Income Growth in the 21st Century : Forecasts with an Overlapping Generations Models

D. de la Croix, Fr. Docquier and Ph. Liegeois

Discussion Paper 2007-29

Département des Sciences Économiques
de l'Université catholique de Louvain

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David de la Croix

dept. of Economics & CORE
Université catholique de Louvain

Frédéric Docquier

FNRS & dept. of Economics
Université catholique de Louvain

Philippe Liégeois

CEPS / INSTEAD
Luxemburg

CORE Discussion Paper 2007/43

[1]Acknowledgements: We thank the participants to the colloquium in the honor of Philippe Michel (Paris, 2002), to the Symposium on Forecasting Global Income Growth (Hawai, Jan 2003 and Uppsala, Dec 2003), to the IRES macro workshop (Louvain-la-Neuve, 2003), to seminars in Lille and IZA Bonn, and to Vincent Bodart, Pierre Pestieau and an anonymous referee for helpful comments on an earlier draft. We thank Marcel Mérette (Ottawa University) for his help in calibrating the model on Canada. David de la Croix acknowledges the financial support of the Belgian French speaking community (Grant ARC 03/08-235 "New macroeconomic approaches to the development problem") and the Belgian Federal Government (Grant PAI P6/07 "Economic Policy and Finance in the Global Economy: Equilibrium Analysis and Social Evaluation"). Part of this paper was written while Frédéric Docquier was visiting the Department of Economics at Ottawa University. He thanks the International Council for Canadian Studies of the Canadian Government for its financial support.
Contact address: David de la Croix, IRES, Place Montesquieu 3, B-1348 Louvain-la-Neuve, Belgium. delacroix@ires.ucl.ac.be.

Abstract

We forecast income growth over the period 2000-2050 in the US, Canada, and France. To ground the forecasts on relationships that are as robust as possible to changes in the environment, we use a quantitative theoretical approach which consists in calibrating and simulating a general equilibrium model. Compared to existing studies, we allow for life uncertainty and migrations, use generational accounting studies to link taxes and public expenditures to demographic changes, and take into account the interaction between education and work experience. Forecasts show that growth will be weaker over the period 2010-2040. The gap between the US and the two other countries is increasing over time. France will catch-up and overtake Canada in 2020. Investigating alternative policy scenarios, we show that increasing the effective retirement age to 63 would be most profitable for France, reducing its gap with the US by one third. A decrease in social security benefits would slightly stimulate growth but would have no real impact on the gap between the countries.

Keywords: Aging, Forecast, Computable General Equilibrium, Education, Experience.
JEL Classification: D58, E6, H55, J11, O40.

Introduction

In most industrialized countries, the rise in life expectancy and the drop in fertility rates progressively increase the share of the elderly in the population. In the next decades, this phenomenon will be particularly strong as large baby boom cohorts reach the retirement age. As illustrated in Cutler et al. (1990), this demographic transition really starts in Japan. The European Union (especially western countries such as Germany, Italy, Belgium and France) and Canada seem to age before the US and after Japan, so quite in the middle of the wave of aging. In the US, the elderly dependency ratio (population aged 65+ / population 15-64) will increase from 18% in 1990 to a peak of 32% by 2035. In France, the share of elderly should double between 1995 and 2045. Movements are stronger in Canada where the dependency rate starts at the US level in 2000 but is expected to reach 42% in 2050. Even if demographic institutes usually provide alternative projections, the extent of these population trends is now estimated with a relative high accuracy level by demographers. Population aging appears as an inescapable ending and its magnitude in the next fifty years cannot be affected by policy.

Economists and policymakers have been concerned in quantifying the potential effects of demographic changes upon the economy. In this paper, we focus on the potential effect of aging on GDP per capita in three important developed countries, Canada, France and the USA. The channels through which demography affects the growth prospect of industrialized economies are manifold. First, population changes have a direct impact on the size of the labor force. After 2000, the growth rate of the population aged 15-64 is expected to decrease in most industrialized countries (especially in France and Canada where the growth rate becomes negative). Second, aging also modifies saving rates and capital accumulation which, in turn, impacts on wages rates and interest rates. Since the seminal overlapping generations model of Auerbach and Kotlikoff (1987), a large number of studies[1] have concluded that aging will stimulate the capital stock per worker and wages rates while reducing interest rates[2]. Third, aging has also large effects on the characteristics of the labor force. As argued

[1] See e.g. Auerbach et al. (1989), Börsch-Supan (1996) or Hviding and Mérette (1998) on various OECD countries, Chauveau and Loufir (1997) on the G7 countries or, more recently Hirte (2002) on Germany, Miles (1999) on the UK and the INGENUE Team (2002) on the World economy.

[2] One exception is Fehr, Jokisch, and Kotlikoff (2003) who argue that the rise in wages tax (particularly payroll taxes) reduce saving and capital accumulation. Over the course of the century, capital shortages progressively lower real wages per unit of human capital and stimulate interest rates.

by Wasmer (2001b), demographic changes in the late 35 years induced a substitution of “low education-high experience” workers by “high education-low experience” workers. The stock of experience is now increasing at a fast pace. However, as the baby boom generations will leave the labor force, the stock of experience will decrease after the year 2020, while the average education level is expected to peak around 2040. Finally, the public finance consequences (and their incidence in terms of intergenerational transfers) have raised a considerable anxiety amongst scholars. The financial sustainability of the social security system is obviously the most important political and economic issue related to aging. Can or should current benefits be maintained? How far can we increase social security contributions?

The consequences of aging described above are still subject to uncertainty and net effects cannot be determined a priori. They must be simulated within a fully articulated and calibrated model. The purpose of our study is to integrate the mechanisms sketched above in a general equilibrium, OLG framework. Compared to existing studies, our model builds on a strong demographic block which allows for life uncertainty and migratory movements. In each country, the evolution of the population size and the structure per age corresponds to official projections. A particular attention is also devoted to the public sector modelling. Using generational accounting studies[3], we closely link the evolution of taxes and expenditures to demographic changes. Finally, we take into account the interactions between education and experience on the labor market. We derive the impact of population changes and educational decisions of the young on the stock of experience and the stock of education.

We use this structural model to forecast the GDP per capita, using the demographic movements as a key source of changes. Our central projection is based on constant policies. Retirement age and the debt-GDP ratio are kept constant, public transfers and government expenditures are indexed on the total factor productivity. The wage tax rate (including social security contribution and income tax) is adjusted to meet the debt-GDP ratio target.

Under these assumptions, forecasted incomes display three main features. In all three countries, the growth rate will be weaker over the period 2010-2040. The gap between the leading country (the USA) and the two other countries (France and Canada) is increasing over the period 2000-2050. France will catch-up and overtake Canada in 2020.

[3]See Gokhale et al. (2001) for the USA, Crettez, Feist, and Raffelüschen (1999) for France and Hicks (1998) for Canada.

The following elements are found essential to generate these results. Potential labor forces shrink in France and Canada between 2020 and 2050, but continue to increase in the USA. The dynamics of education capital is favorable to France and Canada, since they start from a lower level compared to the USA. The dynamics of experience capital is relatively more favorable in the USA.

Next we evaluate the robustness of our results to policy choices. Two different policy measures are simulated. First, we consider that the effective retirement age increases to a similar level (age 63) in all three countries. Such a policy induces major changes on the French economy where the current retirement age is lower than in the other countries. The gap between France and the USA is reduced by one third. Then, we consider a scenario where the level of pension benefits is adjusted downward so as to keep wage taxes constant over the period 2000-2050. This policy change has a small impact on the gap between the different countries.

The rest of this paper is organized as follows. Section 1 describes the model. The calibration is presented in section 2. Section 3 provides the baseline forecasts. The sensitivity of GDP forecasts to policy changes is examined in Section 4. Finally, Section 5 concludes.

1 The Model

We consider a model economy where households and firms maximize their objective subject to resource constraints, and where a government levies taxes and issues debt to finance spending and transfers.[4] All demographic variables, i.e. fertility, mortality and migration, are exogenous. We shall then use the model to map official demographic forecast into predicted level of gdp per capita and other economic variables.

1.1 Population

Model time is discrete and goes from 0 to $+\infty$. At each date, some individuals die and a new generation appears. Households reaching age 15 at year t belong to generation

[4]Compared to our previous work (Bouzahzah, de la Croix, and Docquier 2002), both demographic variables and public finance are much more detailed, and we distinguish experience and education in the modeling of human capital.

t. The size of the young generation increases over time at an exogenous growth rate:

$$N_{0,t+1} = N_{0,t} m_t$$

where $N_{0,t}$ measures the initial size of generation t and m_t is one plus the demographic growth rate, including both fertility and migration.

Each household lives a maximum of 8 periods ($a = 0, ..., 7$) but face a cumulative survival probability decreasing with age. The size of each generation declines deterministically through time. However, this decline is affected by net migration flows:

$$N_{a,t+a} = N_{0,t} \beta_{a,t+a} + M_{a,t+a}$$

where $0 \leq \beta_{a,t+a} \leq 1$ is the fraction of generation t alive at age a (hence, at period $t + a$) and $M_{a,t+a}$ is the stock of migrants of age a. We also have $\beta_{0,t} = 1$. Obviously, the total population at time t amounts to $N_t = \sum_{a=0}^{7} N_{a,t}$.

The demographic growth rate, immigration flows and the survival probability vector vary over time. Taking account of immigration flows enables us to use official demographic observations and projections.

1.2 Households

Individuals have a positive probability to die during each period of life. In the spirit of Arrow-Debreu, we postulate the existence of a market for every contingent consumption. These markets open before the resolution of uncertainty: each individual has the possibility to insure himself against uncertainty at the beginning of his life. Hence, the problem of agents born at time t is to select a consumption contingent plan and his education in order to maximize his expected utility subject to his intertemporal budget constraint, given the sequence of contingent wages and prices. The expected utility function is time-separable and logarithmic:

$$E(U_t) = \sum_{a=0}^{7} \beta_{a,t+a} \ln(c_{a,t+a}) \tag{1}$$

where $c_{a,t+a}$ is the consumption of generation t at age a. The life-cycle budget constraint requires equality between the expected value of expenditures and the value of income. For a household born with age 0 at time t, it is written as

$$\sum_{a=0}^{7} p_{a,t+a} \left[c_{a,t+a}(1+\tau^{c}_{t+a}) - T_{a,t+a} \right] = \sum_{a=0}^{7} \left(\omega^{L}_{a,t+a} + \omega^{E}_{a,t+a} e_{a,t+a} + \omega^{H}_{a,t+a} h_{a,t+a} \right) \ell_{a,t+a} \tag{2}$$

where τ^{c}_{t+a} is the consumption tax rate at period $t+a$; $p_{a,t+a}$ is the discounted price of one unit of good in case he/she is alive at age a; $T_{a,t+a}$ denotes the amount of transfer received at age a including education benefits, pensions and other transfers (health care, family allowances, social benefits...); $\ell_{a,t+a}$ measures labor supply at age a; raw labor, education and experience are supplied at net-of-taxes contingent discounted wages $\omega^{L}_{a,t+a}$, $\omega^{H}_{a,t+a}$ and $\omega^{E}_{a,t+a}$.

As in Fehr, Jokisch, and Kotlikoff (2003), we assume that migrants of each generation have the same characteristics as natives, i.e. they have the same implicit wealth, experience and education.

The vector of labor supply for generation t (defining labor supply at all ages) is

$$\overline{\ell}_t = (q_t(1-u_t),\ q_{t+1},\ q_{t+2},\ q_{t+3},\ q_{t+4}(1-\alpha_{t+4}),\ 0,\ 0,\ 0) \tag{3}$$

where q_t is the exogenous participation rate at time t, $0 \leq u_t \leq 1$ measures the endogenous time invested in education in the first period of life and α_{t+4} stands for the (exogenous) time spent in retirement in the fifth period of life (i.e. between age 55 and age 65). The variable q_t is introduced to capture the rise in women's participation rates in the labor market.

In this model we consider labor supply as exogenous, except in the first period where education decisions occur. In Auerbach and Kotlikoff (1987) and many subsequent works, labor supply was endogenized. It is then necessary to calibrate the age-specific parameter of preference for leisure so as to match the age-profile of participation rates observed in the most recent period. However, all these models fail at matching the time path of participation rates, especially the rise in women participation rates over the last three decades. One way to address this issue would be to assume that preference parameters have changed over time. Such changes can then be calibrated to match observations. To avoid modeling changes in preference parameters and to keep our forecast assumptions as transparent as possible we decided to keep participation rates exogenous.

The education decision made in the first period of life completely determines the vectors of experience, skills, education subsidies and public transfers for generation t. Following Wasmer (2001b), the individual stock of experience sums up past participation rates on the labor market. The stock of education transforms education investment when young into labor efficiency according to a decreasing return function. Public transfers sum up education subsidies, pension benefits and other transfers. These vectors are written as

$$
\begin{aligned}
\overline{e}_t \;=\; & (0,\ (1-u_t)q_t,\ (1-u_t)q_t+q_{t+1},\ (1-u_t)q_t+q_{t+1}+q_{t+2}, \\
& (1-u_t)q_t+q_{t+1}+q_{t+2}+q_{t+3},\ 0,\ 0,\ 0)\,,
\end{aligned}
\tag{4}
$$

$$
\overline{h}_t = \left(0,\ \epsilon u_t^{\psi},\ \epsilon u_t^{\psi},\ \epsilon u_t^{\psi},\ \epsilon u_t^{\psi},\ 0,\ 0,\ 0\right),
\tag{5}
$$

where $\epsilon > 0$ and $\psi \in (0,1)$ are two parameters of the educational technology;

$$
\begin{aligned}
\overline{T}_t \;=\; & \Big(v_t q_t u_t \omega_{0,t}^L + \gamma_0 g_t,\ \gamma_1 g_{t+1},\ \gamma_2 g_{t+2},\ \gamma_3 g_{t+3}, \\
& \alpha_{t+4} b_{t+4} + \gamma_4 g_{t+4},\ b_{t+5} + \gamma_5 g_{t+5},\ b_{t+6} + \gamma_6 g_{t+6},\ b_{t+7} + \gamma_7 g_{t+7})\,,
\end{aligned}
\tag{6}
$$

where v_t is the rate of subsidy on the cost of education, b_t is the pension benefit allocated to each full-time retiree at period t and $\gamma_a g_t$ is the amount of age-related transfer made by the government to agents of age a. The parameter γ_a determines the share of total transfer g_t in favor of age a.

Since there is no utility of leisure, the problem of households is separable. Individuals first maximize the expected value of income - right hand side of (2) - with respect to educational investment u_t. Then, in a second step, they maximize the expected utility function and select the optimal contingent plan subject to the budget constraint in which the education investment is set to its optimal value. The optimal education investment is given by

$$
u_t^* = \left(\frac{\epsilon \psi \sum_{a=1}^{4} \left[\omega_{a,t+a}^H \ell_{a,t+a}\right]}{(1-v_t) q_t \omega_{0,t}^L + \sum_{a=1}^{4} \left[\omega_{a,t+a}^E \ell_{a,t+a}\right]} \right)^{\frac{1}{1-\psi}}
\tag{7}
$$

Obviously, the optimal education investment balances the marginal gain of education at the numerator (future path of net returns on education) and the marginal cost of education at the denominator; the marginal cost includes both the foregone wage when young and foregone net returns on experience.

Maximizing utility with respect to the levels of consumption determines the law of motion of contingent consumption expenditures over the lifetime:

$$c_{a+1,t+a+1} = \frac{(1+r_{t+1})(1+\tau_t^c)}{(1+\tau_{t+1}^c)} \; c_{a,t+a} \qquad \forall a = 0, ..., 6 \tag{8}$$

Substituting (7) and (8) into the budget constraint (2) gives the optimal level of consumption in the first period of life. The aggregated consumption at period t then amounts to $C_t = \sum_a N_{a,t} c_{a,t}$.

1.3 Firms

At each period of time, a representative firm uses labor in efficiency units (Q_t) and physical capital (K_t) to produce a composite good (Y_t). We assume a Cobb-Douglas production function with constant returns to scale:

$$Y_t = A_t K_t^{1-\varphi} Q_t^{\varphi} \tag{9}$$

where φ measures the share of wage income in the national product, and A_t represents total factor productivity. (TFP), growing at the rate $G_t - 1$. We consider a autoregressive process for the growth factor:

$$\frac{A_t}{A_{t-1}} \equiv G_t = (1-\lambda)\overline{G} + \lambda G_{t-1} + \varepsilon_t \tag{10}$$

where $\overline{G}$ is the long run growth factor of the TFP, λ is a parameter of inertia in productivity shocks and ε_t is a iid shock process.

The quantity of efficiency units of labor combines physical labor supply and human capital according to a Cobb-Douglas transformation function. Human capital is itself a linear combination of experience and education. Formally, we have

$$Q_t = L_t^{1-\delta} \left[\mu E_t + (1-\mu) H_t\right]^{\delta} \tag{11}$$

where L_t measures the input of manpower at time t; E_t measures the input of experience; H_t is the input of education; δ is a parameter representing the importance of human capital in the determination of labor income; μ is a parameter of preference for experience. In an other paper (de la Croix and Docquier 2003) we explore the importance of complementarities between education and experience to understand how the skill and experience premium changed in the past. We use here a simplified production function where education and experience are perfect substitutes, after having checked that forecasts are not very sensitive to the assumed elasticity of substitution between the two.

The representative firm behaves competitively on the factor markets and maximizes profits:

$$Y_t - (r_t + d)K_t - w_t^L L_t - w_t^H H_t - w_t^E E_t \tag{12}$$

where d is the depreciation rate of physical capital. This behavior requires the equality of the marginal productivity of each factor to its rate of return. They may be written as

$$\begin{aligned}
r_t &= (1-\varphi)A_t Y_t / K_t - d && (13)\\
w_t^L &= \varphi(1-\delta)A_t Y_t / L_t && (14)\\
w_t^E &= \varphi\delta\mu A_t K_t^{1-\varphi} Q_t^{\varphi-1} L_t^{1-\delta}\left[\mu E_t + (1-\mu)H_t\right]^{\delta-1} && (15)\\
w_t^H &= \varphi\delta(1-\mu) A_t K_t^{1-\varphi} Q_t^{\varphi-1} L_t^{1-\delta}\left[\mu E_t + (1-\mu)H_t\right]^{\delta-1} && (16)
\end{aligned}$$

1.4 The Public Sector

The government issues bonds and levies taxes on labor earnings (τ_t^w), consumption expenditures (τ_t^c) and capital income (τ_t^k) to finance public transfers and general public consumption. Five types of spending are distinguished: education subsidies, social security benefits, other transfers (health care, family allowance, social benefits), non age-specific general consumption expenditure and interest payments on public debt. The government budget constraint may be written as

$$\begin{aligned}
&\tau_t^w(w_t^L L_t + w_t^E E_t + w_t^H H_t) + \tau_t^c C_t + \tau_t^k r_t K_t + D_{t+1} - (1+r_t)D_t \\
=\ & N_{0,t} v_t q_t u_t w_t^L (1-\tau_t^w) + \sum_a N_{a,t}\gamma_a g_t + \vartheta_t Y_t + (N_{4,t}\alpha_t + \sum_{a=5}^{7} N_{a,t}) b_t \qquad (17)
\end{aligned}$$

where D_t denotes the public debt at the beginning of period t; ϑ_t is the share of non-transfer public consumption in GDP and $\gamma_a g_t$ is the amount of transfer per capita allocated to individuals of age a.

Several scenarios can be considered to balance this budget constraint. The budget can be balanced through tax adjustments, expenditure adjustments or changes in the public debt. We assume in the sequel that the path of debt is given and the tax rate τ_t^w adjusts to meet the debt-GDP ratio target.

1.5 Equilibrium

At each date, the composite good is taken as numeraire. The spot price is thus normalized to one: $p_t = 1$. We denote by r_{t+1} the interest rate between dates t and $t+1$, the appropriate discount factor applied to age-a income and spending is given by

$$R_{a,t+a} \equiv \prod_{s=t+1}^{t+a} (1 + r_s(1 - \tau_s^k))^{-1}$$

where, by convention, $R_{0,t} = 1$. Spot gross wages at time $t + a$ are denoted by w_{t+a}^L, w_{t+a}^H and w_{t+a}^E. They correspond to the marginal productivities of labor components, as shown above.

Since there is perfect competition on the insurance market, the contingent prices are related to the spot prices through a set of no arbitrage conditions. The equilibrium (discounted) contingent prices of the consumption good at time t are given by:

$$p_{a,t+a} = R_{a,t+a}\beta_{a,t+a}p_{t+a} = R_{a,t+a}\beta_{a,t+a} \tag{18}$$

Equilibrium (discounted) contingent net wages are:

$$\begin{aligned}
\omega_{a,t+a}^L &= R_{a,t+a}\beta_{a,t+a}w_{t+a}^L(1 - \tau_{t+a}^w) \\
\omega_{a,t+a}^E &= R_{a,t+a}\beta_{a,t+a}w_{t+a}^E(1 - \tau_{t+a}^w) \\
\omega_{a,t+a}^H &= R_{a,t+a}\beta_{a,t+a}w_{t+a}^H(1 - \tau_{t+a}^w)
\end{aligned} \tag{19}$$

where τ_{t+a}^w denotes the rate of tax on labor income at time t. The originality of the model is that labor income consists of three components: manpower, experience and education. Equivalently, individual gross wages are the sum of these three elements so that a tax on labor income τ_t^w affects similarly all wage components.

The equilibrium condition on the goods market writes as follows:

$$Y_t + K_t^\star = \underbrace{\sum_{a=0}^{7} N_{a,t}c_{a,t}}_{C_t} + \underbrace{K_{t+1} - (1-d)K_t}_{I_t} + \underbrace{\vartheta_t Y_t}_{G_t} \tag{20}$$

where $K_t^\star$ represents the asset holdings brought into the country by migrants.

The labor market equilibrium equalizes the demand for labor from firms L_t, E_t and H_t to the sum of the individual supplies:

$$L_t = \sum_{a=0}^{7} N_{a,t}\ell_{a,t}, \qquad E_t = \sum_{a=0}^{7} N_{a,t}\ell_{a,t}e_{a,t}, \qquad H_t = \sum_{a=0}^{7} N_{a,t}\ell_{a,t}h_{a,t} \tag{21}$$

2 Calibration

Three model economies are calibrated following exactly the same methodology in order to make forecasts comparable. Calibration implies using data for observed exogenous variables, fixing some constant parameters, and choosing paths for the unobserved exogenous variables in order to match a series of characteristics. Calibration is not focused on reproducing characteristics of a given steady state, where all the interesting information on population history, experience stocks and skills per age group would be lost. Instead, the equilibrium is computed as a transition from one steady state in 1900 to one another in 2250. By starting in 1900, the stocks of education and experience around 1960 reflect the correct history of the population.

2.1 Simulation Method

Our dynamic model is characterized by a set of non-linear equations of the form:

$$f(z^1_{t-4}, \ldots, z^1_t, z^2_t, \ldots, z^2_{t+4}, x_t) = 0$$

where z^i_t denotes an endogenous variable at t, which can be predetermined (z^1_t), or forward looking (z^2_t). The maximum lead or lag in the model is of 4 periods, which is related to the length of active life. f is a function representing our dynamic model and x_t is the vector of exogenous variables and parameters.

The problem also includes initial conditions on predetermined variables, which here correspond to an initial steady state in 1900:

$$z^1_{-3}, \ldots, z^1_0 = z^1_{\text{init}}.$$

As far as terminal conditions are concerned, we assume that exogenous variables stay constant after a given date. Hence, if the corresponding steady state is a saddle-point, the economy should converge to this steady state, as long as it does not start too far away from it (because the saddle-point stability only applies locally).

Since f is non-linear, it is not possible in general to solve the model analytically. The general problem is to solve a system of finite difference equations with initial and terminal conditions. Approximating the infinite horizon by a finite one, (that means that we assume that the steady state is actually reached at the end of the horizon of simulation) the complete system has as many equations as the number of equations at each period multiplied by the simulation horizon plus the initial and terminal conditions:

$$\left\{\begin{array}{rcl} z^1_{-3}\ldots,z^1_0 & = & z^1_{\text{init}} \\ f(z^1_{-3},\ldots,z^1_1,z^2_1,\ldots,z^2_5,x_1) & = & 0 \\ \vdots & \vdots & \vdots \\ f(z^1_{T-4},\ldots,z^1_T,z^2_T,\ldots,z^2_{T+4},x_T) & = & 0 \\ z^2_{T+1},\ldots,z^2_{T+4} & = & z^2_{\text{steady state}} \end{array}\right. \tag{S}$$

The system (S) is then solved for z_t using a Newton-Raphson relaxation method put forward by Laffargue (1990) and Boucekkine (1995) for solving dynamic nonlinear models with perfect foresight. With this technique, the Newton-Raphson improvement at each iteration is computed by triangulation (instead of inversion) of the matrix of the first derivatives of the system. As Boucekkine (1995) shows, this method allows to characterize the nature of the dynamics of the model (explosivity, saddle-point trajectory or infinite number of stable solutions) without having to linearize it and to compute the eigenvalues of the linearized system. In particular, it is easy to determine whether the convergence of the algorithm is due to the existence of saddle-point trajectory or not. Indeed, the algorithm is characterized by an explosivity property in the case where an infinity of stable solutions exist (see Boucekkine and Le Van (1996)). This explosivity property is in fact common to all convergent relaxation methods. The explosive behavior is put forward by a simple numerical procedure relying on the initialization of the relaxation. Initializing the relaxation with values slightly different from the steady state leads to an explosive behavior at the first Newton-Raphson improvement. This routine is implemented with the package Dynare of Juillard (1996).

2.2 Observed Exogenous Variables

Demography. Past and future survival probabilities $\beta_{a,t}$ and population shares per age are taken from official demographic institutes. For France, we use observations and forecasts from INED and INSEE. For the US, data and forecasts are taken from the Population Division of the US Census Bureau. For Canada, we use observations from the Department of Human Resources and Skills Development and forecasts are taken from the United Nations database. As for demographic projections, we always use the central scenario.

Figures 1, 2 and 3 describe the demographic transition experienced in all three countries. There are important differences in the dynamics of population. After 2000, the population size keeps increasing in the USA. Consequently, the growth rate of the labor force (population aged 15-64) remains positive. In France and Canada (from 2030 onwards), the population stagnates and the labor force decreases. The magnitude of aging is also different. As appearing on Figure 3, the old-age dependency increases much in Canada (from 18 to 42 percent between 2000 and 2050) and France (from 25 to 50 percent) and moderately in the US (from 18 to 32 percent). Hence, Canada is likely to age more drastically than the other two countries.

[Figure 1 about here.]

[Figure 2 about here.]

[Figure 3 about here.]

Education and participation rates. The time invested in education is computed using school attendance and educational attainment measures. For France, the time invested in education is computed using school attendance measures for the 15-24 population reported in Estrade and Minni (1996). For the US, we use the data and projections on educational attainment by Cheeseman Day and Bauman (2000). For Canada, data on educational attainment are taken from Laroche and Mérette (2000) who split the Canadian population by age and by the highest diploma obtained from 1971 to 1996.

The old age participation rate α is computed using the effective retirement age data from Blondal and Scarpetta (1997). Overall participation rates q_t are normalized to 1 in 2000 and computed from Wasmer (2001a) for the three countries.

Public finance. Regarding public finance, our model distinguishes three proportional taxes: the labor income tax, the capital income tax and indirect taxes. For France, the indirect tax rate and the rate of tax on capital income are estimated by Carey and Tchilinguirian (2000) at 18% and 24% respectively for 1995. The labor income tax rate is endogenous in the model but needs a target value: it has been estimated by Eurostat (1999) at 44% in 1995. For the US, we calibrate these tax rates in such a way that the shares of revenues in GDP correspond to the estimations of Gokhale, Page, and Sturrock (1999), i.e. 8% for labor income, 7% for indirect taxes and 5% for capital income in 2000[5]. For Canada, we build on Charbonneau (1997) who provides complete time series of implicit tax rates on labor income, capital income and consumption from 1961 to 1995. We distinguish two types of government spending (net of debt charges), i.e. non age-specific public consumption and age-specific transfers. For the composition of these categories and for the age profiles of transfers, we build on generational accounting exercises, i.e. Crettez, Feist, and Raffelüschen (1999) for France, Gokhale, Page, and Sturrock (1999) for the US and Hicks (1998) for Canada. The history of non age-specific spending is based on OECD data for the period 1960-1995. The history of public debt is taken from official statistics.

2.3 Parameters

A set of parameters is set a priori, the same for all three countries. By doing so, we minimize the amount of assumed differences between them. The labor share in output, φ, is set to 0.7, (this value is commonly used in calibrated model of the US economy. In France, the labor share equals 0.693 in 1995, according to INSEE. For Canada, Fougère and Mérette (1999) use a share of 0.66.) The depreciation rate of capital d equals 0.4. This value implies an annual depreciation rate of 5%. The parameter μ in the production function is a scale parameter which is set to 0.5. Two parameters are important in shaping the wage profile per age: the share of raw labor in labor income $(1-\delta)$ is set to 0.4, and the scale parameter in the production function of human capital ϵ is set to 2.1. They will both deliver an adequate wage profile (see below). The parameter ψ is the elasticity of education capital to investment in education. It should be calibrated using the estimated elasticity of future earnings with respect to additional schooling

[5]In our simulations, we consider (i) that the French tax rate on consumption expenditures increases linearly from 10% in 1940 to 18% in 1990 and (ii) that the tax rate on capital income increases from 15% to 24% over the same period. The same evolution is applied to the US tax rates (from 8% to 14% for the indirect tax rate and from 10% to 28% for the capital income tax rate).

(see e.g. Psacharopoulos (1994) for a survey of these elasticities); we take the value $\psi = 0.6$ which is in accordance with a return to an additional year of schooling of 11.5%, assuming that this additional year of schooling raises education expenditure by 20%.

2.4 Identification of Unobserved Exogenous Variables

The model contains some exogenous variables for which time series data are not available: total factor productivity, A_t, the rate of subsidy on education expenditures, v_t, the level of pension benefit, b_t, and the scale of the age-specific transfer profile, g_t. These four exogenous processes are chosen so as to match available time series data for four endogenous variables which are closely related to the unknowns: the GDP growth rate, the share of social security and other transfers in GDP, and the education investment of young cohorts.

Basically, our identification process implies swapping four exogenous variables for four endogenous variables and solving the identification step with the algorithm proposed by Laffargue (1990) and Boucekkine (1995). Our identification process resembles Sims (1990) backsolving method for stochastic general equilibrium models. We use a similar idea of treating exogenous processes as endogenous, not to solve a model, but as a calibration device in a deterministic framework.

The autoregressive process (10) is calibrated on the resulting TFP dynamics by pooling country results. The average growth factor is set to $\overline{G} = 1.2$, which corresponds to a long-run growth rate of 1.84% per year. The correlation between $G_t - \overline{G}$ and $G_{t-1} - \overline{G}$ then determines $\lambda = 0.384$. The iid shock process ε_t is estimated as a residual. Hence, we consider a similar growth process for all three countries except for the shock term. Figure 4 depicts the growth factor of total factor productivity for the three countries.

[Figure 4 about here.]

Notice that our backsolving identification procedure allows to calibrate the model "dynamically". This is much better and rigorous than calibrating on a hypothetical steady state (in 1900 or in 2250) and re-scaling exogenous variables to obtain reasonable outcomes at a given date, as it is usually done in Auerbach and Kotlikoff (1987) tradition.

2.5 Wage and Assets Profile per Age

The quality of our model depends on its ability to match individual profiles per age. Let us focus on wage and wealth profiles for the US and for France. Figure 5 provides the wage profile per age for the year 2000 in the US, comparing the model's outcome with PSID data. Figure 6 conveys the same information for France, where the actual data were obtained from INSEE. The shape of the profile per age is fully determined by the accumulation of experience; no need to assume an exogenous profile as in Auerbach and Kotlikoff (1987). This figure comforts us in the choice of δ and ϵ. We however overestimate the wage for old workers in the US; to correct for this, one could assume a positive depreciation rate of experience in the US, but we preferred to keep the same specification for all countries.

[Figure 5 about here.]

[Figure 6 about here.]

It is usually argued that the standard life cycle model with selfish households does not provide a good description of wealth accumulation after retirement. Figures 7 and 8 reports asset profiles per age at time 2000, together with their empirical counterpart from PSID for the US and from INSEE for France. It appears that our model matches the profile, except for the very old people (85-94). Hence, there is no need to suppose a pure time preference parameter on top of the mortality rate. The annuity market is also helpful to avoid poverty in the old age.

[Figure 7 about here.]

[Figure 8 about here.]

3 Forecasts

Once the model has been calibrated, we run a baseline simulation over the period 1900-2250, where future values of policy variables are kept at their level observed in 2000. We concentrate our attention on the determinants of economic growth. From (9), growth is driven by total factor productivity, the accumulation of physical capital and the dynamics of employment in efficiency units.

Regarding employment, Figure 2 indicates that the labor force grows at a slower pace in all countries between 2000 and 2040. The phenomenon is particularly important in France and Canada. The characteristics of the labor force also change. The next three figures describe the average education level and the average experience of workers. On the one hand, the average education level will rise in all countries. However, the rise is stronger in France and Canada, since they start from a lower level compared to the USA in 2000. On the other hand, the dynamics of experience capital is more favorable in the USA. In each country, the average experience of worker increases between 2000 and 2010, then decreases (until 2050 in Canada, until 2030 in France and the USA). In 2050, the net gain in experience is important in the US while not significant in France and Canada.

[Figure 9 about here.]

[Figure 10 about here.]

[Figure 11 about here.]

Regarding capital accumulation, it is usually argued that aging raises the stock of capital compared to the supply of labor, hence expanding real wages while decreasing interest rates. The prospect for such a capital deepening arises from the fact that the oldsters are the main suppliers of capital while the young are the main suppliers of labor (more oldsters relative to youngsters means more capital per worker). Fehr, Jokisch, and Kotlikoff (2003) recently questioned this assertion: if benefits are paid as promised, increased taxes possibly undermine capital intensity (as in their simulations). Similarly, the rise in education and/or experience boosts workers' human capital and possibly reduce capital per efficiency unit of labor. Hence, the net impact on capital intensity cannot be determined a priori. Our simulations reveal that capital intensity will rise between 2000 and 2030 and will decrease (very slightly) thereafter. Such a trend translates into an opposite movement in the interest rates, as shown on Figure 12. Note that, in 2050, the Canadian interest rate is roughly equal to its current level whilst the French and US interest rates are below. This reflects that there will be a net increase in capital intensity between 2000 and 2050 in France and the US, while the net effect in Canada will be negligible (the rise in 2000-2020 is compensated by the drop between 2020-2050).

[Figure 12 about here.]

Changes in capital intensity closely depend on public policies. In our baseline forecast, we assume that all transfers (including social security benefits) are perfectly adjusted on the total factor productivity. The government budget is balanced via the wage income tax. As appearing on Figure 13, this policy induces large changes in the income tax rate. Between 2000 and 2050, the tax rates increases from 41 to 56 percent in France, from 31 to 40 percent in Canada and from 13 to 16 percent in the US. These evolutions are mainly driven by the share of social security benefits in GDP (Figure 14). In France, the share of public pensions amounts to 12 percent and would reach 18 percent in 2050. In the US, the share would only move from 6 to 8 percent. In Canada, the size of "Bismarckian" Canadian Pension Plan (CPP) would rise from 4 to 7 percent of GDP. However, the "Beveridgean" Old Age Security (OAS) scheme is also included in our simulations (in other individual transfers). On the whole, the Canadian share of total transfers would rise from 13 to 21 percent of GDP.

[Figure 13 about here.]

[Figure 14 about here.]

Our forecasts of GDP per capita combines all these elements. GDPs per capita from 1900 to 2050 are represented in Figure 15 (in logarithms). Tables 1 and 2 give the simulated levels and annual growth rates for the five next decades (in USD). In 2000, the US leadership appears: the Canadian and French levels are respectively 22 and 26 percent below the US level. Despite the adverse demographic shock, the 2050 level will be roughly twice as important as in 2000. However, population changes should reinforce the leadership of the US. In 2050, the Canadian and French levels will respectively be 34 and 30 percent below the US level. Hence, France will catch-up and overtake Canada in 2020.

[Figure 15 about here.]

Demographic movements have a stimulating effect on growth between 2000 and 2010. Thereafter, annual growth rates of GDP per capita are positive but become lower than the TFP growth after 2010. The minimal growth rates are experienced between 2010 and 2030. In Canada, the GDP per capita increase by less than 1 percent per year on the period 2020-2030 (despite a growth rate of TFP of 1.84 percent per year).

[Table 1 about here.]

[Table 2 about here.]

4 Alternative Policies

The evolution of GDP per capita depends on socio-demographic changes (size and structure of the population, participation rates of men and women, education choices of future young cohorts) and public policy. If most socio-demographic changes can be estimated with a relatively high level of accuracy, policy changes are quite uncertain. More precisely, there is a great deal of uncertainty about the evolution of social security replacement rates (will the current level of benefit be maintained?) and about the labor participation rates of old workers (will the retirement age increase?).

Intuitively, these alternative social policies aims at reducing the fiscal burden of aging. Their impact on the economy are likely to be important. Reducing benefits should stimulate saving and capital intensity. Increasing the retirement age impacts on the size of the labor force and on the stock of experience. Lowering income tax alters the return and the cost of education.

In this section, we evaluate the robustness of our forecasts to policy choices. Two different policy measures are simulated. First, we consider that the effective retirement age increases to 63 in all three countries. Such a policy induces major changes on the French economy where the current effective retirement age is lower than 59. For Canada and the US, the effect is expected to be smaller (current retirement age are respectively 61.5 and 62.5).[6] Second, we consider a scenario where the level of pension benefits is adjusted downward so as to keep wage taxes constant over the period 2000-2050.

Table 3 depicts the growth gain associated to a rise in the effective retirement age. As expected, such a policy change has a deep impact on the French economy. Between 2020 and 2040, the annual growth rate increases by 0.3-0.4 point of percentage. The impact is less important in Canada (except in 2020) and negligible in the US. Conse-

[6] We are aware that there is no systematic mandatory retirement age in the US and Canada. For these two countries, our "policy change" can be seen as resulting from a private decision to increase the participation rate when old. By considering exogenous labor supply, we leave the modeling of incentives to work longer for future research.

quently, a convergence in retirement age would mainly reduce the gap between France and the USA (by one third). It would not strongly modify the Canadian position.

[Table 3 about here.]

Table 4 gives the growth gains associated to a budget adjustment through social security benefits. Such a scenario induces growth gains in all periods and for all countries. By stimulating capital accumulation, the GDP per capita especially increases in countries where the fiscal pressure reaches historical records. However, the gains are quite small (usually lower than 0.1 point of percentage). This policy change has a small impact on the gap between the different countries.

[Table 4 about here.]

5 Concluding remarks

Statistical methods to perform long-run forecast of economic data are strongly subject to the Lucas critique. Indeed, it is very unlikely that the estimated relationships will stay stable over such long period of time, given that changes in the environment and/or in policy will be large. Methods based on quantitative theory are likely to be more robust.

Accordingly, we use a general equilibrium overlapping generations model to forecast the level of income per capita in three major developed countries, Canada, France and the USA. Our model is build so as to integrate the most important sources of economic growth: it reproduces accumulation of physical capital and human capital (distinguishing education and experience), increasing participation rates and technical changes. Such a tool can be calibrated on detailed data, with a special attention to the demography and the public sector.

Our baseline forecast is based on constant policies (the current level of benefits will be paid, the effective retirement age and the debt-GDP ratio are constant). We show that the annual growth rate of GDP per capita will be positive but lower than total factor productivity growth over the period 2010-2040.

The population aging process differs across countries, both in intensity and timing. It is interesting to study the implications of these differences in terms of income convergence or divergence. Our results suggest that the gap between the leading country (the USA) and the two other countries (France and Canada) will increase significantly in the next four decades. Moreover, France will catch-up and overtake Canada in 2020.

A change in social policy could alter these conclusions. It is shown that a rise in retirement age to 63 would be very profitable for France (the gap between France and the USA would be reduced by one third). A decrease in social security benefits would slightly stimulate growth but would have no real impact on the gap between the countries.

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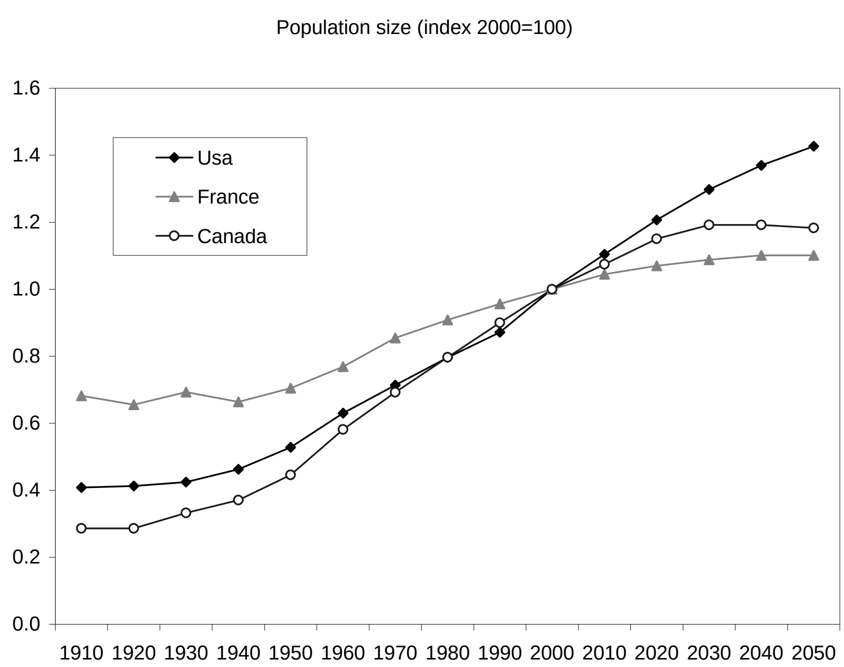
Figures

Figure 1:



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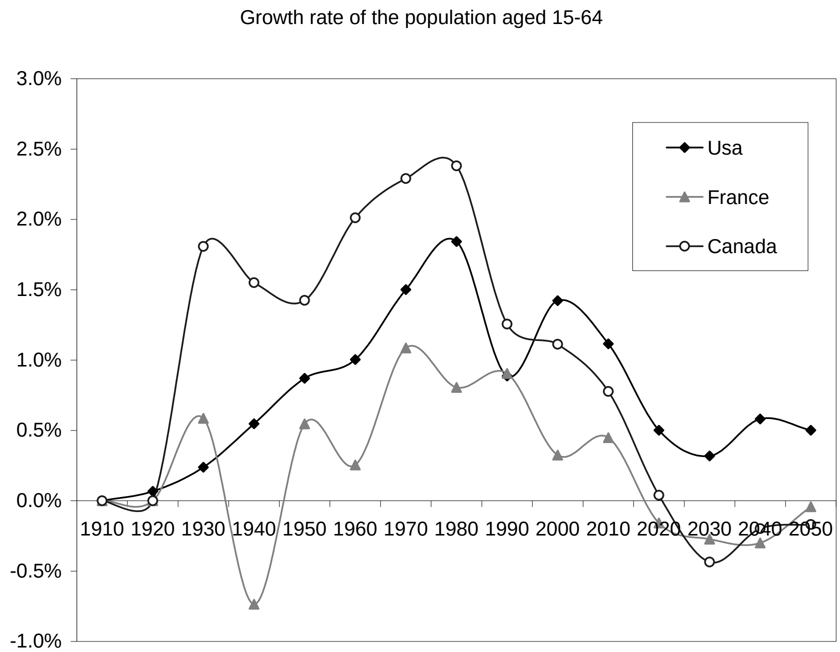

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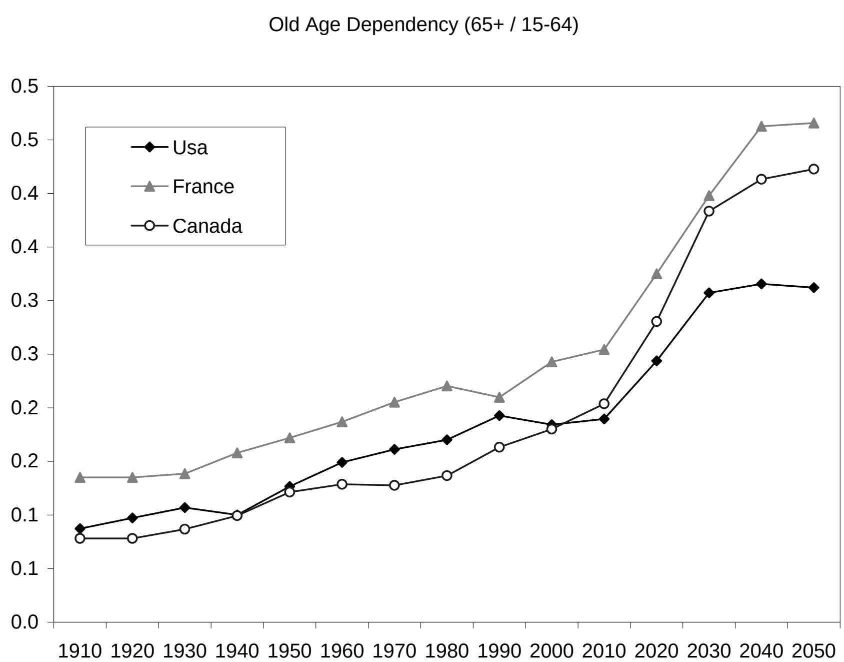

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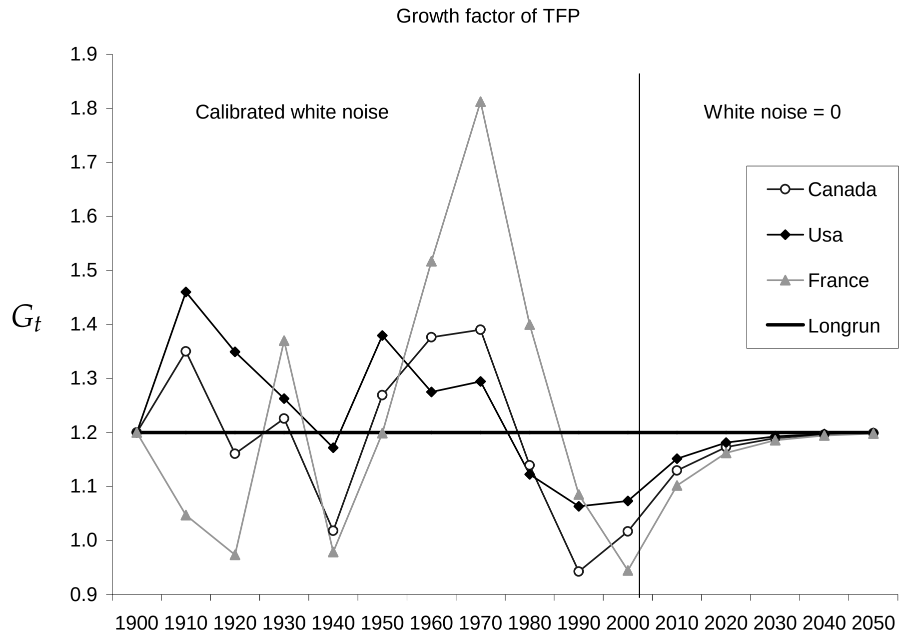

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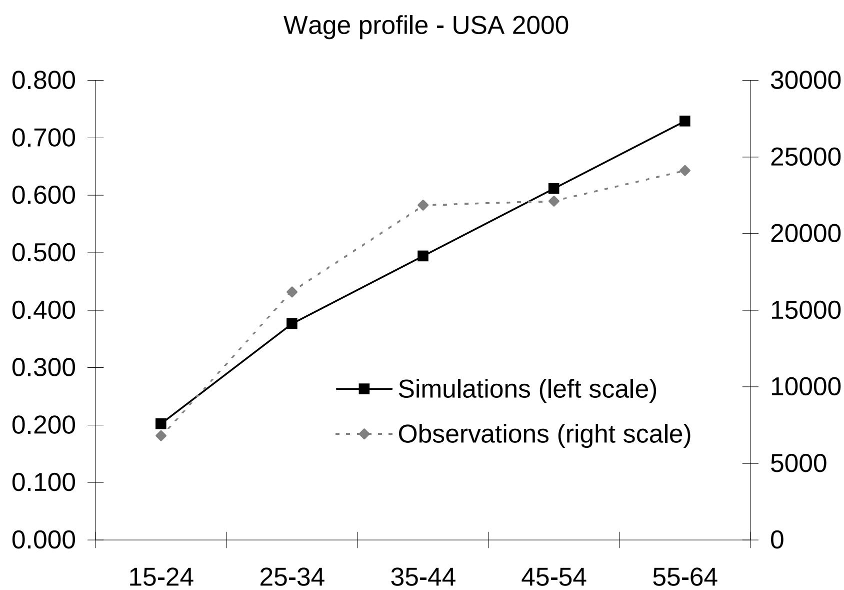

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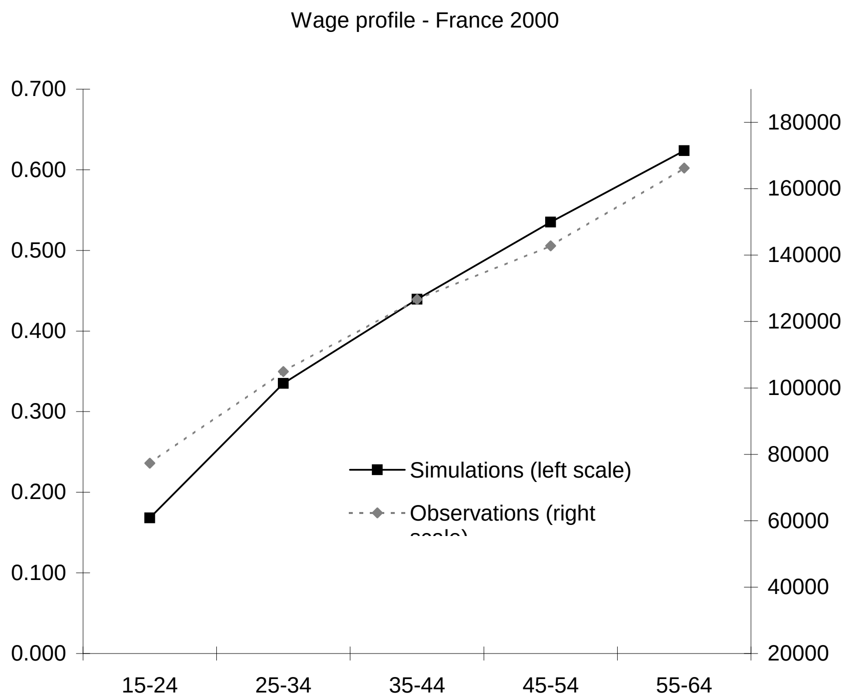

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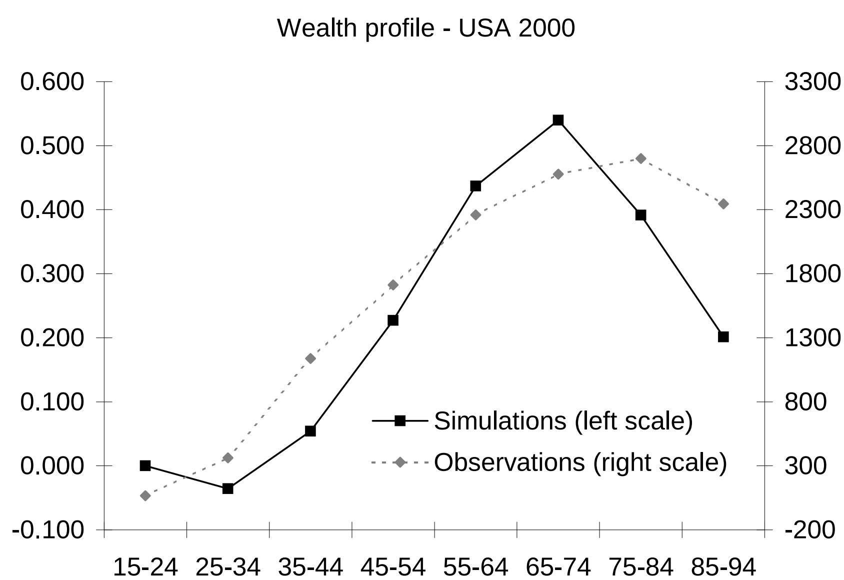

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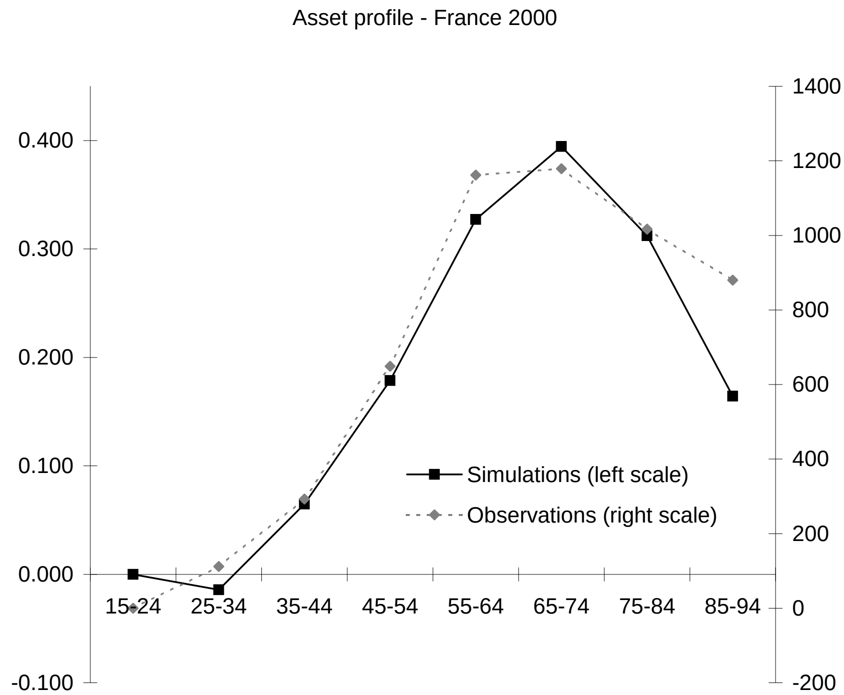


Figure 9: Education and Experience

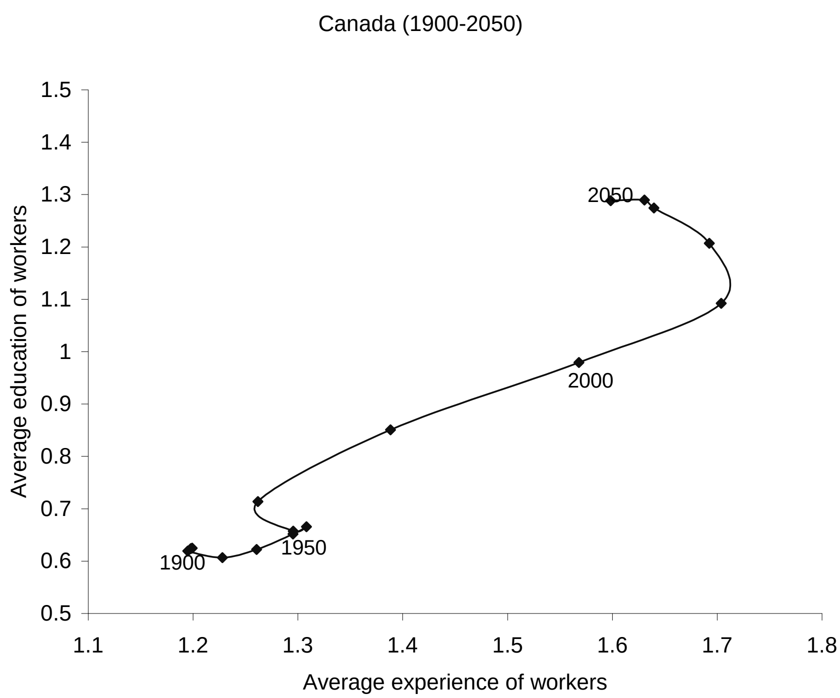


Figure 10: Education and Experience

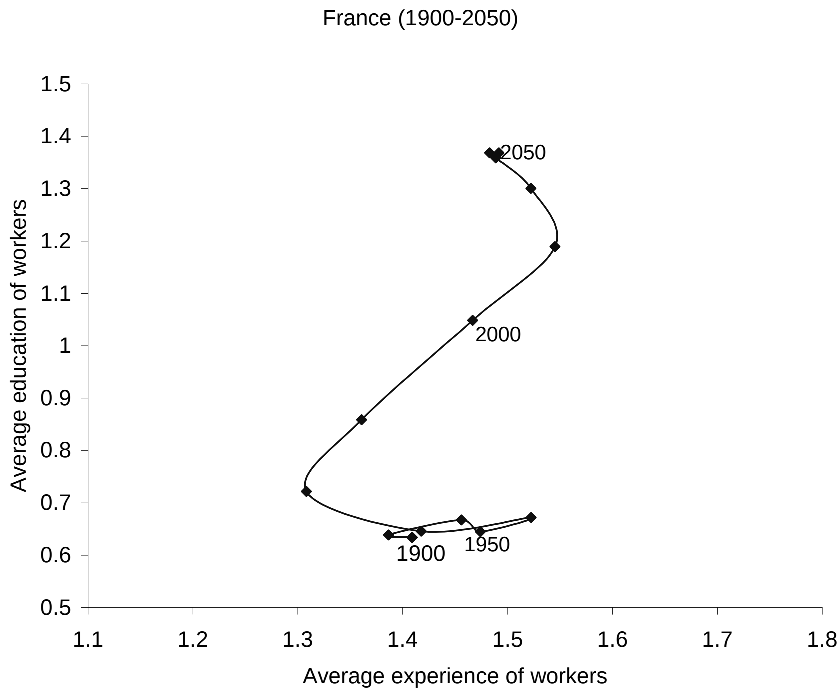


Figure 11: Education and Experience

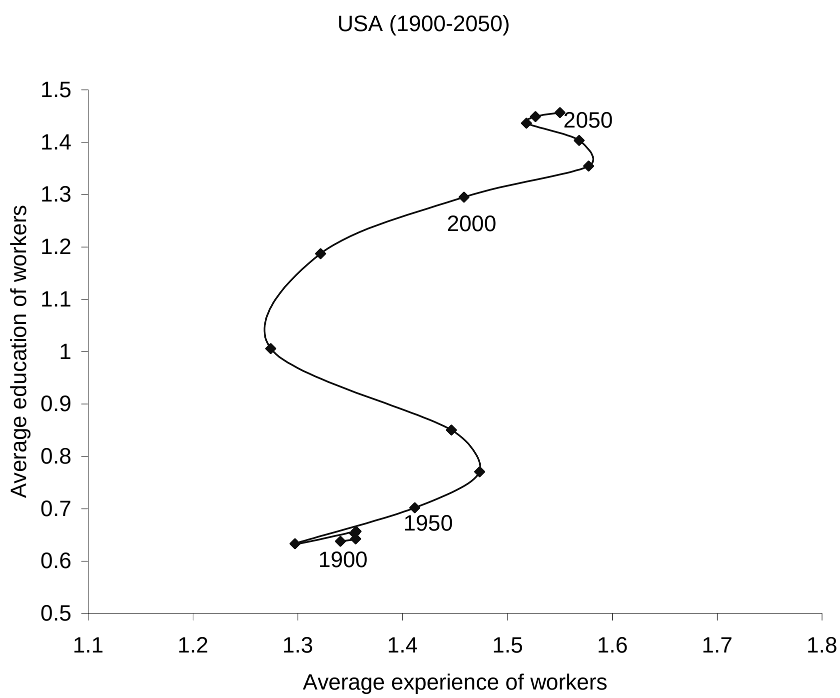


Figure 12: Annual interest rate

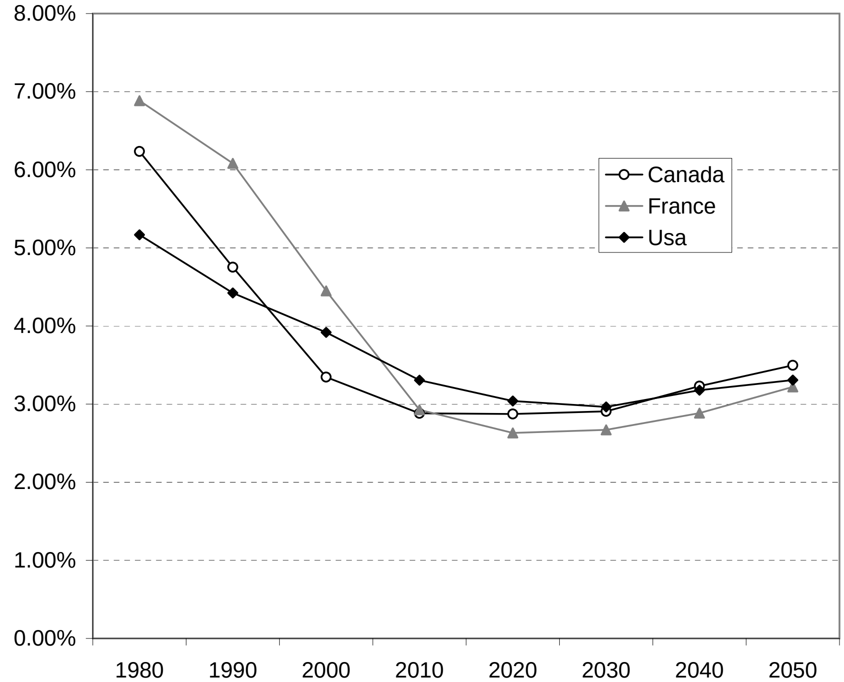
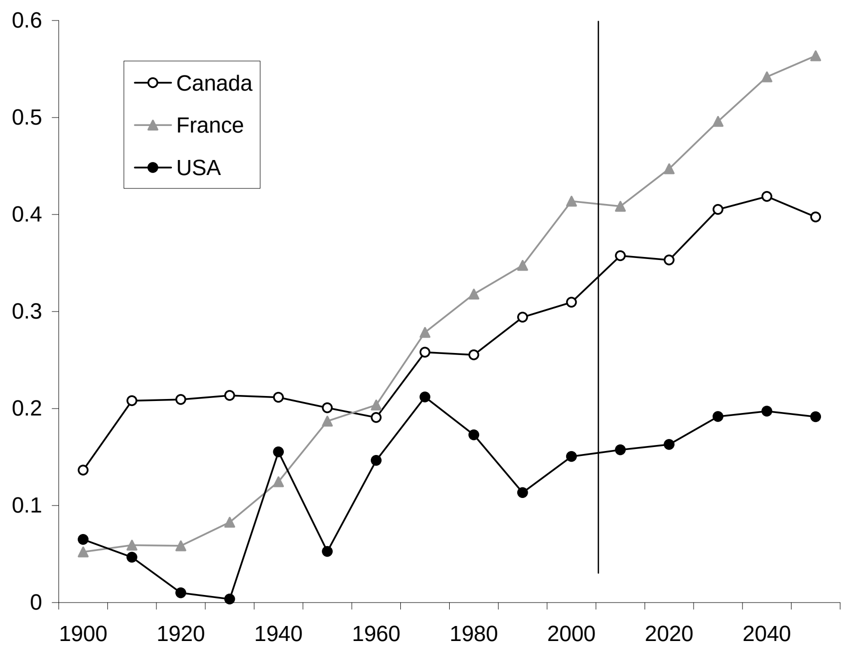


Figure 13: Income tax



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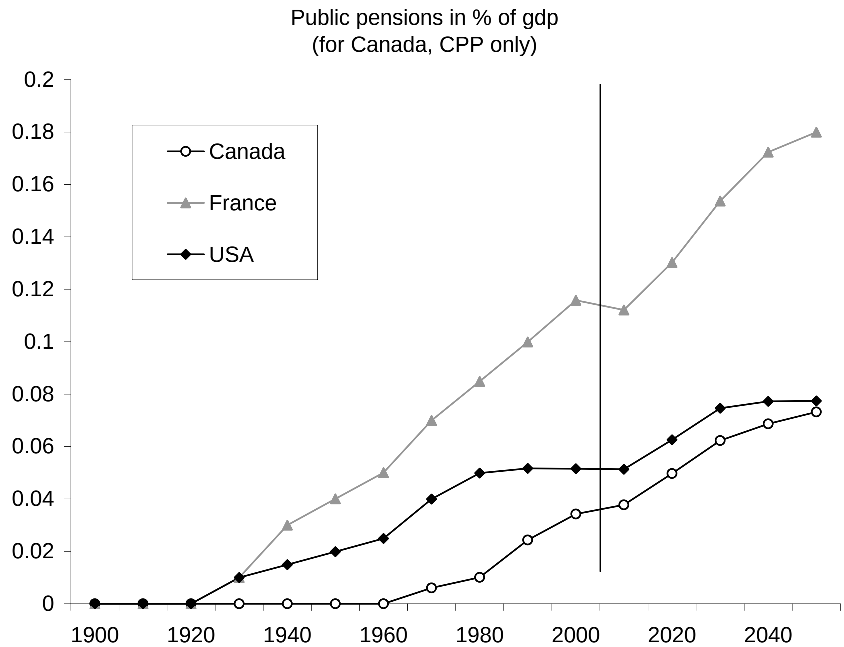
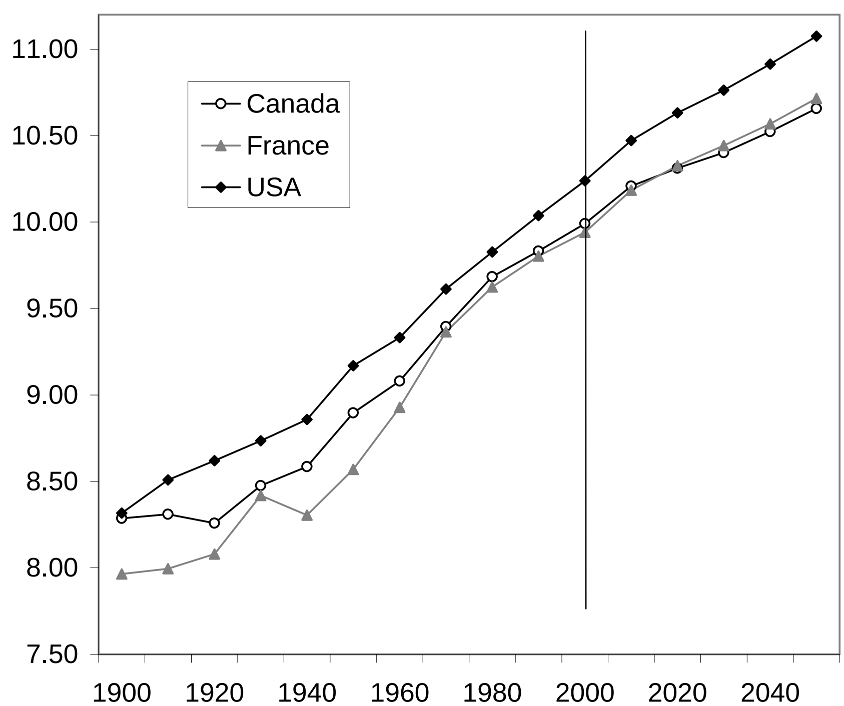


Figure 15: GDP per capita



Tables

Table 1: Forecasted levels of GDP per capita (USD)

	Canada	France	USA
2000	21,843	20,769	27,954
2010	27,126	26,490	35,292
2020	30,091	30,539	41,466
2030	32,908	34,289	47,277
2040	37,175	38,899	54,944
2050	42,522	45,035	64,554

Table 2: Forecasted annual growth rates of GDP per capita

	Canada	France	USA
2000	1.61%	1.39%	2.02%
2010	2.19%	2.46%	2.36%
2020	1.04%	1.43%	1.63%
2030	0.90%	1.16%	1.32%
2040	1.23%	1.27%	1.51%
2050	1.35%	1.48%	1.63%

Table 3: Gain in growth rates of rising the effective retirement age to 63 years

	Canada	France	USA
2000	-0.01%	0.00%	-0.01%
2010	0.20%	0.24%	0.10%
2020	0.35%	0.32%	0.04%
2030	0.06%	0.39%	0.00%
2040	0.04%	0.33%	0.00%
2050	0.05%	0.17%	0.01%

Table 4: Gain in growth rates of adjusting pension benefits to keep income tax constant

	Canada	France	USA
2000	0.05%	0.04%	0.02%
2010	0.06%	0.05%	0.03%
2020	0.05%	0.07%	0.03%
2030	0.07%	0.09%	0.03%
2040	0.08%	0.11%	0.03%
2050	0.08%	0.13%	0.03%

Département des Sciences Économiques
de l'Université catholique de Louvain
Institut de Recherches Économiques et Sociales

Place Montesquieu, 3
1348 Louvain-la-Neuve, Belgique

ISSN 1379-244X D/2007/3082/029