, goods of sector s are assumed differentiated in demand by their geographic origin. A fictitious importer accordingly chooses the optimal basket of domestic and interregional/international goods in each sector, using a CES $(E_{ii,j,s,t}; \alpha^{E}_{ii,j,s}\ \sigma^{c}_{j,s})$ aggregator. The price $P^{c}_{j,s,t}$ can be expressed as a function of each supplying region's producer price $P_{j,s,t}$:

$$(34) \qquad P^{c}_{j,s,t}{}^{1-\sigma^{c}_{j,s}} = \sum_{ii} \alpha^{E}_{ii,j,s} P_{ii,s,t}{}^{1-\sigma^{c}_{j,s}}$$

And the associated demand system is:

(35)

$$E_{ii,j,s,t} = \alpha^{E}_{ii,j,s} \left[\frac{P^{c}_{j,s,t}}{P_{ii,s,t}} \right]^{\sigma^{c}_{j,s}} \left\{ \sum_{ss} XS_{s,j,ss,t} + \sum_{g} Pop_{j,t,g} ConS_{j,s,g,t} + InvS_{j,s,t} + GovS_{j,s,t} \right\}$$

$E_{ii,j,s,t}$ is the demand at time t by region j, for good s produced in region ii. The share parameter α determines the proportion of region j's demand for specific good s of total aggregate demand for good s. The extents to which changes in relative prices modify the composition of the demand depend on the substitution elasticity σ. For instance, if the price of good s produced in region ii decline with respect to the price of the same good produced in other regions, region j's demand for good s through all regions will increase.

The rest of the world at time t

The rest of the world serves to close the model. It is described by a reduced form: its prices and income are exogenously held constant. The rest of world's demand for region j's good s depends on the region's sectorial competitiveness, which depends on the scaling parameter $Sc^{E}_{j,row,s}$ and substitution elasticity η_s.

$$(36) \qquad E_{j,row,s,t} = Sc^{E}_{j,row,s} \left[\frac{P_{row,s,t}}{P_{j,s,t}} \right]^{\eta_s} \qquad \eta_s > 0$$

Consistent with the reduced from description of the rest of the world, it is assumed that the rest of world neither borrows nor lends internationally, so that its trade with the Canadian economy as a whole is calibrated as balanced, and remains such at all t:

$$(37) \qquad \sum_{ii}\sum_{s} P_{ii,s,t} E_{ii,row,s,t} = \sum_{s} P_{row,s,t} \sum_{ii} E_{row,ii,s,t}$$

To describe the equation in words, we can say that at all *t*, the total value of the rest of world's imports from Canada equals the total value of exports towards Canadian regions from the rest of the world.

Equilibrium Conditions

--Market Clearing for goods:

The model assumes that all markets are perfectly competitive. The equilibrium condition for the market for goods states that in each region output (supply) must be equal to total demand.

$$(38) \qquad Z_{j,s,t} = \sum_{ii} E_{j,ii,s,t}$$

The stocks of labour and physical capital are considered immobile across regions, so a market exists for these two factors of production. The stock of effective labour is the number of individuals times their corresponding productivity level.

--Full employment of labour:

$$(39) \qquad \sum_{gj} Pop_{j,gj,t} L^{sup}_{j,itype,iprof,iqual,gj} EP_{gj} = \sum_{s} L^{qual}_{j,s,itype,iprof,iqual,t}$$

--Full employment of capital:

$$(40) \qquad Kstock_{j,t} = \sum_{s} K^{dem}_{j,s,t}$$

--Full integrated asset markets:

As bonds and capital shares are perfect substitutes, expected returns on bonds equal expected return on capital shares.

(41) $$\frac{R\text{int}J_{j,t}P^{Gov}_{j,t+1}}{P^{Gov}_{j,t}} = R\text{Re}t_{j,t+1}$$

As financial capital is assumed perfectly mobile across regions, an interest parity condition applies across regions.

(42) $$R\text{int}_t = \frac{R\text{int}J_{j,t}P^{Gov}_{j,t+1}}{P^{Gov}_{j,t}}$$

This completes the model's description. As the regional markets for financial assets are fully integrated, supply must equal demand. It is easy to check that the model implies asset market clearing at each t:

(43) $$\sum_j \sum_g Pop_{j,g,t} Lend_{j,g+1,t+1} = \sum_j P^{Gov}_{j,t} Bond_{j,t+1} + P^{Inv}_{j,t} Kstock_{j,t+1}$$

Prices of the rest of the world are chosen as numéraire. A static (steady state) version of the model is easily found by setting t-1= t = t+1 in all equations.

V. Data and calibration

The goal of the calibration is to fit a long run macroeconomic steady state consistent with many detailed microeconomic concerns. The challenge is to build a Social Accounting Matrix (SAM) constrained by the preference patterns of the different age groups, the sectoral and regional production, and the distribution of different types of professions and skills. The SAM must be consistent with macroeconomic aggregates such as regional output, consumption, investment, and inter-regional trade data flow. What is more, the calibration procedure must guarantee an inter-temporal consistency of the model since the model is dynamic and characterized by an overlapping generations structure. For example, individual consumption and savings decisions must be compatible with aggregate inter-temporal prices such as the rate of interest. In addition, the amount of savings must be sufficient to cover the stocks of assets existing in the economy. As this is a model that contains many regions, sectors, age groups and types of professions and labour skills, to ensure consistency between all macroeconomic and microeconomic data

coming from different sources is a very challenging task. In the following, we explain the data sources and calibration procedure.

There are seven regions in the model: the rest of world (RoW) and six Canadian regions. They are respectively: the Atlantic provinces (ATL) composed of Newfoundland, Nova Scotia, New Brunswick, the Price Edward Island; the province of Quebec (QUE); the province of Ontario (ONT); the Prairies (PRA) composed of Manitoba, Saskatchewan, North West Territories and the Nunavut; the province of Alberta (ALB); the British Columbia region composed of the British Columbia province and Yukon.

The inter-regional trade flows were taken from the 1999 Interprovincial and International Trade Flows Matrix calculated by Statistics Canada.[16] The model contains 14 sectors in each region. Table 1 summarizes the aggregation rule applied to the large Statistic Canada Table:

Table 1. Sectors of the Economy

	Model Acronym
1. Primary	PRI
2. Manufacture and Public Utility	MAN
3. Construction	CST
4. Transport and Storage	TRA
5. Communication	COM
6. Wholesaling and Retailing	CGD
7. Finance, Insurance and Real Estate Services	FAI
8. Professional Services to Firms and Publicity	SEP
9. Computer and other Services to Firms	ICS
10.Public Administration	ADM
11. Education	EDP
12. Health	SAN

[16] Statistics Canada, Systems of National Accounts, Input-Output Division, Table 386-001

13. Accommodation and Leisure Services	HRD
14. Other Services	AUT

One of the original elements of the model is the specification of labour into many categories of professions and skills. The categories were defined by the National Occupational Classification Matrix 2001 supplied by Human Resources and Development Canada (HRDC). Table 2 summarizes the ten different professions and five skill levels of the matrix. (See the category for the occupation types in Appendix A1)

Table 2. Professions and Qualification Levels

Professions
1. Business, finance and administration occupations
2. Natural and applied sciences and related occupations
3. Health occupations
4. Occupations in social science, education, government service and religion
5. Occupations in arts, culture, recreation and sport
6. Sales and services occupations
7. Trades, transport and equipment operators and related occupations
8. Occupations specific to primary industry
9. Occupations specific to processing, manufacturing and utilities
10. Management
Qualification Levels
1. Management occupation
2. Occupations that usually require university education
3. Occupations that usually require college education or apprenticeship training
4. Occupations that usually require secondary school and/or occupation specific training
5. On-the-job training is usually provided for these occupations

Some calibrated values for parameters and variables are reported in Table 3. Canadian GDP is normalized to one so that regional GDPs in Table 3 are shares of national activity

generated in each region. Government debt and public expenditures (on health care and on education) are reported with respect to regional GDP. We can note that in the table, the debt-GDP ratios are particularly small in the ALB and BCO. Public health care with respect to GDP is distributed unevenly through the whole country but is always larger than public education in all regions. The capital tax is higher than two other tax rates everywhere in Canada and reaches its maximum in Ontario (ONT).[17]

Table 3. Parameters and Exogenous Variables

	ATL	QUE	ONT	PRA	ALB	BCO
GDP	.057	.213	.414	.069	.120	.127
Government Debt/GDP	.422	.433	.288	.226	.018	.110
Public Health Care/GDP	.077	.066	.053	.066	.045	.070
Public Education/GDP	.060	.052	.032	.039	.041	.045
Wage tax rate	.318	.374	.313	.295	.304	.318
Capital tax rate	.382	.478	.562	.407	.384	.446
Consumption tax rate	.234	.219	.200	.193	.137	.199

Because of the lack of statistical evidence on regional differences, many parameters are assumed identical across the country. Particularly, the household preferences are, in the sense that both the inter-temporal and inter-regional elasticities of substitution, as well as bequest rates are common to all regions. As shown in Table 4, we choose the value of the inter-temporal elasticity of substitution $1/\theta$ as 0.175, slightly lower than the 0.25 used by Auerbach and Kotlikoff (1987). As no literature is available for the value of inter-regional elasticities of substitution ($\sigma^{Con}_{j,s}$, $\sigma^{Inv}_{j,s}$, $\sigma^{Gov}_{j,s}$), we choose a reasonable average value of 2.5. The bequest parameter (BeqR) was set equal to 0.40; the inheritance rate (InhR) was set to 0.20 as private bequests are assumed equally distributed among the working age groups. The pension replacement rate (PenR) was set to 0.30. The various labour demand substitution elasticities ($\sigma^{Ldem}_{j,s}$, $\sigma^{Ltype}_{j,s,itype}$, $\sigma^{Lqual}_{j,s,iqual}$) were inferred from

[17] Regional GDP is for 1998 and was taken from Statistics Canada, Cansim Matrix 9014-9024; effective tax rates from Charbonneau (1997); public debt, health care and education spending were calculated from data supplied in King and Jackson (2000).

Mercenier and Mérette (2002). The elasticity across types of occupations ($\sigma^{Ldem}_{j,s}$) is assumed to be 0.5 and identical across any combination of two of the three types of labour. Since professions of type 2 are more heterogenous and more knowledge specific, the elasticity for itype=2 is 1.3, the smallest of all. And the elasticities for itype1 and itype3 are 2.0 and 2.5 respectively, as it is assumed that it is relatively more difficult for firms to substitute among professions of type 1 than of type 3. Furthermore, as it is reasonable to believe that the labour demand elasticity across qualifications is greater than across occupations, the labour demand elasticity across qualifications ($\sigma^{Prof}_{j,s,iprof}$) is set to 3.0 in this model. The elasticity of substitution for intermediate goods ($\sigma^{X}_{j,s}$) is set to 2.0 and is assumed to be identical for all regions and sectors. A necessarily calibrated interest rate (*R*int) to generate large enough life-cycles savings to match data on stocks of physical capital and government bonds in Canadian economy[18] is set to 3.8 percent and is applied in all regions as financial assets are perfectly substitutable and mobile across regions. Finally, the calibrated depreciation rate equals 5.1 percent, whereas the export price elasticities (η_s) to the RoW are set to be 5.0 in all sectors.[19]

Table 4. Parameters common to all regions

$1/\theta$	.175	$\sigma^{Ldem}_{j,s}$	0.5
$\sigma^{Con}_{j,s}$	2.5	$\sigma^{Ltype}_{j,s,itype}$, *itype*=1	2.0
$\sigma^{Inv}_{j,s}$	2.5	$\sigma^{Ltype}_{j,s,itype}$, *itype*=2	1.3
$\sigma^{Gov}_{j,s}$	2.5	$\sigma^{Ltype}_{j,s,itype}$, *itype*=3	2.5
$\sigma^{c}_{j,s}$	3.0	$\sigma^{Prof}_{j,s,iprof}$	3.0
BeqR	.40	$\sigma^{X}_{j,s}$	2.0
InhR	.25	*R*int	.038

[18] In their pioneer computable OLG work, Auerbach and Kotlikoff (1987) use an interest rate equal to 7.3 percent.

[19] It is clear form the model description that the RoW plays no role here other than to match base year data; therefore, adopting high export price elasticity values is both realistic and consistent with the model structure.

PensR	.3	*DepR*	.051
η_s	5		

With assumed perfectly identical preferences across Canada, spending shares with respect to various industrial goods and services are also identical across the country. However, the spending shares differ along the lifestyle. Table 5 reports the spending shares for the six age groups of the model which are calculated using the 1999 consumers' spending survey data of Statistics Canada. Note that the shares in each column of Table 5 sum to one.

Table 5. Spending shares by age group (%)

Age-group	15-24	25-34	35-44	45-54	55-64	65-85
PRI	2.9	3.2	3.3	3.5	3.9	3.8
MAN	22.8	18.4	19.2	19.0	19.1	20.8
CST	16.8	16.5	14.8	12.2	11.5	12.7
TRA	4.6	3.2	3.0	3.1	3.1	2.9
COM	2.5	1.9	1.7	1.6	1.8	2.1
CGD	14.0	11.3	11.8	11.6	11.7	12.7
FAI	3.9	8.4	8.6	9.4	8.6	6.2
ADM	13.0	24.2	24.5	26.0	24.4	19.4
SEP	0	0	0	0	0	0
ICS	0	0	0	0	0	0
EDP	3.1	1.0	0.7	1.3	0.8	0.1
SAN	1.1	0.8	1.1	1.3	1.6	2.6
HRD	9.1	7.2	6.8	6.8	7.5	8.0
AUT	3.0	3.7	4.4	4.1	5.9	8.7

From that survey, goods and services were gathered into the 14 types of goods included in this model. Moreover, a SAS simulation program has been used to calculate consumption behavior parameters of the six different age groups consumers of the model.

Of the results shown in Table 5, a few observations deserve attention. **1**, consumers' spending shares equal zero in the SEP and ICS sectors inspective of the age group, since these sectors refer to services to enterprises who uses these goods as inputs. **2**, spending in some sectors is very sensitive to the age group. For example, young people spend more on education (EDP) while the middle age group spend more on finance, insurance and real estate services (FAI). Obviously, elder people spend more on health care (HRD) than the other age groups. It is worth noting that because of the public funding of education and health care services in Canada, the size of their spending shares here, which reflects private spending only, is relatively small. **3**, government expenditures are divided into four types: health (HRD), education (EDP), construction (CST), and administration (ADM) as a residual. This permits to capture the nature of current government expenditures. However, it does not make these expenditures sensitive to changes in the composition of the population. We will discuss this issue further below.

While a country's demographic structure changes, public health and education expenditures will both alter throughout the process of aging. Obviously, the sensitivity will depend on the distribution of these expenditures per age group, which is reported in Table 6. The distribution is assumed identical across regions. We can notice from the table that the public health care expenditure is increasing in age. While an individual of age group 15-24 receives 6 percent of each per capita dollar spent in public health care, an individual of age 65-84 receives as much as 36.0 percent. In contrast, what individuals receive in education is decreasing as they become older. In other words, health care is concentrated among the older age groups, whereas education expenditure clusters in the youngest and middle age groups.

Table 6. Public expenditure per age group (Dollar share per capita, %)

Age-group	15-24	25-34	35-44	45-54	55-64	65-84
Health	6.0	8.0	10.0	15.0	25.0	36.0
Education	26.0	40.0	20.0	7.0	5.0	2.0

In order to ensure a macroeconomic equilibrium, we must have data for both the supply and demand sides. For the supply side of the economy, it is easier to find published data (for example, output, capital stock, and labour) than for households' behavior. For this reason, the calibration of the model is mainly based on the demand side. It includes the determination of the life-cycle consumption profile, the consumer's rate of time preference, and government expenditure besides those for health care and education. To begin with, we calibrate these aggregate variables to be consistent with steady state equilibrium and the base year dataset. Then we adjust the sectoral structure of consumption baskets across age groups accordingly. The structure of wealth portfolios is determined in a similar fashion. It is assumed that all age groups have the same portfolios structure.

VI. Regional demographic projections

Aging will affect Canadian regions disproportionately. When looking at projections of the future demographic structure for the six Canadian regions by Mercenier and Mérette (2002), we should note: In 2000, which is the base year, the middle age individuals, who are the baby boomers, represent the most important age group in all regions across Canada. But in 2020 and early 2030, the 65-85 age group becomes the largest group in all six Canadian regions. However, different regions have different aging intensities. For example, in 2030, the old dependency ratio reaches 45 percent in the Atlantic region, and 42.8 percent in Quebec. These two regions have the fastest aging process. Comparatively, Ontario has smaller old dependency ratio, reaching 34 percent, and 35.5 percent in the Prairies and Alberta, and 37.1 percent in British Columbia.[20]

The simulation experiments will consist in changing the composition of the population to match that projected by demographers for the next two decades, say, 2020. Final and intermediate demands will thus be affected and we will analyze the inter-regional, inter-sectoral and occupational effects arising from these changes.

[20] Mercenier and Mérette. "The Economic Impact of Aging on Production Sectors and Occupations in Six Canadian Regions", 2002, pp 21

VII. Simulation results

The computable model is solved using the General Algebraic Modeling System (GAMS) software. We first report the baseline scenario. Then we concentrate on the issue of education expenditure and immigration.

A. Baseline scenario

To investigate the inter-regional, inter-sectoral, and inter-occupational effects arising from the shifts in aggregate consumption demand due to population aging in Canada, by assuming that labour supply and the capital stock are constant at the regional level in simulation experiments, we can control for macroeconomic effects and thus isolate demand from supply effects. Thus, the development of the aggregate demands will involve relative changes across regions, sectors and occupations rather than aggregate changes. This strategy ensures the link between the simulation results and the demand side effects rather than with a mix of both supply and demand effects.

In the model, regional GDPs respond only to inter-sectoral reallocation that follows changes in relative prices. In Table 7 below, we report regional percentage changes in GDP in 2020 with respect to the benchmark year 2000. We can see that though unevenly distributed, only small relative changes occur in GDP when labour and capital are held constant at the regional level.

Table 7. GDP, percentage change with respect to baseline year

Regions	ATL	QUE	ONT	PRA	ALB	BCO
2020	1.78	1.18	-0.04	-0.51	4.04	0.30

The total population in each region is maintained constant so that only the relative size of the different age groups changes. The shock imposed on the base year 2000 is equivalent to a change in household preferences at the aggregate level combined with a sectorial reallocation of government expenditures that reflects the new priorities of the government

given the change in the composition of the population. The results reported in the tables below are presented in different terms with respect to the 2000 benchmark year.

Output

The percentage changes in real output by sectors of production with respect to the base year data are reported in Table 8. The figures show that there are major changes in real output for the education and health care sectors. Although total factors of production at the regional level to their initial level are fixed, the changes of real output for health care services (*SAN*) and education (*EDP*) are two of the greatest in absolute value for year 2020. While being around 10 percent for all regions, in some regions such as in the Atlantic and Alberta regions, output changes are close or even greater than 15 percent. Also, we find that in all regions, the health services (*SAN*), the transport and storage (*TRA*), the communication (*COM*), and the primaries (*PRI*) have larger positive changes. The accommodation and leisure services (*HRD*) increase too, especially in the Atlantic, Quebec and Alberta regions. In contrast, the construction (*CST*) and the education (*EDP*) sectors have negative real output changes with respect to the base year data.

Table 8. Output Changes, year 2020 (percentage changes w.r.t baseline year)

Sectors	ATL	QUE	ONT	PRA	ALB	BCO
PRI	3.34	3.75	4.58	4.98	0.92	4.63
MAN	1.50	1.22	2.39	3.15	0.93	2.29
CST	-2.59	-2.00	-3.21	-4.16	-2.10	-3.25
TRA	4.13	3.52	3.41	4.50	2.72	3.26
COM	4.78	4.36	1.91	1.50	10.74	3.08
CGD	-0.72	-0.46	-0.31	-0.11	1.82	0.04
FAI	2.03	0.19	-1.00	-0.68	4.87	-0.59
SEP	0.07	0.20	0.95	0.46	-1.94	0.43
ICS	-0.17	0.06	0.96	0.47	-2.12	0.40
ADM	0.79	0.53	0.49	0.24	1.81	-0.13
EDP	-15.8	-12.25	-9.10	-8.20	-10.53	-10.70
SAN	14.55	13.64	7.44	7.60	15.04	9.89
HRD	6.59	4.39	1.87	1.49	7.83	1.77
AUT	3.23	2.22	0.78	-0.31	4.74	1.42

Occupational wages

We assume that labour markets are in equilibrium and that labour supply is exogenous to the model. Thus the relative scarcity of labour translates into changes in the relative wage rates, which have been normalized to one in the base year so that figures reported in Table 9 are indices. As for output prices, wage rates were all normalized to unity in the benchmark year. We can see from these tables, health occupations (Prof 3) will benefit large increases in wages for all skill levels (Qual2, Qual3, and Qual4). In contrast, relative wages for occupations in trades, transport, and equipment operators and relative occupations (Prof 7) will be hurt by changes in demand induced by population aging, especially at the lowest skill level (Qual5).

In the simulation exercises, we control for supply side effects. Thus the relative wage changes reported in Table 9 abstract from the expected decline in the growth rate of aggregate labour supply. The relative wage changes are important and signal sizeable adjustment challenges to come in the labour market because the numbers reported only reflect inter-sectoral reallocation effects.

Table 9. Wage indices by occupation, year 2020

Iprof	*Iqual*	ATL	QUE	ONT	PRA	ALB	BCO
Prof1	Qual2	1.02	1.01	1.00	0.99	1.04	1.00
Prof1	Qual3	1.02	1.01	1.00	0.99	1.05	1.00
Prof1	Qual4	1.02	1.01	1.00	0.99	1.05	1.00
Prof4	Qual2	1.02	1.01	1.00	0.99	1.05	1.00
Prof4	Qual3	1.02	1.02	1.00	0.99	1.05	1.01
Prof10	Qual1	1.02	1.01	0.99	0.99	1.04	1.00
Prof2	Qual2	1.03	1.02	1.01	1.00	1.05	1.01
Prof2	Qual3	1.03	1.02	1.01	1.00	1.05	1.01
Prof3	Qual2	1.07	1.06	1.03	1.02	1.12	1.05
Prof3	Qual3	1.08	1.06	1.03	1.02	1.12	1.05
Prof3	Qual4	1.08	1.05	1.03	1.02	1.13	1.05
Prof5	Qual2	1.04	1.02	1.01	1.00	1.07	1.02
Prof5	Qual3	1.04	1.02	1.01	1.00	1.07	1.02

Prof6	Qual3	1.04	1.02	1.00	1.00	1.08	1.01
Prof6	Qual4	1.04	1.02	1.00	1.00	1.08	1.02
Prof6	Qual5	1.03	1.02	1.00	1.00	1.08	1.02
Prof7	Qual3	0.99	0.99	0.97	0.97	1.01	0.98
Prof7	Qual4	1.00	1.00	0.98	0.98	1.01	0.99
Prof7	Qual5	0.99	1.00	0.97	0.97	1.01	0.98
Prof8	Qual3	1.01	1.02	1.00	1.00	1.02	1.00
Prof8	Qual4	1.01	1.02	1.01	1.00	1.01	1.00
Prof8	Qual5	1.00	1.01	0.99	0.98	1.02	0.99
Prof9	Qual3	1.00	1.00	1.00	1.00	1.01	1.00
Prof9	Qual4	1.00	1.00	1.00	1.00	1.01	1.00
Prof9	Qual5	1.00	1.00	1.00	1.00	1.01	1.00

Sensitivity analysis for occupation elasticities

When the labour demand elasticity across qualifications ($\sigma^{Prof}_{j,s,iprof}$) increases from 3 to 4, the effect on wage rates across professions is more spread out. It is not surprising to find the opposite results when we adjust the labour demand elasticity across qualifications downward (from 3 to 2). (See Appendix A3a and A3b)

When all labour demand elasticities across different types ($\sigma^{Ltype}_{j,s,ityp}$) increases by 20 percent (now they are 2.4 for type 1, 1.56 for type 2 and 3.0 for type 3), wage rates change in opposite directions. In other words, now it is easier for firms to substitute among professions of all types and some occupations benefit while others lose from this change. Specifically, the wage rates decreases in business, education, health, arts and primary industries. And sales, management, and applied sciences see an increase in wage. (See Appendix A3c)

But the above results show very small changes, some even not noticeable. When we change the magnitude of the labour demand elasticity across types ($\sigma^{Ltype}_{j,s,itype}$) between type 2 and type 3, (that is, the labour demand elasticity for type 2 increases while that for type 3 decreases; now they are 2 for type 1, 2.5 for type 2 and 1.3 for type 3), we find that the education (Prof4) wage decreases while applied science (Prof2), primary industries (Prof8) and manufacturing (Prof9) increase. For type 1, although the elasticity across types does not change, occupation wages are still affected by the change in magnitude

between types 2 and 3, and in a larger amount compared to previous experiments. (Refer to Appendix A2d)

Judging from these four experiments on labour demand elasticity, we find that while the absolute value of the elasticity does not matter much, the order of magnitude of elasticities can cause larger changes in wage rates. Up to now, we analyze changes in the relative scarcity of labour qualifications through changes in relative wage rates. Thus, in all the experiments, the excess labour demand does not change at all. Strictly speaking, the wage rate change is the only correct measure of relative scarcity.

Projecting future labour imbalances

Up to now, the model has assumed that labour markets balance. As population ages, we expect that wage-rental rates and aggregate demands will change correspondingly. As a result, firms will attempt to adjust their production technologies by substituting capital to labour. Since the demographic shock will affect each labour type differently, the relative scarcity across professions and qualifications will also be affected. It can be predicted that the substitution of some qualified labour factor to some other categories of labour factor will result. We can read changes in relative scarcity of labour qualifications through changes in relative wage rates after comparing the new equilibrium to the old one as we did up to now. We believe it is the only correct measure of relative scarcity in terms of labour markets imbalance.

Hence, we report the results of the following experiments. The original equilibrium condition freezes the relative prices of all primary factors at their pre-shock equilibrium level, and then we modify the model and substitute to the labour market equilibrium conditions. We get some measures of the excess labour demands or supplies that might result from the demographic shock by this mean. Note that, because households' budget constraints cannot be satisfied, the numbers reported in the tables are not entirely meaningful. In the experiment, firms hire as much labour as they feel profitable given the relative prices they face, and produce goods with this labour, even though it might be in fact unavailable and hence the experiment may overestimate excess labour demand. The labour earnings that enter the households' budget constraints depend on the amount of

labour the household supplies. But by relaxing the labour market equilibrium condition, labour supply only appears in the model through the budget constraints of households. As a result, there is income leakage and Walras' law is not satisfied anymore.

In Tables 10 we report the excess demands of each category of labour qualifications within occupations, measured as a percent of the base employment level. It is clear from these tables that the demographic shock will affect very differently two groups of regions within Canada: excess labour demands are larger in the Atlantic Provinces, Alberta, Quebec and British Columbia, as opposed to Ontario and the Prairies. Similarly, labour excess demands will be more intensive in the health profession (Prof3) in every region and in every decade investigated. Consistent with the relative wages effects, excess labour demands will be absent for occupations such as low skilled trades, transport and equipment operators and related occupations (Prof7-Qual5).

Table 10. Excess Labour Demands, year 2020 (as percentage of initial employment)

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	-0.44	-0.25	-0.28	-0.20	-0.27	-0.19
Prof1	*Qual3*	-0.40	-0.42	-0.24	-0.24	-0.22	-0.26
Prof1	*Qual4*	-0.39	-0.41	-0.28	-0.22	-0.25	-0.28
Prof4	*Qual2*	-0.86	-0.71	-0.61	-0.36	-0.51	-0.54
Prof4	*Qual3*	0.05	0.42	0.489	0.31	0.89	0.89
Prof10	*Qual1*	-0.31	-0.27	-0.21	-0.17	-0.12	-0.20
Prof2	*Qual2*	-0.50	-0.39	-0.27	-0.28	-0.34	-0.23
Prof2	*Qual3*	-0.57	-0.45	-0.34	-0.31	-0.41	-0.39
Prof3	*Qual2*	3.96	4.78	2.57	2.11	4.67	4.33
Prof3	*Qual3*	6.72	4.39	2.88	1.90	4.37	3.17
Prof3	*Qual4*	6.70	2.92	3.62	4.31	6.91	4.87
Prof5	*Qual2*	-0.35	-0.29	-0.29	-0.23	-0.29	-0.29
Prof5	*Qual3*	-0.43	-0.41	-0.29	-0.14	-0.35	-0.11
Prof6	*Qual3*	-0.34	-0.35	-0.33	-0.28	-0.33	-0.42

Prof6	*Qual4*	-0.01	-0.08	-0.07	-0.04	0.10	0.17
Prof6	*Qual5*	0.05	-0.02	0.00	0.09	0.14	0.10
Prof7	*Qual3*	-0.22	-0.30	-0.19	-0.16	-0.16	-0.29
Prof7	*Qual4*	-0.25	-0.24	-0.16	-0.10	-0.12	-0.16
Prof7	*Qual5*	-0.40	-0.64	-0.30	-0.30	-0.38	-0.46
Prof8	*Qual3*	-0.12	-0.03	-0.06	-0.10	-0.10	-0.14
Prof8	*Qual4*	-0.18	-0.04	-0.08	-0.09	-0.01	-0.11
Prof8	*Qual5*	-0.48	-0.45	-0.41	-0.35	-0.27	-0.33
Prof9	*Qual3*	-0.05	0.02	0.00	-0.05	-0.06	-0.01
Prof9	*Qual4*	-0.04	0.01	0.00	0.00	-0.04	-0.01
Prof9	*Qual5*	-0.01	0.04	0.02	0.05	-0.01	0.01

B. Education and immigration impact on labour market

We now conduct experiments in order to analyze the education and immigration impacts on the labour market. We use the model to project wage changes and future labour market imbalances caused by different scenarios on education and immigration. We start with various scenarios regarding the sensitivity of public expenditure in education with respect to the different age groups. The DE (the public expenditure share per age group for education reported in Table 5) distribution composition and changes we made are shown in Table 11.

Table 11. DE distribution in three scenarios

Age group	G1524	G2534	G3544	G4544	G5564	G6585
DE original data set	0.26	0.40	0.20	0.07	0.05	0.06
DE more post-sec. edu.	0.36	0.35	0.15	0.07	0.05	0.02
DE life long training	0.20	0.30	0.20	0.16	0.12	0.02

1. More post secondary education investment scenario

Assuming that more households will increase their investment on post secondary education in a knowledge-based economy, we could represent this potential change by making the DE distribution more intensive during the first two period of life, say, from 15-34. So the government now spends more on post secondary education relative to basic

education. The simulation results show very small downward changes for wages for occupations in education and in government service sectors, and only Ontario manages to maintain the predicted wage rate level. Meanwhile, the other wage rates almost do not change. (See the table 12)

Table 12. Wage changes w.r.t. baseline scenario (2020): More post-secondary education investment DE: 0.36, 0.35, 0.15, 0.07, 0.05, 0.02

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof4	*Qual2*	-0.0002	-0.0001	0.0000	-0.0001	-0.0001	-0.0001
Prof4	*Qual3*	0.0000	-0.0001	0.0000	0.0000	0.0000	-0.0001

When we fix the change of wages, the results indicate again small impacts on education's excess labour demand (See Table 13).

Table 13 Excess labor demand changes w.r.t. baseline scenario (2020): More post-secondary education investment DE: 0.36, 0.35, 0.15, 0.07, 0.05, 0.02

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.0002	-0.0082	0.0004	-0.0036	0.0022	-0.0105
Prof1	*Qual3*	0.0005	-0.0050	0.0008	-0.0029	0.0041	-0.0097
Prof1	*Qual4*	0.0003	-0.0067	0.0007	-0.0058	0.0016	-0.0129
Prof4	*Qual2*	-0.0255	-0.0327	-0.0008	-0.0344	-0.0570	-0.0499
Prof4	*Qual3*	-0.0874	-0.0290	0.0002	-0.0115	-0.0066	-0.0106
Prof10	*Qual1*	0.0064	0.0099	0.0010	0.0064	0.0245	0.0075
Prof2	*Qual2*	0.0004	-0.0084	0.0004	-0.0042	-0.0009	-0.0101
Prof2	*Qual3*	0.0014	-0.0011	0.0006	-0.0003	0.0059	-0.0041
Prof3	*Qual2*	-0.0004	-0.0008	0.0001	-0.0012	-0.0012	-0.0014
Prof3	*Qual3*	-0.0003	-0.0010	0.0000	-0.0012	-0.0012	-0.0012
Prof3	*Qual4*	-0.0004	-0.0012	0.0000	-0.0007	-0.0014	-0.0009
Prof5	*Qual2*	-0.0165	-0.0158	0.0000	-0.0215	-0.0329	-0.0296
Prof5	*Qual3*	-0.0098	-0.0122	0.0003	-0.0114	-0.0115	-0.0401
Prof6	*Qual3*	0.0000	-0.0074	0.0009	-0.0046	0.0018	-0.0089
Prof6	*Qual4*	-0.2778	-0.0319	0.0000	-0.0535	-0.0345	-0.0172
Prof6	*Qual5*	-0.0264	0.0142	0.0385	-0.0113	-0.0147	-0.0078
Prof7	*Qual3*	0.0459	0.0529	0.0027	0.0504	0.0704	0.0353
Prof7	*Qual4*	0.0144	0.0319	0.0013	0.0290	0.0350	0.0264
Prof7	*Qual5*	0.0287	0.0188	0.0023	0.0248	0.0292	0.0215
Prof8	*Qual3*	0.0229	0.0576	0.0016	0.0109	0.0263	0.0179
Prof8	*Qual4*	0.0090	-0.0084	0.0000	0.0011	0.1509	0.0063
Prof8	*Qual5*	0.0068	0.0040	0.0010	0.0020	0.0089	0.0066
Prof9	*Qual3*	0.0189	0.0065	-0.0833	-0.0022	0.0108	0.0759

Prof9	*Qual4*	0.0229	0.1061	0.0000	5.0000	0.0200	0.0412
Prof9	*Qual5*	-0.0161	-0.0081	-0.0051	-0.0038	-0.0438	0.0000

2. Life long training scenario

We now suppose that population aging will push people to try to conduct life long training to follow technology development. This decision will expand their working expectancy and probably improve their labour earnings. Public expenditure in education is now distributed more evenly. (We change the DE to DE: 0.20, 0.30, 0.20, 0.16, 0.12, 0.02) From the results reported in table 14, we see that all wages in the education sector increase under this scenario. And the industries which lose from the change are those mainly in type 3 occupations (Prof7, Prof8 and Prof9), including primary, trade and manufacturing etc.

Table 14 Wage changes w.r.t. baseline scenario (2020): Life long training scenario DE: 0.20, 0.30, 0.20, 0.16, 0.12, 0.02

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.0002	0.0002	0.0000	0.0001	0.0001	0.0002
Prof1	*Qual3*	0.0002	0.0002	0.0000	0.0000	0.0001	0.0003
Prof1	*Qual4*	0.0002	0.0002	0.0000	0.0001	0.0001	0.0003
Prof4	*Qual2*	0.0008	0.0006	0.0005	0.0002	0.0008	0.0009
Prof4	*Qual3*	0.0005	0.0005	0.0003	0.0002	0.0004	0.0005
Prof10	*Qual1*	0.0001	0.0001	0.0001	0.0001	0.0000	0.0002
Prof2	*Qual2*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001
Prof2	*Qual3*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001
Prof3	*Qual2*	0.0001	0.0002	0.0000	0.0001	0.0002	0.0003
Prof3	*Qual3*	0.0001	0.0002	0.0000	0.0001	0.0003	0.0003
Prof3	*Qual4*	0.0001	0.0001	0.0001	0.0001	0.0004	0.0003
Prof5	*Qual2*	0.0003	0.0002	0.0000	0.0001	0.0003	0.0003
Prof5	*Qual3*	0.0002	0.0002	0.0001	0.0001	0.0002	0.0002
Prof6	*Qual3*	0.0000	0.0001	0.0001	0.0000	0.0001	0.0002
Prof6	*Qual4*	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001
Prof6	*Qual5*	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001
Prof7	*Qual3*	-0.0005	-0.0006	-0.0003	-0.0002	-0.0005	-0.0005
Prof7	*Qual4*	-0.0004	-0.0004	-0.0003	-0.0001	-0.0003	-0.0004
Prof7	*Qual5*	-0.0006	-0.0005	-0.0003	-0.0002	-0.0005	-0.0004
Prof8	*Qual3*	-0.0002	-0.0002	-0.0001	-0.0001	-0.0003	-0.0003
Prof8	*Qual4*	-0.0002	-0.0001	-0.0001	-0.0001	-0.0002	-0.0003
Prof8	*Qual5*	-0.0004	-0.0004	-0.0002	-0.0001	-0.0003	-0.0002
Prof9	*Qual3*	-0.0002	-0.0003	-0.0001	-0.0001	-0.0003	-0.0002
Prof9	*Qual4*	-0.0002	-0.0002	-0.0001	-0.0001	-0.0002	-0.0002
Prof9	*Qual5*	-0.0001	-0.0002	-0.0001	-0.0001	-0.0001	-0.0002

Table 15 reports the excess labor demand changes under the life long training scenario. The excess labour demand for education increases in this scenario for business, applied science, management (Prof1, 2, 10) while those in type 3 and the excess demands decline. The increase in the excess labour demand in the education sector has the opposite trend compared to the *more post secondary* scenario. The largest increase in this case happens in Atlantic Provinces (ATL). We also find that the excess labour demand for the health occupation (Prof3) increases at all skill levels (Qual2, Qual3 and Qual4) under this scenario.

Table 15 Excess labor demand changes w.r.t. baseline scenario (2020): Life long training scenario DE: 0.20, 0.30, 0.20, 0.16, 0.12, 0.02

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	-0.0005	0.0335	0.0033	-0.0015	-0.0112	0.0523
Prof1	*Qual3*	-0.0007	0.0190	-0.0129	-0.0046	-0.0185	0.0471
Prof1	*Qual4*	-0.0010	0.0266	-0.0057	0.0045	-0.0080	0.0656
Prof4	*Qual2*	0.1650	0.1390	0.1292	0.0988	0.2585	0.2721
Prof4	*Qual3*	0.5772	0.1217	0.0354	0.0274	0.0296	0.0570
Prof10	*Qual1*	-0.0399	-0.0446	-0.0499	-0.0341	-0.1133	-0.0467
Prof2	*Qual2*	-0.0008	0.0352	0.0059	0.0018	0.0032	0.0503
Prof2	*Qual3*	-0.0080	0.0029	-0.0178	-0.0090	-0.0269	0.0186
Prof3	*Qual2*	0.0026	0.0033	0.0031	0.0020	0.0053	0.0073
Prof3	*Qual3*	0.0021	0.0043	0.0030	0.0020	0.0054	0.0065
Prof3	*Qual4*	0.0024	0.0049	0.0033	0.0016	0.0066	0.0050
Prof5	*Qual2*	0.1075	0.0662	0.0377	0.0563	0.1508	0.1607
Prof5	*Qual3*	0.0641	0.0514	0.0201	0.0199	0.0530	0.2120
Prof6	*Qual3*	0.0012	0.0303	-0.0043	0.0025	-0.0081	0.0447
Prof6	*Qual4*	1.7778	0.1299	0.1015	0.1123	0.1545	0.0922
Prof6	*Qual5*	0.1638	-0.0900	0.9231	0.0214	0.0644	0.0389
Prof7	*Qual3*	-0.2956	-0.2302	-0.2100	-0.1698	-0.3205	-0.1964
Prof7	*Qual4*	-0.0913	-0.1384	-0.1115	-0.0975	-0.1590	-0.1499
Prof7	*Qual5*	-0.1839	-0.0826	-0.1622	-0.0882	-0.1342	-0.1210
Prof8	*Qual3*	-0.1460	-0.2407	-0.1675	-0.0388	-0.1146	-0.1012
Prof8	*Qual4*	-0.0573	0.0449	-0.0035	-0.0103	-0.6132	-0.0366
Prof8	*Qual5*	-0.0440	-0.0187	-0.0341	-0.0169	-0.0408	-0.0387
Prof9	*Qual3*	-0.1071	0.0258	0.4167	0.0043	-0.0418	-0.3797
Prof9	*Qual4*	-0.1422	-0.4242	-0.0526	-13.000	-0.0923	-0.1856
Prof9	*Qual5*	0.0968	0.0538	0.0408	0.0208	0.2117	0.0758

3. The impact of immigration

It is reasonable to assume that most immigrants are in working-age and have more incentives to invest in education or training. Moreover, most of these investments are in post secondary education or training in order to transfer and enhance their human capital in the destination country. This can influence the demand for education occupation in the labour market. We use this model to conduct experiments under 5 scenarios based on different immigration conditions. The results are investigated in the following tests:

We first assume that immigration increases from the actual 0.75 percent to 1 percent a year, with a unchanging distribution of those immigrants across regions (that is, concentrated in Ontario and in British Columbia). The results regarding labour excess demand in Ontario is spectacular. The excess labour demand for education increases by 94 percent with respect to the baseline scenario. The increase in British Columbia is also significant (See the Appendix A5a, A5b-- first immigration scenario).

We then assume that immigrants locate in the different regions according to their respective population weights. The results are now quite different from the first experiment. The education (Prof4) wages increase in ONT and BCO only, and decrease in other regions (See Appendix A7a). It is worth noting that the excess labour demand of education (Prof4) has totally opposite trends between Qual2 and Qual3 in different regions (See Appendix A7b). For higher qualification (Qual 2), except British Columbia (BCO) and Ontario (ONT), all of the other four regions' excess labour demand rise. However, in lower qualification (Qual 3), the excess labour demand has the totally opposite trend compared with Qual 2. (See the Appendix A6a, A6b---second immigration scenario)

VIII. Conclusion

The upcoming demographic change is expected to have large macroeconomic as well as microeconomic implications. This paper uses a computable multi-good multi-region overlapping generations model to show how changes in the aggregate consumption

demands due to aging could alter output and occupations. Besides, the model offers a measure of the labour market imbalances that may accompany population aging. And we apply the model to the education and immigration effects on the future labour market in the context of an aging population. The simulation results show that those microeconomic effects on the labour market may be significant.

In those experiments we analyzed the impact of education, and could see that the shift of the public expenditure share per age group for education follow the change of the labour markets. And after considering the immigration factor, we get the conclusions that different immigration distributions have different impacts on the education excess labour demand.

The results suggest that private and public consumption demand changes due to aging will have significant inter-regional, inter-sectoral and occupational effects. The source of these effects are complex combination of factors that include, besides the demographic projections, the change of the choices in the consumption basket of goods over the lifecycle, the governments' spending reallocation priorities in the context of an aging population, the technology structures and the inter-regional trade flow matrix.

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Appendix

A1. Occupation Types

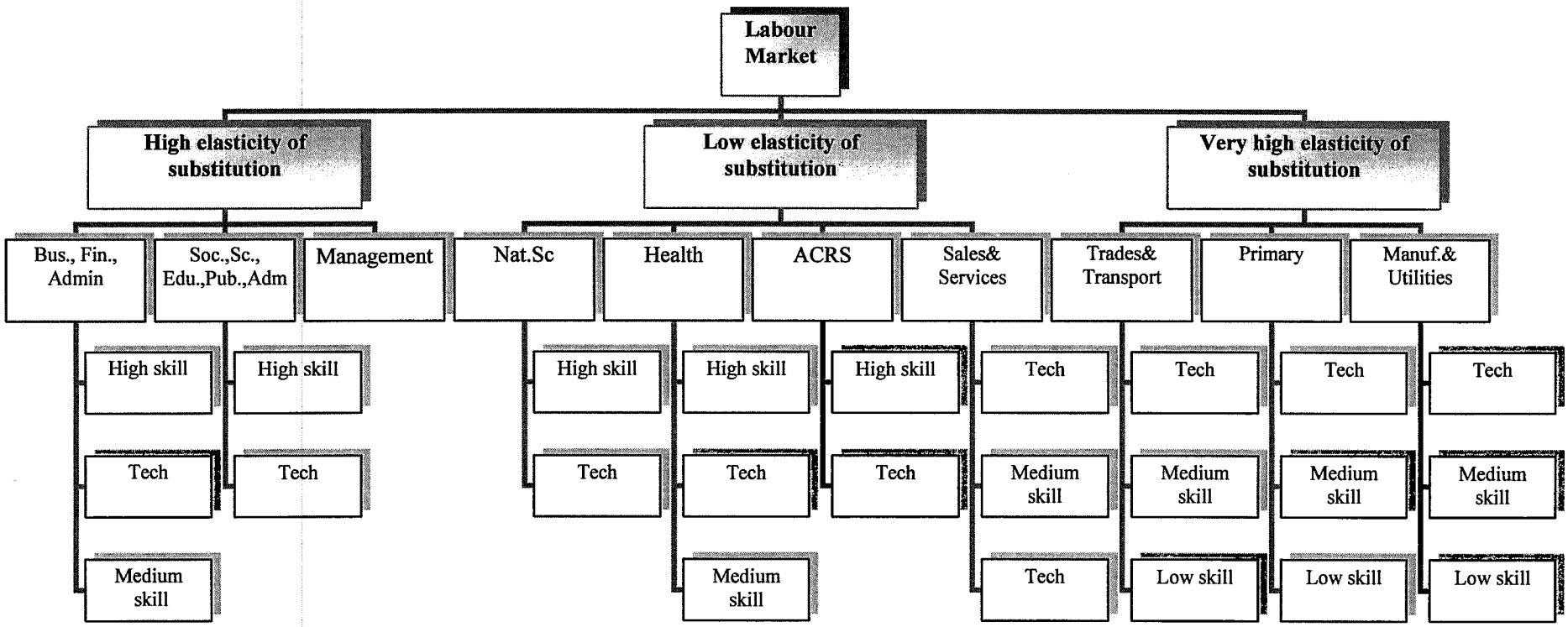
Type 1						
Profession 1				Profession 4		Prefession 10
Qual. 2	Qual. 3	Qual. 4	Qual. 5	Qual. 2	Qual.3	Qual.1

Type 2									
Prof. 2		Prof. 3			Prof. 5		Prof.6		
Qual.2	Qual.3	Qual.2	Qual.3	Qual.4	Qual.2	Qual.3	Qual.3	Qual.4	Qual.5

Type 3								
Profession 7			Profession 8			Profession 9		
Qual.3	Qual.4	Qual.5	Qual.3	Qual.4	Qual.5	Qual.3	Qual.4	Qual.5

Appendix 2

Structure of the labour market



A3a . Wage indices by occupations, year 2020 $\sigma^{Prof}_{j,s,iprof}$ increase from 3 to 4

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.0002	0.0004	0.0000	0.0003	0.0009	0.0002
Prof1	*Qual3*	0.0001	0.0000	0.0002	0.0002	0.0002	0.0003
Prof1	*Qual4*	0.0000	0.0000	-0.0001	-0.0001	-0.0004	-0.0001
Prof4	*Qual2*	0.0002	0.0003	0.0002	0.0001	0.0001	0.0003
Prof4	*Qual3*	-0.0005	-0.0009	-0.0005	-0.0002	0.0000	-0.0008
Prof10	*Qual1*	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000
Prof2	*Qual2*	0.0002	0.0000	0.0000	0.0000	0.0002	0.0001
Prof2	*Qual3*	-0.0001	0.0001	0.0002	0.0001	-0.0002	0.0001
Prof3	*Qual2*	0.0008	-0.0004	0.0002	0.0004	0.0003	-0.0001
Prof3	*Qual3*	-0.0013	-0.0006	-0.0001	0.0004	0.0009	0.0009
Prof3	*Qual4*	-0.0009	0.0009	-0.0001	-0.0012	-0.0016	-0.0003
Prof5	*Qual2*	-0.0004	-0.0001	0.0000	0.0000	-0.0011	-0.0001
Prof5	*Qual3*	0.0004	0.0002	0.0001	0.0001	0.0008	0.0001
Prof6	*Qual3*	0.0000	0.0000	0.0001	-0.0001	0.0003	0.0003
Prof6	*Qual4*	-0.0002	-0.0002	-0.0001	-0.0001	-0.0001	-0.0003
Prof6	*Qual5*	0.0004	0.0002	0.0002	0.0002	0.0000	0.0003
Prof7	*Qual3*	0.0005	0.0003	0.0003	0.0005	0.0004	0.0004
Prof7	*Qual4*	-0.0013	-0.0007	-0.0015	-0.0019	-0.0012	-0.0014
Prof7	*Qual5*	0.0007	0.0002	0.0014	0.0009	0.0002	0.0011
Prof8	*Qual3*	-0.0006	-0.0007	-0.0006	-0.0009	0.0002	-0.0004
Prof8	*Qual4*	-0.0005	-0.0012	-0.0023	-0.0014	0.0006	-0.0011
Prof8	*Qual5*	0.0008	0.0017	0.0019	0.0029	-0.0007	0.0013
Prof9	*Qual3*	0.0001	0.0000	-0.0001	0.0000	0.0000	0.0001
Prof9	*Qual4*	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001
Prof9	*Qual5*	-0.0001	0.0000	0.0000	-0.0005	0.0002	-0.0002

A3b. Wage indices by occupations, year 2020 $\sigma^{Prof}_{j,s,iprof}$ decrease from 3 to 2

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	-0.0004	-0.0007	0.0000	-0.0004	-0.0016	-0.0004
Prof1	*Qual3*	-0.0002	0.0000	-0.0004	-0.0005	-0.0004	-0.0005
Prof1	*Qual4*	0.0001	0.0002	0.0001	0.0003	0.0008	0.0004
Prof4	*Qual2*	-0.0004	-0.0005	-0.0003	-0.0002	-0.0001	-0.0004
Prof4	*Qual3*	0.0011	0.0020	0.0011	0.0006	0.0002	0.0014
Prof10	*Qual1*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Prof2	*Qual2*	-0.0005	0.0000	0.0000	-0.0001	-0.0004	-0.0001
Prof2	*Qual3*	0.0001	-0.0001	-0.0003	-0.0002	0.0004	-0.0001
Prof3	*Qual2*	-0.0017	0.0008	-0.0004	-0.0007	-0.0005	0.0002
Prof3	*Qual3*	0.0025	0.0011	0.0002	-0.0008	-0.0016	-0.0014
Prof3	*Qual4*	0.0017	-0.0018	0.0002	0.0023	0.0033	0.0007
Prof5	*Qual2*	0.0008	0.0004	-0.0001	-0.0001	0.0021	0.0001
Prof5	*Qual3*	-0.0009	-0.0003	-0.0001	-0.0001	-0.0014	-0.0004
Prof6	*Qual3*	0.0000	-0.0001	-0.0001	0.0000	-0.0006	-0.0005
Prof6	*Qual4*	0.0003	0.0003	0.0002	0.0000	0.0002	0.0004
Prof6	*Qual5*	-0.0009	-0.0004	-0.0004	-0.0006	0.0000	-0.0006
Prof7	*Qual3*	-0.0009	-0.0007	-0.0006	-0.0012	-0.0009	-0.0008
Prof7	*Qual4*	0.0024	0.0014	0.0027	0.0036	0.0023	0.0027
Prof7	*Qual5*	-0.0014	-0.0003	-0.0027	-0.0019	-0.0002	-0.0021
Prof8	*Qual3*	0.0011	0.0010	0.0010	0.0015	-0.0005	0.0006
Prof8	*Qual4*	0.0008	0.0020	0.0041	0.0025	-0.0009	0.0020
Prof8	*Qual5*	-0.0014	-0.0027	-0.0030	-0.0048	0.0012	-0.0023
Prof9	*Qual3*	-0.0001	-0.0001	0.0002	-0.0001	-0.0002	-0.0001
Prof9	*Qual4*	-0.0001	-0.0001	0.0000	-0.0003	0.0001	-0.0001
Prof9	*Qual5*	0.0004	0.0000	0.0001	0.0010	-0.0002	0.0004

A3c . Wage indices by occupations, year 2020

$\sigma_{j,s,itype}^{Ltype}$ *type1*=2.4, *type2*=1.56,*type3*=3.0, all increase by 20%

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.0000	0.0000	0.0000	0.0001	-0.0003	-0.0001
Prof1	*Qual3*	0.0000	0.0000	0.0000	0.0000	-0.0003	0.0000
Prof1	*Qual4*	0.0000	0.0000	0.0000	0.0000	-0.0003	0.0000
Prof4	*Qual2*	-0.0003	-0.0004	-0.0004	-0.0001	-0.0007	-0.0004
Prof4	*Qual3*	-0.0002	-0.0004	-0.0004	-0.0001	-0.0008	-0.0005
Prof10	*Qual1*	0.0005	0.0004	0.0006	0.0007	0.0004	0.0007
Prof2	*Qual2*	0.0012	0.0007	0.0001	0.0000	0.0030	0.0008
Prof2	*Qual3*	0.0012	0.0008	0.0001	0.0000	0.0031	0.0008
Prof3	*Qual2*	-0.0060	-0.0051	-0.0034	-0.0031	-0.0064	-0.0048
Prof3	*Qual3*	-0.0059	-0.0050	-0.0034	-0.0030	-0.0065	-0.0048
Prof3	*Qual4*	-0.0059	-0.0051	-0.0035	-0.0031	-0.0064	-0.0048
Prof5	*Qual2*	-0.0001	-0.0001	-0.0002	0.0001	0.0004	0.0002
Prof5	*Qual3*	-0.0002	-0.0002	-0.0001	0.0002	0.0002	0.0002
Prof6	*Qual3*	0.0002	0.0002	0.0005	0.0004	-0.0007	0.0005
Prof6	*Qual4*	0.0002	0.0002	0.0004	0.0004	-0.0006	0.0004
Prof6	*Qual5*	0.0002	0.0002	0.0005	0.0004	-0.0006	0.0003
Prof7	*Qual3*	0.0005	0.0004	0.0010	0.0010	0.0000	0.0008
Prof7	*Qual4*	0.0004	0.0005	0.0011	0.0011	0.0001	0.0009
Prof7	*Qual5*	0.0004	0.0004	0.0008	0.0010	0.0001	0.0007
Prof8	*Qual3*	-0.0011	-0.0015	-0.0012	-0.0014	-0.0011	-0.0013
Prof8	*Qual4*	-0.0012	-0.0013	-0.0010	-0.0014	-0.0009	-0.0011
Prof8	*Qual5*	-0.0014	-0.0019	-0.0014	-0.0018	-0.0013	-0.0014
Prof9	*Qual3*	-0.0008	-0.0005	-0.0017	-0.0021	-0.0005	-0.0016
Prof9	*Qual4*	-0.0007	-0.0005	-0.0017	-0.0020	-0.0004	-0.0016
Prof9	*Qual5*	-0.0007	-0.0005	-0.0017	-0.0019	-0.0004	-0.0015

A3d . Wage indices by occupations, year 2020

$\sigma^{Ltype}_{j,s,itype}$ *type1*=2.0, *type2*=2.5,*type3*=1.3, change the order of magnitude between type2 and type3

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	-0.0007	-0.0005	-0.0004	-0.0006	-0.0012	-0.0007
Prof1	*Qual3*	-0.0006	-0.0004	-0.0004	-0.0007	-0.0010	-0.0006
Prof1	*Qual4*	-0.0006	-0.0004	-0.0005	-0.0007	-0.0010	-0.0006
Prof4	*Qual2*	-0.0007	-0.0004	-0.0003	-0.0006	-0.0010	-0.0005
Prof4	*Qual3*	-0.0006	-0.0004	-0.0002	-0.0006	-0.0012	-0.0005
Prof10	*Qual1*	-0.0006	-0.0003	-0.0002	-0.0005	-0.0009	-0.0005
Prof2	*Qual2*	0.0025	0.0016	-0.0011	-0.0015	0.0086	0.0011
Prof2	*Qual3*	0.0026	0.0016	-0.0010	-0.0015	0.0090	0.0013
Prof3	*Qual2*	-0.0183	-0.0155	-0.0114	-0.0104	-0.0197	-0.0156
Prof3	*Qual3*	-0.0182	-0.0156	-0.0114	-0.0105	-0.0198	-0.0156
Prof3	*Qual4*	-0.0184	-0.0155	-0.0114	-0.0104	-0.0194	-0.0155
Prof5	*Qual2*	-0.0014	-0.0013	-0.0018	-0.0011	0.0007	-0.0007
Prof5	*Qual3*	-0.0014	-0.0013	-0.0016	-0.0011	0.0003	-0.0007
Prof6	*Qual3*	-0.0004	-0.0001	0.0005	0.0000	-0.0032	0.0002
Prof6	*Qual4*	-0.0003	-0.0001	0.0004	-0.0001	-0.0030	-0.0001
Prof6	*Qual5*	-0.0004	-0.0001	0.0005	0.0000	-0.0031	0.0000
Prof7	*Qual3*	-0.0025	-0.0024	-0.0046	-0.0050	-0.0017	-0.0040
Prof7	*Qual4*	-0.0025	-0.0024	-0.0050	-0.0050	-0.0015	-0.0041
Prof7	*Qual5*	-0.0024	-0.0021	-0.0036	-0.0046	-0.0017	-0.0033
Prof8	*Qual3*	0.0048	0.0055	0.0056	0.0058	0.0035	0.0055
Prof8	*Qual4*	0.0048	0.0050	0.0044	0.0057	0.0029	0.0050
Prof8	*Qual5*	0.0062	0.0084	0.0073	0.0087	0.0053	0.0067
Prof9	*Qual3*	0.0028	0.0017	0.0066	0.0081	0.0007	0.0063
Prof9	*Qual4*	0.0029	0.0018	0.0067	0.0081	0.0008	0.0063
Prof9	*Qual5*	0.0027	0.0017	0.0067	0.0076	0.0007	0.0061

A4a. ***Wage change w.r.t baseline scenario (2020) under first immigration scenario***

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.0236	-0.0013	-0.0071	0.0073	-0.0004	-0.0006
Prof1	*Qual3*	0.0244	-0.0014	-0.0075	0.0076	-0.0005	-0.0004
Prof1	*Qual4*	0.0239	-0.0016	-0.0078	0.0070	-0.0013	-0.0011
Prof4	*Qual2*	0.0239	-0.0014	-0.0078	0.0077	-0.0013	-0.0006
Prof4	*Qual3*	0.0236	-0.0030	-0.0102	0.0068	-0.0021	-0.0028
Prof10	*Qual1*	0.0262	-0.0005	-0.0065	0.0089	0.0009	0.0008
Prof2	*Qual2*	0.0205	-0.0045	-0.0107	0.0045	-0.0031	-0.0052
Prof2	*Qual3*	0.0204	-0.0042	-0.0108	0.0046	-0.0030	-0.0052
Prof3	*Qual2*	0.0202	-0.0169	-0.0330	0.0004	-0.0151	-0.0210
Prof3	*Qual3*	0.0196	-0.0171	-0.0336	0.0003	-0.0151	-0.0195
Prof3	*Qual4*	0.0200	-0.0150	-0.0347	-0.0016	-0.0166	-0.0215
Prof5	*Qual2*	0.0233	-0.0059	-0.0154	0.0060	-0.0071	-0.0071
Prof5	*Qual3*	0.0224	-0.0056	-0.0142	0.0056	-0.0058	-0.0068
Prof6	*Qual3*	0.0255	-0.0047	-0.0153	0.0065	-0.0061	-0.0061
Prof6	*Qual4*	0.0252	-0.0053	-0.0161	0.0063	-0.0067	-0.0073
Prof6	*Qual5*	0.0254	-0.0046	-0.0157	0.0066	-0.0063	-0.0065
Prof7	*Qual3*	0.0311	0.0042	0.0023	0.0148	0.0117	0.0079
Prof7	*Qual4*	0.0246	0.0021	-0.0004	0.0095	0.0069	0.0047
Prof7	*Qual5*	0.0332	0.0044	0.0029	0.0158	0.0118	0.0091
Prof8	*Qual3*	0.0170	-0.0055	-0.0076	0.0011	0.0032	0.0007
Prof8	*Qual4*	0.0152	-0.0066	-0.0095	0.0001	0.0020	-0.0004
Prof8	*Qual5*	0.0257	0.0000	-0.0034	0.0107	0.0064	0.0033
Prof9	*Qual3*	0.0120	-0.0013	-0.0003	0.0026	0.0032	-0.0003
Prof9	*Qual4*	0.0125	-0.0011	-0.0003	0.0028	0.0037	-0.0003
Prof9	*Qual5*	0.0102	-0.0013	-0.0002	0.0017	0.0026	-0.0008

A4b. ***Excess Labour Demands change w.r.t baseline scenario (2020) under first immigration scenario***

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.1097	0.4043	0.7703	0.3191	0.2495	0.4801
Prof1	*Qual3*	0.1134	0.3888	0.7491	0.3178	0.2480	0.4764
Prof1	*Qual4*	0.1134	0.3965	0.7587	0.3254	0.2519	0.4914
Prof4	*Qual2*	0.1288	0.5164	0.9423	0.3795	0.3590	0.6618
Prof4	*Qual3*	0.1931	-0.2298	-0.7202	-0.2682	-0.2367	-0.3865
Prof10	*Qual1*	0.1055	0.3213	0.7007	0.3002	0.2105	0.3994
Prof2	*Qual2*	0.1084	0.4051	0.7730	0.3191	0.2545	0.4775
Prof2	*Qual3*	0.1068	0.3699	0.7418	0.3110	0.2421	0.4513
Prof3	*Qual2*	-0.0889	-0.3608	-0.7633	-0.2967	-0.2476	-0.4282
Prof3	*Qual3*	-0.0902	-0.3598	-0.7634	-0.2967	-0.2475	-0.4289
Prof3	*Qual4*	-0.0905	-0.3589	-0.7628	-0.2988	-0.2472	-0.4302
Prof5	*Qual2*	0.1263	0.4398	0.8179	0.3544	0.3146	0.5695
Prof5	*Qual3*	0.1185	0.4229	0.7935	0.3383	0.2748	0.6134
Prof6	*Qual3*	0.1127	0.4017	0.7613	0.3205	0.2511	0.4739
Prof6	*Qual4*	1.2037	-0.2120	-0.6224	0.4626	-0.1785	-0.3537
Prof6	*Qual5*	0.0094	0.3223	2.2308	-0.2652	-0.2185	-0.3946
Prof7	*Qual3*	0.0601	0.1213	0.4859	0.2055	0.1241	0.2739
Prof7	*Qual4*	0.0985	0.2206	0.6177	0.2656	0.1915	0.3133
Prof7	*Qual5*	0.0768	0.2791	0.5499	0.2573	0.1988	0.3362
Prof8	*Qual3*	0.0883	0.0847	0.5378	0.2863	0.2050	0.3518
Prof8	*Qual4*	0.1017	0.3876	0.7527	0.3075	-0.0094	0.4021
Prof8	*Qual5*	0.1006	0.3477	0.7212	0.3054	0.2379	0.4039
Prof9	*Qual3*	0.1071	-0.4323	-1.0000	0.3204	0.2337	0.0506
Prof9	*Qual4*	0.1032	-1.0152	-1.3158	-5.0000	0.2120	0.2268
Prof9	*Qual5*	0.2742	-0.3468	-0.7602	-0.2879	0.3285	-0.4697

A5a. ***Wage change w.r.t baseline scenario (2020) under second immigration scenario***

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	-0.0382	-0.0155	0.0107	-0.0162	-0.0156	0.0215
Prof1	*Qual3*	-0.0394	-0.0165	0.0117	-0.0168	-0.0166	0.0230
Prof1	*Qual4*	-0.0390	-0.0162	0.0115	-0.0167	-0.0167	0.0230
Prof4	*Qual2*	-0.0388	-0.0155	0.0115	-0.0175	-0.0167	0.0217
Prof4	*Qual3*	-0.0403	-0.0176	0.0127	-0.0183	-0.0167	0.0234
Prof10	*Qual1*	-0.0401	-0.0171	0.0121	-0.0172	-0.0164	0.0240
Prof2	*Qual2*	-0.0390	-0.0143	0.0099	-0.0177	-0.0145	0.0213
Prof2	*Qual3*	-0.0395	-0.0148	0.0107	-0.0177	-0.0153	0.0226
Prof3	*Qual2*	-0.0641	-0.0318	0.0280	-0.0344	-0.0290	0.0433
Prof3	*Qual3*	-0.0685	-0.0314	0.0279	-0.0334	-0.0282	0.0402
Prof3	*Qual4*	-0.0683	-0.0303	0.0290	-0.0389	-0.0305	0.0443
Prof5	*Qual2*	-0.0483	-0.0192	0.0156	-0.0235	-0.0206	0.0266
Prof5	*Qual3*	-0.0455	-0.0180	0.0144	-0.0216	-0.0188	0.0259
Prof6	*Qual3*	-0.0497	-0.0221	0.0178	-0.0235	-0.0226	0.0314
Prof6	*Qual4*	-0.0496	-0.0222	0.0179	-0.0240	-0.0226	0.0320
Prof6	*Qual5*	-0.0487	-0.0223	0.0179	-0.0242	-0.0229	0.0321
Prof7	*Qual3*	-0.0324	-0.0144	0.0095	-0.0125	-0.0125	0.0187
Prof7	*Qual4*	-0.0288	-0.0132	0.0089	-0.0102	-0.0109	0.0163
Prof7	*Qual5*	-0.0349	-0.0160	0.0112	-0.0131	-0.0129	0.0205
Prof8	*Qual3*	-0.0242	-0.0121	0.0101	-0.0045	-0.0091	0.0161
Prof8	*Qual4*	-0.0216	-0.0110	0.0091	-0.0037	-0.0073	0.0140
Prof8	*Qual5*	-0.0317	-0.0150	0.0118	-0.0123	-0.0132	0.0177
Prof9	*Qual3*	-0.0148	-0.0023	0.0001	-0.0060	-0.0080	0.0056
Prof9	*Qual4*	-0.0154	-0.0031	0.0003	-0.0060	-0.0084	0.0058
Prof9	*Qual5*	-0.0131	-0.0023	0.0001	-0.0053	-0.0074	0.0047

A5b. ***Excess Labour Demands change w.r.t baseline scenario (2020) under second immigration scenario***

Iprof	*Iqual*	*ATL*	*QUE*	*ONT*	*PRA*	*ALB*	*BCO*
Prof1	*Qual2*	0.4764	0.3513	-0.4561	0.5642	0.1920	-0.4545
Prof1	*Qual3*	0.4695	0.3383	-0.4455	0.5577	0.1886	-0.4525
Prof1	*Qual4*	0.4689	0.3457	-0.4502	0.5625	0.1933	-0.4645
Prof4	*Qual2*	0.5928	0.4493	-0.5510	0.7067	0.2714	-0.6148
Prof4	*Qual3*	-0.5264	-0.2185	0.4253	-0.6392	-0.1909	0.3855
Prof10	*Qual1*	0.4487	0.2810	-0.4189	0.5188	0.1581	-0.3894
Prof2	*Qual2*	0.4788	0.3539	-0.4572	0.5727	0.1976	-0.4517
Prof2	*Qual3*	0.4754	0.3247	-0.4399	0.5623	0.1881	-0.4322
Prof3	*Qual2*	-0.5145	-0.3222	0.4499	-0.6331	-0.1974	0.4196
Prof3	*Qual3*	-0.5126	-0.3213	0.4500	-0.6336	-0.1974	0.4202
Prof3	*Qual4*	-0.5116	-0.3210	0.4498	-0.6278	-0.1969	0.4211
Prof5	*Qual2*	0.5446	0.3815	-0.4833	0.6460	0.2426	-0.5350
Prof5	*Qual3*	0.5194	0.3682	-0.4691	0.5714	0.2126	-0.5677
Prof6	*Qual3*	0.4722	0.3488	-0.4517	0.5732	0.1922	-0.4527
Prof6	*Qual4*	0.0370	-0.2132	0.3612	0.5107	-0.1622	0.3600
Prof6	*Qual5*	-0.5518	0.2133	-1.5385	-0.6546	-0.1849	0.3946
Prof7	*Qual3*	0.3014	0.1139	-0.3009	0.3740	0.0992	-0.2851
Prof7	*Qual4*	0.4199	0.1938	-0.3727	0.4263	0.1449	-0.3157
Prof7	*Qual5*	0.3716	0.2471	-0.3353	0.4756	0.1553	-0.3379
Prof8	*Qual3*	0.3846	0.1254	-0.3269	0.5249	0.1640	-0.3475
Prof8	*Qual4*	0.4396	0.3876	-0.4429	0.5456	0.0472	-0.3887
Prof8	*Qual5*	0.4543	0.3049	-0.4294	0.5563	0.1827	-0.3946
Prof9	*Qual3*	0.3845	-0.2258	0.9167	0.5312	0.1842	0.0127
Prof9	*Qual4*	0.3601	-0.5455	0.9474	-43.000	0.1671	-0.1546
Prof9	*Qual5*	0.2581	-0.2446	0.4694	-0.6458	0.2628	0.5909