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Macroeconomic Consequences of Pension Reforms in Europe: An Investigation with the INGENUE World Model

Equipe Ingénue

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Abstract

This paper presents some results of the computable, general-equilibrium, multi-regional overlapping-generations model INGENUE. The purpose of this research is to analyse the issues relating to wealth accumulation and alternative pension reforms in the context of global finance. Hence it focuses on the international capital flows that ought to be induced by differential aging of the various regions of the world, as depicted by the UN demographic projections. The first section exhibits the stylized facts which suggest that a world equilibrium approach is appropriate and leads to an analysis of the convergence processes. The second section lays out the analytical structure of the world model and detail our choices of calibrating. The third section presents a baseline scenario of the world economy in the XXIth century. The fourth and final section analyses European public pension reforms scenarios.

Résumé

Ce papier présente une série de résultats obtenus grâce au modèle d'équilibre général, multi-régional et à générations imbriquées INGENUE. L'objet de ce projet est d'étudier des questions relatives à l'accumulation de richesse et au développement de support d'épargne en vue de la retraite dans le contexte d'un monde de finance globalisée. Sur cette base on étudie les flux internationaux de capitaux qui pourraient être induits par les différentiels de vieillissement dans les différentes régions du monde tels qu'ils sont décrits par les projections démographiques des Nations Unies. Nous commençons par étudier en quoi les faits stylisés recommandent une approche mondiale de l'équilibre et motivent un approfondissement des processus de convergence. Nous présentons ensuite le cadre théorique du modèle ainsi que les choix de calibrage retenus. Dans la partie suivante on décrit une projection centrale de l'économie mondiale au cours du siècle. Enfin on se penche sur la question des réformes des régimes de retraite publics de l'Europe dans un tel contexte.

J.E.L. classification number: F21, C68, D91, H55.

Keywords: CGEM, Demographics, International capital flows, OLG model.

Mots Clés : MEGC, Démographie, Flux internationaux de capitaux, modèle OLG.

Summary

The demographic transition features an aging process which is putting the pay-as-you-go pension systems of OECD countries under stress. This challenge has fostered various proposals of reform whose economic consequences are likely to be important and far-reaching, both for the domestic economies of the countries implementing them and for the world economy, given the current and foreseeable degree of international economic and financial integration. Current population structures and demographic projections for the various regions of the world show that the aging process is not synchronous: over the next decades, while OECD countries – and most notably Europe and Japan – will experience large increases in their old-age dependency ratios, other regions of the world will be facing relatively low ratios and still rising working-age populations. This difference in time profiles of demographic changes suggests that inter-temporal trade, in the form of international capital flows, would be mutually advantageous and might improve the economic outcomes of aging compared to a situation of economic and financial autarky.

This paper presents and briefly discusses the INGENUE model, an applied, international, overlapping-generations, general-equilibrium model of the world economy that has been built to analyze the interplay of pension schemes and reforms with domestic capital accumulation in the various countries and with international capital flows, in a world of global finance. After a short description of the major features of the baseline scenario of the model for the world economy over the next century, we systematically compare the domestic and international macroeconomic consequences of broad classes of pension reforms in Europe in the INGENUE model with those obtained in similar models where Europe is treated either in autarky or as a small, open economy. This comparison allows a better understanding of the role of financial openness and international capital flows in smoothing and spreading the effects of pension reforms in developed countries.

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Résumé Long

Le processus de transition démographique caractérisé par un vieillissement continu des populations rend difficile l'équilibre des régimes publics de retraite par répartition des pays de l'OCDE en l'absence de modifications des modalités actuelles de ces régimes. De nécessaires ajustements de ces règles d'équilibre des régimes publics sont attendues. Différents types de réformes peuvent être envisagés. Celles-ci auront des conséquences économiques propres et diverses non seulement sur l'économie domestique des pays qui les ont mises en œuvre mais aussi, en raison de l'accroissement prévisible des interdépendances économique et financière des économies, sur les autres pays du monde. Les pyramides des âges actuelles ainsi que les projections démographiques correspondantes font apparaître une dé-synchronisation des processus de vieillissement démographique entre les différentes régions du monde : ainsi au cours des prochaines décennies les pays de l'OCDE –plus particulièrement l'Europe et le Japon– vont connaître une hausse importante de leur ratios de dépendance, dans le même temps les autres régions du monde conserveront des ratios de dépendance bas et des taux de croissance élevés de la population en âge de travailler. Une telle différence dans les profils temporels des processus de transition démographique laisse suggérer que l'échange inter-temporel –sous forme de flux internationaux de capitaux– pourrait être mutuellement avantageux et améliorerait notablement les performances des économies face au vieillissement au regard de ce qu'elles pourraient en attendre dans des situations d'autarcie économique et financière.

Ce papier présente rapidement le modèle INGENUE et certains de ces enseignements sur ces questions. INGENUE est un modèle appliqué d'équilibre général de l'économie mondiale avec générations imbriquées de ménages. Cet outil a été construit afin d'analyser les interactions entre les modalités propres des régimes de retraite et leurs éventuelles réformes avec les comportements d'accumulation de capital et les mouvements internationaux de capitaux dans un monde de finance globalisée. Après une description rapide des caractéristiques essentielles d'un scénario central de l'économie mondiale sur l'ensemble du siècle, nous comparerons de façon systématique les conséquences macroéconomiques domestiques et internationales d'un large éventail de réformes des régimes publics de retraite de l'Europe avec les résultats obtenus dans des modèles comparables mais tels que l'Europe soit envisagée soit comme une économie autarcique soit comme une petite économie ouverte. Une telle comparaison permet une meilleure compréhension du rôle de l'ouverture des marchés de capitaux et des flux internationaux de capitaux correspondants dans le "lissage" et la propagation des effets des réformes des régimes de retraite au sein des pays développés.

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Macroeconomic consequences of pension reforms in Europe : an investigation with the Ingenue world model[1]

INGENUE team[2]

1. INTRODUCTION

While populations in OECD countries have been aging for a long time now, raising living standards in other parts of the world are also bringing longer life expectancy and falling fertility rates in developing countries: the so-called demographic transition pattern is progressively spreading over the entire world; thus, the world population is aging, but at a different pace in the various regions of the world. Whereas various economic and social consequences of aging have been investigated in OECD countries, very few analyses have explicitly taken the worldwide aspect of the problem into account. Indeed, this generalized but differentiated aging process is occurring in a world of increasing capital mobility and financial globalization, which suggests that it may give rise to new opportunities for profitable exchanges amongst regions, a situation of mutually beneficial gains from inter-temporal trade through international financial transactions. The purpose of this analysis is therefore to evaluate the potential magnitude of such capital flows: if they are found very large compared to what has been observed in the past (end of the XIX century up to World-War-I) or in more recent years, such a prospect raise the issue of international financial instability and of the institutions and regulations that would have to be set up to make such large capital flows between developed and aging countries and developing countries with younger populations sustainable.

This paper presents, and makes use of, an applied, international, overlapping-generations, general-equilibrium (OGGE) model of the world economy built upon the 1998 UN demographic projections to study the prospects of asset accumulation and investment in the various regions of the world and of international capital flows over the next few decades. In the INGENUE model, the world economy is divided into six zones, according to demographics: three developed areas with already advanced aging processes - the European Union, the United States and Japan - and three developing

[1]The team acknowledges financial support from CEPII, CEPREMAP and OFCE, co-developers of the model, as well the Institut Caisse des dépôts and the Conseil national du crédit et des titres. We thank participants in Max Plank Institute "Demographic Macroeconomic Modeling" workshop (Rostock 2000), Forum Retraites Caisse des dépôts (Bordeaux, 2000 and 2001), SCED symposia (Barcelona 2000, Yale 2001), ESPE conference (Athenes 2001) and ESEM (Lausanne 2001), IFAC (Klagenfurt, 2001). Correspondence : ingenue@cepremap.cnrs.fr.

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areas in which aging processes have started later (see Section 2 for a presentation of the six regions). The structure of the model is conceptually very simple and familiar: INGENUE is an OGGE model with exogenous growth; there are only one good and one asset, and world markets are perfectly integrated, whereas individuals are immobile between regions; there is no money and all relative prices are perfectly flexible, so that all markets clear at all times; there is no uncertainty whatsoever, including over the date of individual death, and expectations are perfect-foresight. To our knowledge, it is the first time that such a computable OGGE world model, with realistic demographics, exogenous growth and technological convergence, is built and solved both for the steady-state, long-run equilibrium, characterized by a constant rate of technical progress on which all economies have eventually converged, as well as constant populations everywhere, and for the transition path from the present situation to this long-run, steady state, as well for policy simulations.

The section 2 of the paper introduces the issues, and puts our analytical framework into perspective, comparing it with previous work on the macroeconomic consequences of aging in OECD countries and on economic convergence. Section 3 presents the model, and discusses a number of aspects of the calibration process. The steady state and transition path of the baseline scenario are described and briefly commented in Section 4. Section 5 compares the results of simulating pension reforms in the INGENUE model with outcomes of models of a similar structure, but either autarkic, closed economies, or small, open economies, in order to illustrate the advantages of explicitly accounting for financial openness and equilibrium in integrated world capital markets. Section 6 offers some concluding remarks and suggests directions for further research with this class of models.

2. FINANCIAL GLOBALIZATION, DEMOGRAPHIC TRANSITION, AND ECONOMIC CONVERGENCE

In OECD countries, where the old-age dependency ratios - the shares of people over a certain age (65, usually) in total population - are rapidly increasing, this aging process is putting public, pay-as-you-go retirement systems under stress and pushing for reforms that, in most cases, introduce individual or collective capitalization mechanisms. In developing countries and emerging economies, where aging is less advanced, working-age population is growing fast, whereas old-age dependency ratios are still low and are expected to rise only later in this century. In a world of integrated capital markets, such staggered and overlapping demographic transitions are likely to give rise to net capital transfers amongst regions with different demographic dynamics. Indeed the life-cycle hypothesis suggests that households tend to save most between 40 and 60-65, when children have left their parents' home, labor incomes are high and retirement is coming near, and to dissave afterwards, during retirement. Hence in OECD countries the numerous cohorts of the baby-boom generations will be high-saving cohorts over the next decade or so, then will start dissaving, whereas less numerous cohorts will enter their high-saving age; in the rest of the world, the share of high-saving cohorts will stay low over the next decades, and will start increasing only later in the century.

This should generate a long international accumulation cycle, in which OECD country residents would first accumulate, then decumulate assets from the rest of the world.

2.1. Existing analyses of the economic consequences of aging

Most recent studies of the future of national pension schemes rely on mechanical projections of demographics, on the one hand, and of the macroeconomic environment on the other hand. Insofar as the present study aims at analyzing the interactions between demographic trends and economic variables, it seems appropriate to rely on Modigliani's life-cycle hypothesis of saving (Ando and Modigliani 1957, Modigliani 1986) and to use the general-equilibrium, overlapping-generations framework, as proposed by Samuelson (1958), and amended by Diamond (1965). These, by now familiar, theoretical models have inspired applied developments that have been used increasingly in recent years to study the prospects of national pension schemes. However, many such studies, starting with the pioneering work of Auerbach and Kotlikoff (1987) on the US economy[3], have been conducted in the closed-economy framework.

In recent years, the necessity to take economic and financial openness into account (Fisher and Reisen (1994); Bank (1994); Reisen (2000)) has led to the development of new varieties of open-economy models for the analysis of pension prospects and reforms. Many such models[4] consider small, open economies, in which case either international capital mobility is imperfect, so that domestic interest rate may differ from world interest rate, in which case the current account is driven by an ad-hoc mechanism; or capital is fully mobile, in which case most essential variables are, in fact, exogenous: such models are, in effect, partial equilibrium models, and the exogenously given interest rate completely determines other important relative prices, because it determines the capital intensity of production. In another class of models, the representation of the world economy is a genuine multinational, general equilibrium (as in Turner, Giorno, De Serres, Vourc'h and Richardson (1998), but the specification of the saving behavior is, in turn, ad-hoc and not quite appropriate for the analysis of the economic consequences of aging[5]. These shortcomings of existing applied models plead in favor of building a world model, in which such variables as interest rates, domestic saving and investment in the various countries are endogenous, and to model demographics in such a way as to faithfully picture the aging process. Two-country, OGGE theoretical models of the world economy, represented as a closed system, have first been proposed by Buiter (1981), then extensively used by Obstfeld and Rogoff (1996) in their recent

[3] Closed-economy, applied OGGE models of a similar structure have been developed for other OECD countries by Auerbach, Kotlikoff, Hagemann and Nicoletti (1989), Cazes, Chauveau, LeCacheux and Loufir (1992b, 1992a, 1994)

[4] A simple, theoretical, small, open-economy OGGE model has been initially proposed by Persson (1985). Followers, using a variety of specifications, include Perraudin and Pujol (1991), Chauveau and Loufir (1995), Raffeluschen and Risa (1995), Kenc and Sayan (1997), Miles (1997). A recent collection of such models is Broer and Lassila (1997)

[5] In the model of Turner et al. (1998), the specification relies on the Yaari-Blanchard version of the life-cycle model (Blanchard 1985) in which individuals face a constant probability of death, which is not a proper representation of the aging process.

text on international macroeconomics. But to our knowledge, such a complete, applied general-equilibrium model of the world economy, with fully specified life-cycle behavior of individuals in overlapping generations and endogenous determination of the major economic variables does not presently exist.

2.2. Inter-temporal trade

If the residents of developed countries most advanced in the aging process were to rely on financial autarky and exclusively invest their additional saving in their home countries, it would generate an over-accumulation of productive capital, the rise in the capital-labor ratio of production leading to a decline in the marginal productivity of capital, hence in its rate of return. Financial globalization instead allows for a process of equalizing rates of return on capital worldwide: retired households from developed countries would benefit from additional income from their investment abroad, while numerous working-age cohorts in less-developed countries would benefit from a higher capital stock, hence a higher capital-labor ratio, therefore higher labor productivity and better wages. Moreover, investment abroad leads to a better diversification of non systematic risk, but possibly also to an increase in systemic risk, as recent financial crises have illustrated: thus, if our analysis leads to the conclusion that large amounts of capital would likely be transferred from OECD to developing countries as a result of differences in their demographic dynamics, it would raise the issue of the stability of the international financial system.

2.3. Worldwide convergence in the very long run?

Building an international-inter-temporal model of the world economy that is supposed to depict the macroeconomic consequences of demographic transition implies a complete characterization of the steady-state equilibrium of the economy: in the very long run, all individual variables in all regions of the world grow at a constant pace, which is the exogenous rate of technical progress. One crucial issue therefore is the convergence process that is built into the model's assumptions, a process on which there is very little empirical evidence. For demographics, we simply rely on the UN projections, that assume slow demographic convergence and a constant world population in the very long run[6]. Concerning institutions - comprising only a pay-as-you-go retirement scheme in all regions of the world in this version of the model -, we have opted in this paper[7], quite arbitrarily, for an assumption of indefinitely persistent differences amongst regions.

[6] In practice, this version of the INGENUE model is based on the 1998 UN revised, medium projections.

[7] In another recent paper (Ingenue (2001d)), we investigate the consequences of various scenarios of institutional convergence: as developing countries get richer, they may want adopt pension systems that resemble those currently existing in developed countries; and conversely, because of tensions arising from population aging, some developed countries may decide to reform their existing schemes and switch to less generous pension devices; in either case there would be some sort of institutional convergence.

With regard to technology, we also have to make arbitrary assumptions about convergence. Indeed, while the initial situation is clearly characterized by wide gaps between total factor productivities in the various regions, our model incorporates a single good and the various regions' production functions only differ by a scale factor. Although existing empirical evidence on the international convergence of living standards does not seem to support such an assumption (see, for instance, Barro and Sala i Martin (1992); Sala i Martin (1996); Bernard and Jones, 1996; Evans (1997); Jones (1997a, 1997b); Cortes and Pisani-Ferry (1997); Pritchett (1997); Quah (1997); Temple (1999)), we do impose an ad-hoc, exogenous, convergence process, so that all regional economies eventually grow at the same, constant rate. Following the rationale given in Lucas (2000) to reconcile the lack of convincing evidence on a convergence process over the past century with the hypothesis that convergence should indeed happen, we specify a mechanism of exogenous international diffusion of technical progress, so that total factor productivity in the various regions of the world slowly converge. In practice, we assume that the US economy is the leader and sets the long-run, steady pace of technical progress, which is supposed to be close to the observed secular trend, i.e. 2%. Other regions are then supposed to progressively catch up thanks to productive capital accumulation and to some exogenously set technical convergence functions, the choice of which is an essential step in the model's calibration process[8].

Initial differences amongst regions are so large in the data - especially with respect to capital stocks and current accounts - that they are difficult to reconcile with the simple assumptions made in the model, especially that of perfectly integrated world capital markets and a single interest rate. For calibration purposes, in order for our model to mimic these initial differences, we have also assumed that individuals in the various regions initially may have different rates of time preference. In practice, it proved sufficient to set the time preference parameter for the US residents at a higher value, while keeping all the others equal.

However, insofar as we want to emphasize the role of demographic factors and differences in the process of capital accumulation and in shaping international capital flows over the next decades, we do not want other differences amongst our six regions to permanently interfere with population dynamics. We have therefore chosen to have all other differences - except for the institutional ones (see above) - progressively vanish in the long run. Hence, not only are rates of technical progress supposed to converge, but so is the US rate of time preference[9].

[8] A detailed analysis of our convergence hypothesis, along with comparisons of the outcomes of various assumptions concerning the speed of the catching-up process, is available in Ingenue (2000).

[9] In another recent paper (Ingenue 2001c), we systematically investigate the consequences of different assumptions and parameter values and test the robustness of our conclusions.

3. AN INTERNATIONAL, INTER-TEMPORAL MODEL OF THE WORLD ECONOMY WITH REALISTIC DEMOGRAPHICS

The INGENUE model is a multi-region, world model, in the spirit of those developed by Obstfeld and Rogoff (1996), in which the structure of each regional economy is similar to that of other applied, OGGE models, such as Auerbach and Kotlikoff (1987) or Cazes, Chauveau, LeCacheux and Loufir (1992b, 1994), except that labor supply is exogenous. The world is divided into six regions, each of which is made of three categories of economic agents: the households, the firms, and the public sector, which is simply a pay-as-you-go retirement pension system. There is only one good, and only one financial asset, which is an ownership stake in the firms' productive capital ; both the good and the financial asset are freely traded on perfectly competitive world markets. There is no money and hence only two relative prices in each region of the world: the (real) wage rate accruing to local, internationally immobile, workers; and the single (real) price of financial assets, both expressed in terms of goods, which may be chosen for *numéraire*. Hence, the various regions of the world are economically and financially perfectly integrated and there is only one world market for goods and one for financial assets.

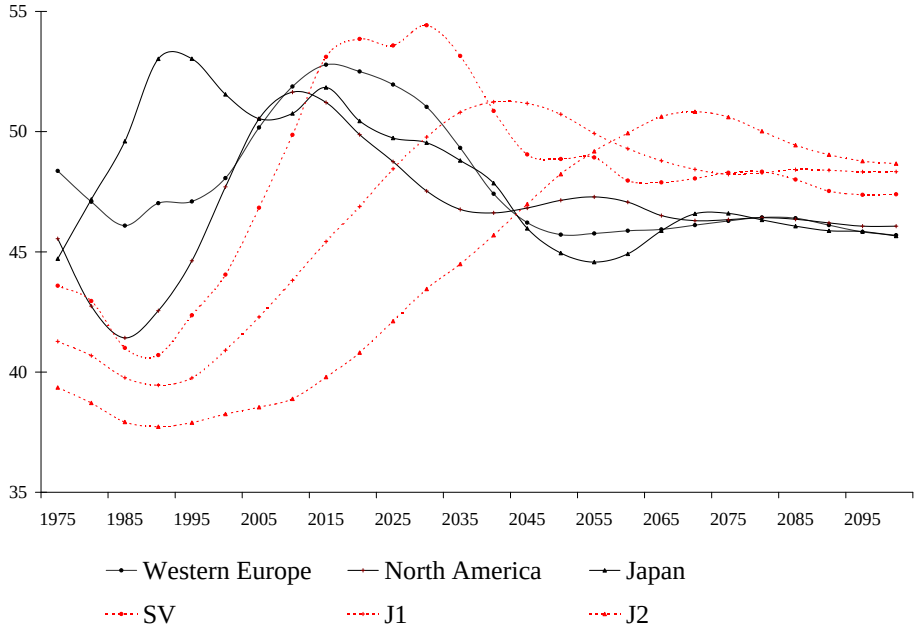
3.1. The structure of the model

3.1.1. The regions of the world

For the sake of simplicity, the world has been divided into six large regions, three developed areas and three conglomerates of more or less advanced, emerging or developing countries, that have been grouped together according to their demographics as projected by the UN (1998). Consistent with the life-cycle hypothesis, the demographic structures of the various countries have been characterized by six criteria: population growth rate, youth dependency ratio (population under 15 in total population), old-age dependency ratio (population over 65 in total population), very old-age dependency ratio (population over 80 in total population), working-age population ratio (share of people aged between 20 and 65 in total population) and high-saving population ratio (share of people aged between 40 and 65 in total population). Based of these criteria, we get six relatively homogeneous regions - at least demographically and economically speaking –: (North) America (essentially the US and Canada, plus Australia and New Zealand); (Western) Europe (mostly the EU); Japan; emerging or transition countries with an already aging population (China, South Korea, Russia, etc.) called SV; emerging and developing countries just starting their demographic transition (India, most of Latin America, etc.), called J1; and finally those developing countries that are lagging behind in terms of demographic transition (Africa, Pakistan, etc.), called J2[10]. In developed regions, the standard demographic transition process combines with post-world-war-II baby booms, so that the aging process in these areas is the result of a long-term tendency plus a temporary hump in the age-pyramid.

[10]The list of countries in the six regions is given in Annex 1.

Chart 1: High Savers (40 - 65 years) percentage share in total Population



In the medium scenario of the UN demographic projection for the first half of this century, these six regions are going through the demographic transition process one after the other, starting with Japan, then Europe, America, SV, J1 and J2. This succession of transition processes is best illustrated by Chart 1, in which the six regions are characterized by their high-savers ratios.

3.1.2. The household sector

During any five-year period, in each region of the world, the household sector is made of fifteen overlapping cohorts of adults, of age between 20 and 94, and four cohorts of ”young”, dependent on their parents: individuals become adults when they turn 20, and remain in the labor force until legal, mandatory retirement age, which differs according to the region. Because labor supply is exogenous, their only economic decisions are their consumption and saving decisions, made with perfect foresight at the beginning of their adult life. Over a given sub-period of their adult life - between 20 and 39 –, adults are supposed to give birth to children, according to a time distribution that tries to mimic the actual time pattern of births in the various regions; children are dependent until they turn 20, with a cost per child that is supposed to be proportional to the parents income - functioning like a ”tax” - and exogenous; the children in turn become adult households; hence, sometimes between 40 and 60, all households are made of two adults without dependent children: this is the beginning of the ”high saving” period, that lasts until retirement.

In each zone, the household sector comprises 15 overlapping generations of adult agents. Each cohort is divided into sub-groups, homogenous with regard to the lifetime, which is certain: hence, by progressively increasing the proportion of the sub-groups living longer, we can mimic the projected lengthening of life expectancy.

In a given area, J indicates the number of groups of overlapping generations which compose the household sector. $A_{j=1...J}$ denotes the lifespan for an individual in the group j. By convention, we suppose: $A_J > ... > A_2 > A_1$. The size of the generation of age a in group j is $N_{a,j}$. The ratio $\frac{N_{aj}}{\sum_j N_{aj}}$ represents the proportion of people who will die at the age A_j.

In each group, each generation can be represented by the behavior of a representative household. The intertemporal preferences are given by the following function[11]:

$$U = \sum_{a=1}^{A_j} \rho^{a-1} u\left(c_a\right) \tag{1}$$

where ρ is the psychological discount factor and where u is a time separable utility which measures the level of welfare obtained from a consumption equal to c_a at age a with $u' > 0, u'' < 0$. In the model, u is a CARA function: $u\left(c\right) = \frac{c^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}$, where σ is the intertemporal substitution rate. There is no bequest motive and no leisure motive (labor supply is exogenous).

At any given period, the budget constraint is:

$$\beta_a c_a = w_a + Rs_{a-1}^{-} - s_a \tag{2}$$

$w_{a=1...A_J} = \lambda_a \cdot (1-\tau) \cdot w\left(\frac{K^-}{L}\right) + P_a$ is net labor income after transfers and taxes (τ) ; Rs_a^- is financial income (capital return time saving). w is the wage and P is an age depending benefit: $(\lambda_a = 0, P_a > 0)$ for $a \geq A^{act}$ (retirement age) and $(\lambda_a = 1, P_a = 0)$ for $a < A^{act}$. s_a and c_a denote respectively saving and consumption at the age a. The β_a term is an equivalence scale. It takes account the direct and indirect costs of child-rearing. We assume this cost is proportional to the consumption. We assume that household can never have a negative net worth. First order conditions yield:

$$\begin{cases} c_{a=1...A_j-1} = \left(\rho R^+ \frac{\beta_a}{\beta_{a+1}^+}\right)^{-\sigma} c_{a+1}^+ \\ s_{a=1...A_j-1} = w_a - c_a + Rs_{a-1}^- \\ s_0 = 0 \\ s_{a \geq A_j} = 0 \end{cases} \tag{3}$$

[11]For simplicity, when they are not useful, time (t), regional (i) or group (j) subscripts will be omitted and the signs + and - will respectively designate the past and future periods.

3.1.3. The production sector

Because there is a single, composite good that may be used for consumption and investment, this good can also be taken as a *numéraire*. It is produced by firms located in the various regions and operating in perfectly competitive world markets for goods and capital, as well as perfectly competitive local labor markets. Hence, in equilibrium profits are zero and fully employed production factors remunerated at their marginal productivity.

The production technology is the same in all regions, except for a scale factor, that characterizes the level of total factor productivity (Γ), and that is driven by the exogenous growth and convergence process. Production is obtained by combining local labor with internationally traded capital, in a constant-returns-to-scale technology. We use a Cobb-Douglas technology: $Y = \Gamma K^{\alpha} L^{1-\alpha}$ where α is the share of capital. In addition, productive capital is assumed to depreciate at a constant, uniform rate δ. The level of total marginal factor productivity is exogenous and grows at a constant rate, in each region. This rate is the result of a given, exogenous growth of 2% per annum in America ($i = 1$), supposed to be the technological leader, and a region-specific, exogenous, catching-up factor, reflecting international diffusion of technological progress, according to the following law of diffusion[12]:

$$\frac{\Gamma_{i,t}}{\Gamma_{i,t-1}} = \left[1 + \lambda^t\right] \times \frac{\Gamma_{1,t}}{\Gamma_{1,t-1}} \times \left[\mu^t + \left(1 - \mu^t\right) \frac{\Gamma_{1,t-1}}{\Gamma_{i,t-1}}\right] \tag{4}$$

where Γ_i is a measure of this level of knowledge ; λ plays a role of a accelerator to the convergence in the growth rates, while μ is a brake on the convergence in terms of levels.

3.1.4. The public sector

In this version of the INGENUE model, the public sector is reduced to a social security department; it is a pay-as-you-go public pension scheme, that is supposed to exist in all regions of the world. It is financed by a payroll tax on all labor incomes and pays pensions to retired households. Because labor supply is assumed to be exogenous, the payroll tax induces no distorsion in individuals' economic decisions; but the generosity of the local pension scheme has an influence on individuals' saving decisions. In all the following, the regional public retirement systems operate according to a defined-benefit rule: in each region, pensions paid to individual retired are a fraction - or replacement rate (κ) – of the current average wage, meaning that pensions are effectively indexed on (net of tax) wages; payroll tax rates (τ) are therefore endogenous, as a result of the balanced-budget rule for the social security department in each region:

[12] In Ingenue (2000), we investigate various scenarios of international technological diffusion. In Ingenue (2001e), we combine assumptions on technological diffusion with scenarios of pension reform in the various regions, to analyse the outcomes of complex scenarios of evolution of the world economy in the very long run.

$$\frac{\tau}{1-\tau} = \frac{\sum_{a=A^{act}}^{A_J} N_a}{\sum_{a=1}^{A^{act}-1} N_a}\kappa \tag{5}$$

where $N_a = \sum_{j=1}^{J} N_{a-1,j}$. κ is fix but τ is endogenous. A^{act} is an institutional parameter. It designates the legal retirement age.

3.1.5. Equilibrium

The general equilibrium of the model is solved simply by equating, in each region, the labor demand emanating from domestic firms to the exogenous, local labor supply, which yields the regional wage rate, and the sum of regional supplies of saving with the sum of regional demand for investment, this equilibrium condition on the world capital market yielding the interest rate. These variables in turn determine regional GDP, aggregate consumption and saving, as well as their distribution over living cohorts in the various regions. In any given period, the difference between the flow of domestic saving and domestic investment in any of the six regions gives the inflow or outflow of capital for the region, while the discrepancy between the stock of accumulated wealth and the stock of accumulated productive capital in the region, defined as the ownership ratio, gives an indication of the net external position of the region *vis-à-vis* the rest of the world.

The world general equilibrium can be obtained by aggregating regional supplies and demands of capital and by setting excess demand to zero. The intertemporal world equilibrium exists if there is a unique sequence $\{R_t\}_{t\geq 0}$ which is a perfect-forecast stable solution of:

$$\sum_{i=1}^{I} \left[f_i'^{-1}\left(R^+\right) L_i^+ - S_i \right] = 0 \tag{6}$$

where $S_i = \sum_{a=1}^{A_J-1} N_a s_a$ and K_i^+ are respectively the regional saving and capital demand.

3.2. Calibration

The model is calibrated with the UN (1998) demographic projections, completed over the second part of the XXI century, with parameter values for the households' and firms' behaviors, and with macroeconomic data over the period 1970-1995, as well as exogenous growth rates and international technological convergence, and finally pension schemes in the various regions of the world, the criteria being the fit of simulated outcomes with observed macroeconomic aggregates, in particular current accounts, over the period 1995-1999 and the, admittedly debatable, plausibility of the time path and long-run equilibrium value of the interest rate.

3.2.1. Demographics

Though crucial for the behavior of the model, the specification of precise demographic structures and evolutions in the long run is all but easy and straightforward. Until 2050, we rely on an aggregation, over our six regions, of the demographic projections performed by the UN, as revised in 1998. We have chosen, rather arbitrarily, the medium fertility scenario. But we also need the evolution of regional populations well after 2050[13]. In this version of the model, we abruptly set reproduction rates of generations equal to one in all regions, so that populations become stationary after 2100.

In order to account for the aging process arising from ever longer life expectancy without introducing uncertainty over the date of individual death and related probabilities[14], we have divided each cohort into six sub-groups, according to the date of their death, assuming for simplicity that no one dies before reaching 60; then some die when they are 60-64, some when they 65-69, etc. We then progressively increase the proportions of the populations dying at older ages in each region, while letting individuals in each sub-group perfectly anticipate the date of their own death. Taken together, these assumptions about demographics allow our model to mimic the UN projections for the six regions until 2050 and then to yield reasonable demographic evolutions afterwards.

3.2.2. Households' behavior

It is of course hardly possible to gather detailed information about observed life-cycle profiles of individual consumption and saving in the six regions. We therefore chose to adopt a similar set of parameter values for the calibration of individual utility functions. The criteria to select these numerical values have been the world interest rate, the initial constellation of regional capital stocks and current accounts, as well as the cross-section and longitudinal consumption inequalities between the youngest and the oldest cohorts. The rate of inter-temporal substitution is set everywhere at $\sigma = 0.98$. However, due to the necessity of accounting for the specifics of the initial period, characterized by a large US current account deficit that cannot easily be reconciled with the long-run logic of the model[15], we had to differentiate the numerical values of the discount factor ρ, which has been set equal to 0.99 in all regions but America, where it

[13] In practice, we run our simulations until the year 2500, as the steady-state of the model is reached in a quite far distant future, because of the five-year periodicity chosen here. The regional populations, and most other variables in fact stabilize shortly after 2100, so that most charts in the paper are drawn over the century.

[14] The problem with individual uncertainty about life expectancy is of course the presence of unintentional bequests. In a new version of the model being under construction, we try to improve the way demographics are modeled, in particular the lengthening of life expectancy. But it should be clear that, although cumbersome, the current procedure has the advantage of effectively accounting for ever longer lives, which is what aging is about, at least in developed countries.

[15] A plausible reconciliation route lies in the fact that the calibration period is probably one of relatively low, or at least imperfect, international capital mobility, and one in which the US capital markets have been less regulated and more efficient than those in the rest of the world, so that American residents have been able to save less and even go into debt, thus attracting a disproportionate share of the world capital. In addition, as is well known, the technological changes that happened in the late 1990's probably accelerated the rate of productivity growth in the US.

Table 1: Retirement Age by zone

i	W. Europe	N. America	Japan	SV	J1	J2
A_i^{act}	60	65	70	65	65	65

is initially set to 0.975, and then progressively converges to the common value[16].

3.2.3. Growth, technological diffusion and economic convergence

The regional production functions are assumed to be Cobb-Douglas, with the share of capital $\alpha = 0.3$, and an exogenous rate of depreciation of productive capital, set at in all regions for lack of reliable empirical evidence that it should be different. The exogenous rate of growth of total factor productivity is assumed to be 2% per annum in America, the technologically leading region, and, in all other regions of the world, there is supposed to be a long-run convergence process, by which the levels of total factor productivity asymptotically reach the American level, so that in the very long run, all countries grow at the same rate.
However, our calibration choices are such ($\mu = 0.9995$; $\lambda = 0.001$) that the economic convergence process is very slow indeed in our baseline scenario: in Europe and Japan, total factor productivity respectively reaches 98% and 97% of the American level in 2100; but in the three developing regions, it is only slightly above 40% of the American productivity in 2100[17].

3.2.4. Pension systems

As already emphasized, the public sector in each region is reduced to a pay-as-you-go pension system, with permanently balanced budget. Two parameters are enough to fully characterize each region's public pension scheme: the legal – and compulsory, it is assumed – retirement age; and the replacement rate, i.e., the ratio of average pensions to the average net-of-tax wage earned by the same individuals when in employment. The numerical values chosen for the three developed regions are close to average observed rules, while those for the three developing regions are admittedly arbitrary, the intention being to depict a number of practices – mostly within the household and the family – functioning as implicit pay-as-you-go pension devices in these countries[18].
We define the following regional institutional environment in terms of retirement age: and in terms of replacement rate to compute the levels of retirement benefits:

[16] Various sensitivity analyses have been performed and are reported in a mimeo, available from the authors under request.

[17] For this calibration choice too, various sensitivity analyses have been conducted and various convergence scenarios are explored and reported in a mimeo document available from the authors upon request, as well as in a published paper in French.

[18] Along with technological convergence, one may imagine that some form of institutional convergence may happen in the very long run. A number of such complex scenarios have been investigated in Ingenue (2001e).

Table 2: Net Replacement Ratio by zone

i	W. Europe	N. America	Japan	SV	J1	J2
κ^i	75.8 %	30.6 %	41.3 %	10 %	10 %	10 %

In principle, these values have been obtained after an examen of different institutions providing retirement benefits in the different zones. For the more-developed zones, this choice is relatively realist. For the less-developed zones, these values have been mainly invented and they are supposed to reproduce an implicit pay-as-you-go system.

4. BASELINE SCENARIO : A PATH FOR THE WORLD ECONOMY IN THE XXIst CENTURY

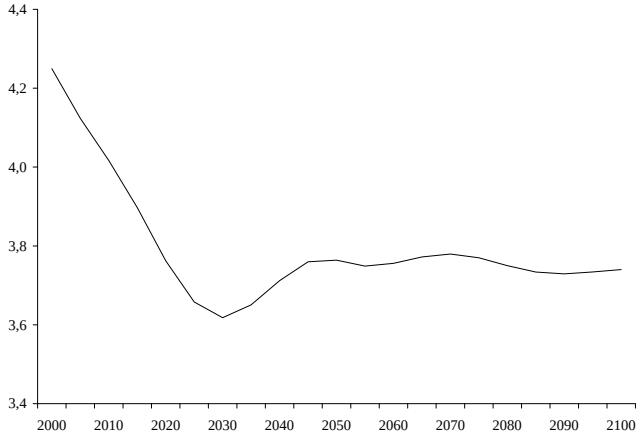
Under our assumptions and numerical values described above, simulating the INGENUE model yields a dynamic equilibrium path for the world economy that slowly converges in the very long run of stationary populations and a steady-state economic growth of 2% per annum. Over the XXI century, this equilibrium path of the world economy may be briefly characterized along three major dimensions: the world capital market equilibrium, economic growth in the various regions, and the distribution of wealth and current accounts, i.e. the magnitude of international capital flows.

4.1. The world interest rate and international capital market equilibrium

At each point in time, the world real interest rate is determined on the single world capital market by equating world capital demand – the sum of regional gross investment flows – and world capital supply – the sum of regional saving, or equivalently the stocks of accumulated productive capital and accumulated wealth. In practice, due to the inertia of OGGE models in general, and the fact that the consequences of demographic evolutions in the various regions of the world partly cancel out in terms of investment and saving – which is precisely the rationale for building an integrated world model –, the interest rate does not vary much, after its initial, marked decline – from over 4.2% in 2000 to about 3.6% in 2035 – and slight recovery – up to a little over 3.7% in 2045 (Chart 2). Such variations do have important consequences on growth, saving and investment in the various regions of the world insofar as the interest rate is the discounting factor for all individual decisions: small fluctuations in the world interest rate therefore have large consequences on regional wealth distribution and the constellation of current accounts, as well as on inter-generational distribution of wealth and welfare.

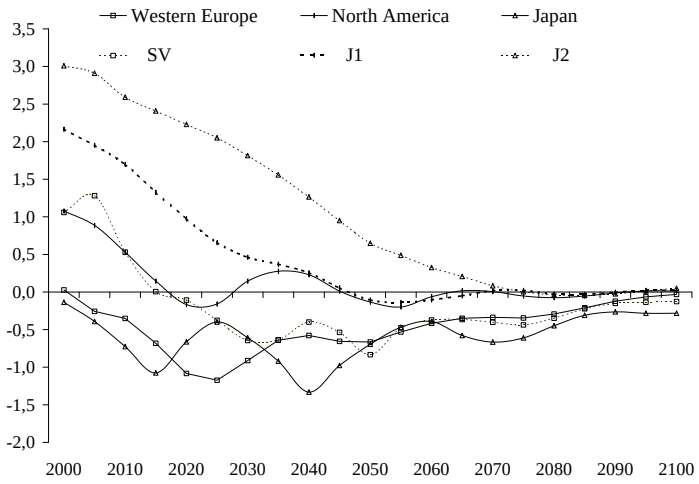
The interest rate fluctuations are mostly attributable to those of regional saving rates, while the demands for capital are relatively smooth. Indeed, the latter depend on technical factors, working-age populations in the various regions – initially rapidly growing in the three developing regions, but then stabilizing, or even decreasing in developed

Chart 2: Base Scenario : Annual World Interest Rate



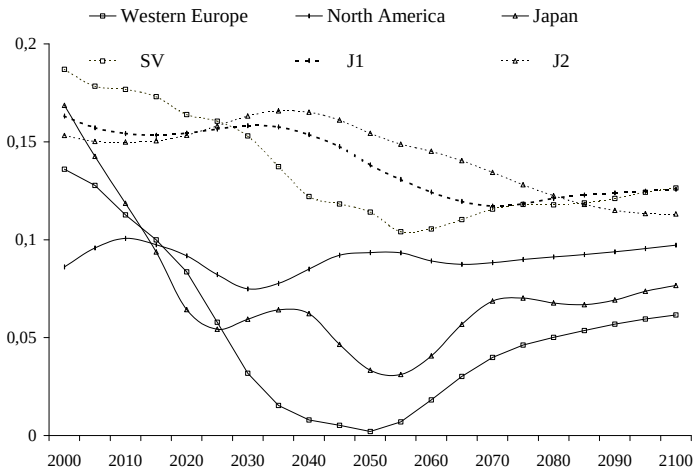
regions (Chart 3) –, the speed of convergence, which we have assumed to be slow in the baseline scenario, and the capital intensity of production, which in turn depends on the interest rate.

Chart 3: Active Population Growth Rate



Most of the action moving the world interest rate is on the supply side of the world capital market and results from demographic changes: the aggregate households' saving rates of the six regions amply fluctuate, and especially those of the two out of the three most developed regions: Europe and Japan, whose saving rates are initially high, but decline quite sharply until 2050 (Chart 4).

Chart 4: Base scenario: regional saving rate (% of regional GNP)



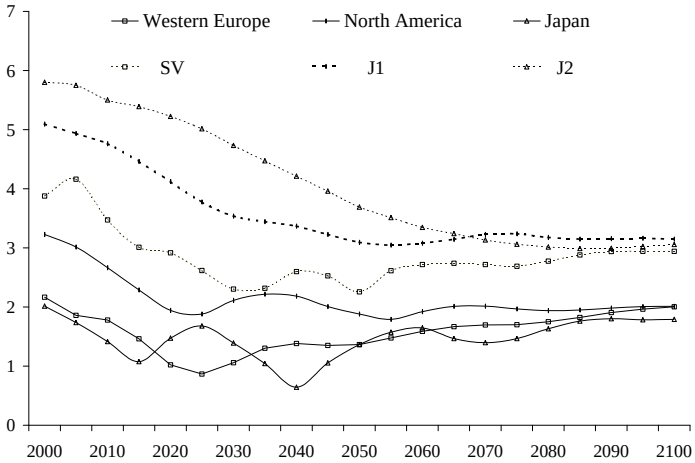
The impact of such fluctuations in regional saving rates on the world interest rate is all the more important in the first decades of the century as these regions have a relatively large weight in world GDP and total world wealth and developing region that is most advanced in the demographic transition process (SV) has a similar profile of aggregate saving rate.. In the other regions, including America, aggregate saving rates fluctuate relatively less over the first four decades of the century, then gently decline as populations age. As a result of these regional saving fluctuations, the world capital supply markedly increases up until 2025, then much more slowly until about 2050. Afterwards, the relative stabilization of the world interest rate is mostly attributable to a slight recovery in saving rates of those regions having experienced the sharpest decline and a mild reduction in those of the others, in particular the two youngest developing regions whose weight in world population and world accumulated wealth has increased in the meantime.

4.2. Regional and world economic growth

Because of the assumed technology and slow convergence, the regional growth rates are essentially determined by working-age population dynamics, especially over the first half-century (Chart 5); afterwards, the effects of the, albeit slow, diffusion of technical progress is noticeable on the growth rates of relatively backward regions, with annual growth rates around 3%. Over the first decades of the century, Europe and Japan experience a marked decline in annual growth, reflecting the reduction in working-age populations.

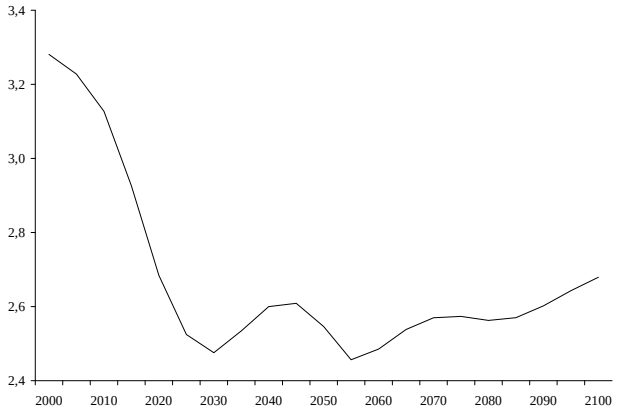
The resulting time profile of aggregate, world GDP growth is shown on Chart 6. It first declines sharply until 2025, parallel to the movement of the world interest rate, then

Chart 5: Base Scenario: Annual Growth Rate of regional GDP



fluctuates over the rest of the century, around a relatively low level, mostly due to our conservative assumption with respect to technological convergence.

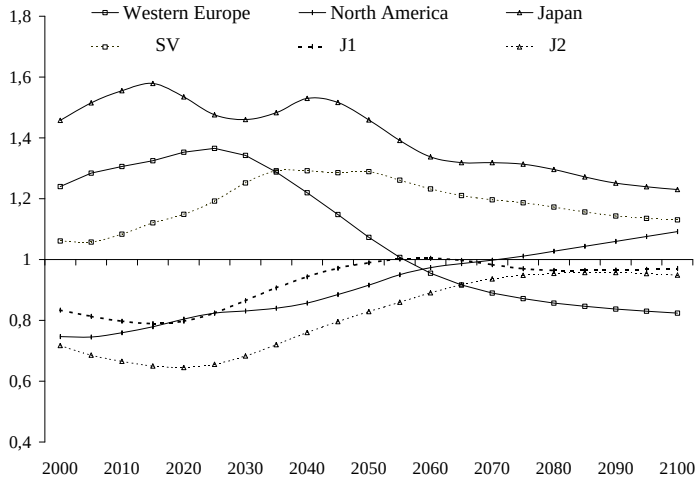
Chart 6: Base Scenario: Annual World GDP Growth Rate



4.3. Regional current accounts and the distribution of wealth

Given the small magnitude of the fluctuations in regional capital demands (investment flows), most of the action on regional current accounts is the result of differences in time profiles of wealth accumulation across regions, such differences being in turn

Chart 7: Base Scenario: regional ownership ratio (assets / capital stock)



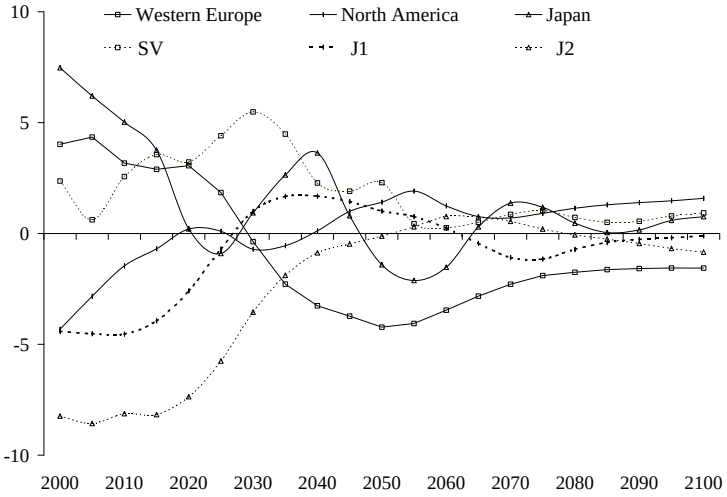
largely due to discrepancies in demographic evolutions, especially time lags in the changes in the share of high-savers in total populations of the six regions. Resulting differences between domestic saving and domestic investment in each of the six regions yield current account surpluses or deficits. In stock terms, at a point in time, the ratio of the stock of productive capital installed in a region and the stock of accumulated wealth of households resident in that region, which we call the ownership ratio, is an indicator of the net external position of the region considered.

Given the differentiated effects of variations in the interest rate and other economic variables on the saving and investment behaviors in the various regions, these regional ownership ratios do fluctuate considerably over the century in our baseline scenario (Chart 7). Starting from a net lender initial position – ownership ratios above one – , Japan, Europe and, to a much lesser extent, the SV region (China) have ownership ratios that increase until 2015 for Japan, 2025 for Europe, and 2045 in the case SV, then decrease thereafter, mostly reflecting the evolution of the shares of high savers in the three regions.

Strikingly, though, Europe, one of the large creditors at the beginning of the century, turns into a net debtor in the second half of the century, with an ownership ratio reaching 80% by the year 2100: this is due to the low saving rate of Europe over the first half of the century, a result of the low retirement age and generous pension scheme; although the saving rate rises again afterwards, with the decline in the old-age dependency ratio, this is not enough to restore the net external position of Europe. In the other three regions, ownership ratios are initially well below one, and they mostly raise all along the century, except for an initial mild decrease for J2, the region with the youngest population. In particular, America becomes a net creditor region in the last third of the century.

Consistent with the changes in regional saving and investment flows, and the resulting

Chart 8: Base Scenario: regional current accounts (% of regional GNP)



evolutions of ownership ratios, the current accounts, and hence the international capital flows, reach significant magnitudes, and do vary a great deal over the century (Chart 8 and 9). The relationship between stocks and flows is, indeed, simple in steady state: in the very long run, when populations have become stationary, an ownership ratio above (resp. below) one is associated with a current account surplus (resp. deficit). But during transitions, this simple relationship does not hold.

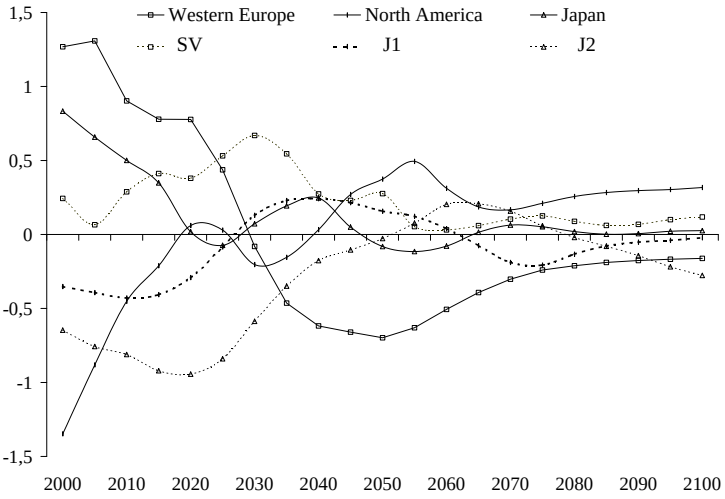
At the beginning of the century, thanks to the large shares of high-savers in their populations, Japan and Europe are the two regions exporting capital, while the three developing regions, but also America, whose demographics are more dynamic than those of other developed regions and which we endowed with a larger time preference parameter, attract these capital flows. After 2020, the Japanese current account is no longer in surplus; it starts fluctuating around equilibrium. And after 2030 Europe plunges into a persistent current account deficit, that reaches almost 5% of its GNP in 2055.

Evaluated in terms of ratios to world GDP, in order to make them comparable and have a visual indication of the worldwide polarization of international capital flows (Chart 9), current account positions appear to reach large values: at the beginning of the century, a European surplus of almost 1.5% of world GDP is matched by an American deficit of approximately the same size, while other regions have smaller inflows or outflows of capital; by 2050, the situation is almost exactly the opposite, with Europe running a deficit that represents about .75% of world GDP and America a surplus of slightly less than .5% of world GDP.

5. PENSION REFORMS IN EUROPE : FULL ECONOMIC AND FINANCIAL INTEGRATION, AUTARKY AND SMALL, OPEN ECONOMY

In order to highlight the specific features of our integrated world model, we first describe the major macroeconomic consequences of a set of generic pension reforms in

Chart 9: Base Scenario: current accounts in terms of world GDP



Europe, then systematically compare their macroeconomic and distributional consequences in three different model environments: the INGENUE model, with complete financial integration, as described above; the same European model simulated in complete autarky (closed economy); and the European model simulated in an exogenous economic and financial environment (small, open economy). In addition to the baseline scenario of unchanged rules in the European public pension system (constant net replacement rate set at its initial value), we study three plausible reforms: a constant gross replacement rate, which, in practice, slightly raises pensions compared to current levels; a constant rate of payroll contributions, which makes the replacement rate endogenous through the balanced-budget constraint; and a progressive postponement of legal retirement by five years, lengthening the working life.

5.1. Pension reforms in Europe: a baseline evaluation

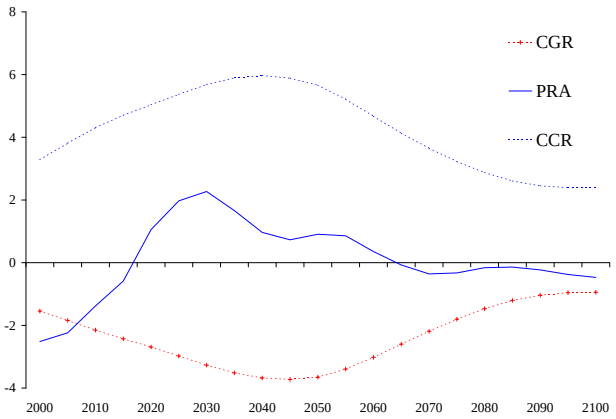
In the baseline scenario, the European pension system is characterized by two major features, which we have supposed untouched all along the century: a low legal retirement age (60); and a fairly high replacement rate (70%). We now propose to investigate the consequences, in our model, of three kinds of pension reforms in Europe, keeping the institutions in other regions of the world identical to baseline:

– Constant contribution rate (CCR): Blocking pension contribution rates to the level they reached at the end of the XX century (22.5%). The result is a progressive and significant decline of the replacement rate as European population ages: by 2050, it would be reduced by 50%. But in the baseline scenario, keeping the replacement rate constant induces a marked increase in the contribution rate that

reaches 37.5% by mid-century, and stabilizes around 32% in the very long run, in the aftermath of the baby-boom shock.

– PRA: Postponing the legal retirement age from 60 to 65, progressively over the period 2000-2020 (one additional year of working life per five-year period). In this scenario, the replacement rate is held constant at its initial level, and, as a result, the contribution rate increases much less than in the baseline scenario: it reaches 29% in 2050, and about 25% in the very long run.
– Constant gross replacement (CGR): Indexing pensions on gross, instead of net wages. This, of course, corresponds to a scenario whose philosophy is opposite to the two previous ones: the replacement rate is actually fixed at a higher level, so that the contribution rate raises even higher than in the baseline scenario[19].

Chart 10: Pension Reforms : Changes in the European saving rate compared to baseline

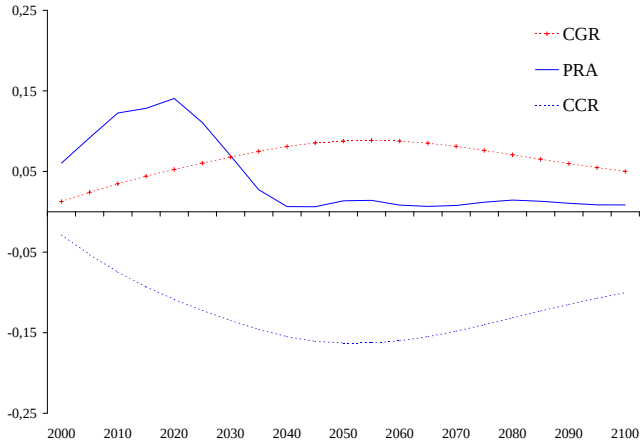


Because these reforms are assumed to be perfectly anticipated as soon as they are announced (end of the XX century, in the cases depicted here), their major direct and most immediate effects are, of course, on individual saving behavior, hence on aggregate saving. Unsurprisingly, compared to the baseline scenario (Chart 10), CCR raises the saving rate all along the century, while CGRR lowers it: as the public pension system is made less (more) generous, households save and accumulate more (less) in order to compensate the effect of lower pensions on consumption in retirement[20]. The direct effects of the second reform (PRA) are less easily depicted and explained: initially, the announcement and progressive implementation of this reform reduces aggregate saving in Europe, as those initially concerned are the high-savers, who immediately expect a

[19] Although implausible at first sight, this reform scenario may be interpreted as representing the case in which health care costs of aging would rise significantly and would be financed by a public scheme that levies a contribution over wages, in addition to the retirement pension schemes modeled here.

[20] Because labor supply is exogenous, this saving effect is this only direct effect on households, and it corresponds to a change in the time profile of their budget constraint.

Chart 11: Pension Reforms : Changes in the world interest rate compared to baseline



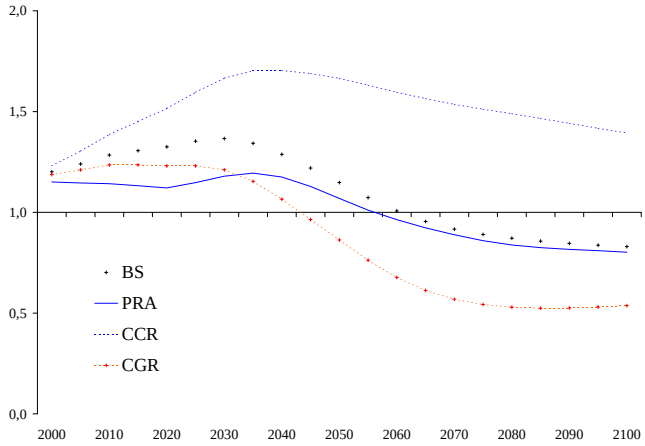
higher life-cycle income and the necessity to finance consumption over a shorter retirement period. But after 2025, the European aggregate saving rate is, in the PRA scenario, permanently above those of the baseline and CGR, due to general-equilibrium, indirect effects mostly via the world interest rate.

The effects of the various European pension reforms on the world interest rate are shown in Chart 11. As expected, the CCR reform is associated with a permanently lower interest rate, as European saving rate is constantly above its baseline level; symmetrically, the CGR reform yields a persistently higher world interest rate. The effects of the PRA reform are more ambiguous. Initially, the world interest rate is higher than in any other scenario, mostly as a result of two mechanisms: as already stated, European aggregate savings are initially lower than in the baseline scenario; and in addition, there are more working-age workers in the economy, that have to be equipped with capital, so that European investment is permanently higher than in the baseline scenario. Consequently, until 2035, the world interest rate is higher than in the baseline; afterwards, it is almost identical, as the PRA reform has little persistent effect with stationary population.

These European pension reforms thus have induced consequences on the rest of the world, via the changes in the world capital market equilibrium, hence on the world interest rate[21]. Our focus being on international capital flows, we briefly comment on these induced changes in these variables and, as a result, on regional ownership ratios. As expected, the CCR reform that increases European aggregate savings over the whole century also improve the ownership ratio of Europe (Chart 12); conversely for the CGR reform, the ownership ratio is always below the baseline, and its deterioration is much more pronounced after 2035, so that it reaches a very low level (around 55%) at the end of the century. In the PRA reform scenario, the European ownership ratio is permanently lower than in the baseline case, as European investment is permanently

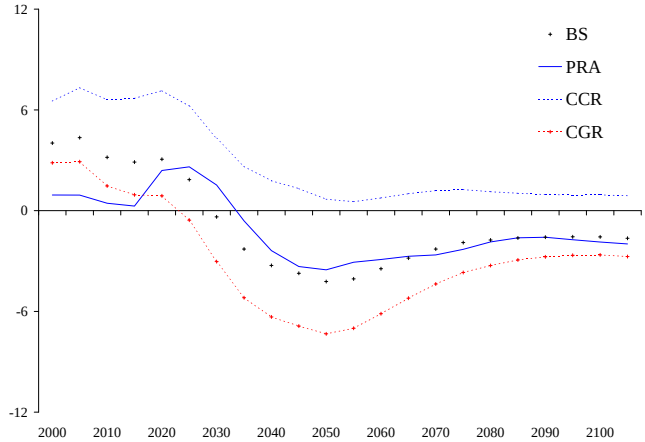
[21] For a more detailed presentation of these scenarios, see INGENUE, 2001d.

Chart 12: Pension Reforms : Ownership ratio of Europe



increased, whereas the initial increase in savings is only temporary.
In this last case, therefore, Europe exports much less capital to the rest of the world over the first decades of the century (Chart 13). Compared to the baseline current account evolutions, two reforms scenarios (PRA and CGRR) yield a substantially smaller European surplus over the first two decades of the century. After 2025, however, the outcomes are opposite: the PRA reform leads to increasing current account surpluses in Europe, as the transitory implementation effects of the reform on saving and investment have vanished; thereafter, the European current is close to its baseline. In the CCPR reform scenario, on the contrary, Europe is a permanent exporter of capital to the rest of the world, with very large initial current account surpluses. In the rest of the world, the constellation of regional current accounts is only mildly affected by European pension reforms, their consequences being only indirect, via the world interest rate.

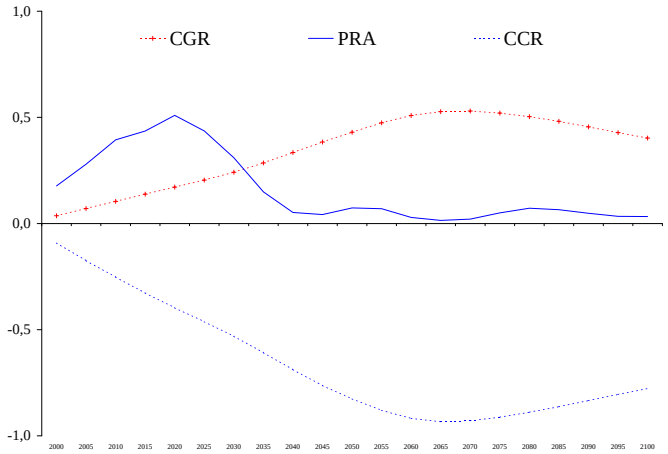
Chart 13: Pension Reforms : Current account of Europe in percentage of GNP



5.2. INGENUE versus autarkic Europe

Many, if not most analyses of pension reforms, whether they use the OGGE framework or not, have been conducted with closed economy models under the assumption of economic and financial autarky[22]. The building of the INGENUE model was, conversely, predicated upon the hypothesis that economic and financial openness and the possibility of conducting trade in goods and financial assets does make a difference, especially for those regions where baby-boom cohorts are numerous and would likely generate large transitory unbalances in pay-as-you-go public pension systems. In this sub-section, the outcomes of the three European pension reforms analyzed above with the INGENUE model, are compared with what we would get by running the European part of the INGENUE model as a financially closed, autarkic region, with exchanges whatsoever in net financial assets with the rest of the world. The variations of domestic savings are then trapped in the domestic capital market, so that their effects on the interest rate are magnified, compared to the INGENUE environment, where it is spread over a much larger, world capital market. The feedback effects of interest rate changes are therefore much larger too; but, by construction, there are no induced effects on the rest of the world.

Chart 14: Closed economy: changes in the European interest rate compared to baseline



Charts 11 and 14 show the simulated evolutions of the European interest rate changes under the three institutional reforms for with respect to the baseline pension specification , respectively, the INGENUE and the closed-economy models, both in levels and in differences with the baseline pension scenario. In the closed economy, all four scenarios yield an initial level of the European interest rate that is lower than in the INGENUE world model, due to abundant saving that has to be invested exclusively in the domestic economy. Similarly, the subsequent fluctuations in the interest rate are much

[22] See for instance: Auerbach and Kotlikoff (1987), Cazes, Chauveau, LeCacheux and Loufir (1992b), Kotlikoff (n.d., 1996), etc.

more pronounced in all reform scenarios, especially the CCR reform, where European saving is significantly higher over the first decades of the century: in a way, financial openness allows Europe initially to export excess savings, so that the world interest rate falls and the rest of the world cushions the feedback effects. These cushioning effects of world financial integration are even more apparent when looking at differences with respect to the baseline pension scheme (Chart 14).

The fluctuations of European growth rates over the century in the four scenarios tell a very similar story, insofar as they most parallel those of the interest rate (Charts 15 and 16). Overall, the growth performance of Europe in an autarkic environment is significantly less in all cases; it also fluctuates a good deal more. And again the differences compared to the baseline pension scheme are amplified in the closed economy, especially for the PRA scenario. But, as expected, GNP time profiles are almost identical in the INGENUE and the closed economy environment (Chart 17): exporting capital and investing in the rest of the world, where it yields a higher return, compensates the effects on domestic wages of investing domestically and having a more capital-intensive production.

Chart 15: INGENUE: changes in the European GNP growth rate compared to baseline

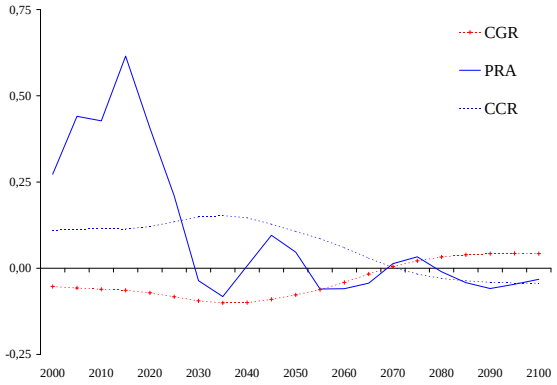


Chart 16: Closed economy: changes in the European GNP growth rate compared to baseline

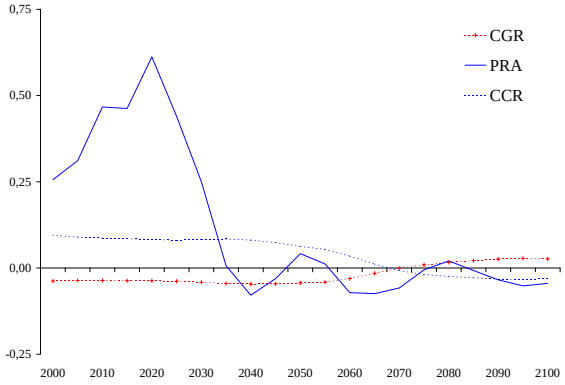
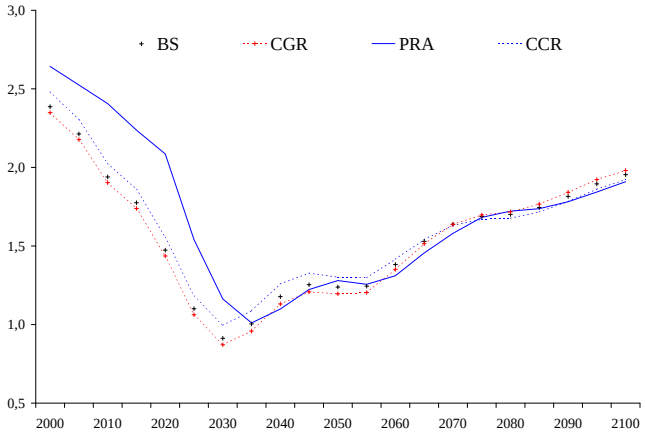


Chart 17: Closed economy: European GNP growth rate compared to baseline



These distributional consequences affect the time profiles of average consumption by the various age groups (Charts 18 and 19). This effect is especially evident for the two reform scenarios that clearly benefit the old (CGR) or the young (CCR) in the autarkic European economy. Hence the criterion of intergenerational equity that evaluates the distributional effects of the various pension schemes fluctuates much more widely in autarky too (Charts 20 and 21).

Even though the aggregate and average per capita income and consumption are not much different in the autarkic economic from what the integrated scenarios yield, taking explicitly into account financial globalization alters the intergenerational, distributional consequences of the various pension reforms analyzed, as evidenced in Charts 18 and 19 which show the changes induced in the time profiles of consumption for the various cohorts in the three reforms scenarios studied.

Hence, for instance, the PRA reform, which appears to dominate the other two in terms of average consumption, appears much less desirable for the 20-39 cohorts than the CCR reform in the autarkic version of the model: this is due to the fact that, in an autarkic Europe, the latter reform would boost saving and accumulation, thus lowering the interest rate and increasing capital intensity, hence also the wages of young workers; by contrast, in the financially integrated world, additional saving in the CCR reform scenario is invested in the world capital market, and has much less incidence on the (world) interest rate and capital in-tensity, whereas increased capital accumulation in the PRA reform scenario is then financed partly by the rest of the world, and hence benefits all generations. The other two reforms ap-pear to have rather more ambiguous effects on the intergenerational distribution of consumption in the globalized world of INGENUE than in the autarkic environment. In the latter, the CCR reform benefits the young, and is detrimental to the old and the CRR reform produces the opposite outcome, whereas in the former, the consequences of these two reforms on the old are less clear.

These differences in the distributional consequences of the various reforms investigated

Chart 18: INGENUE: profiles of average consumption (% changes to baseline)

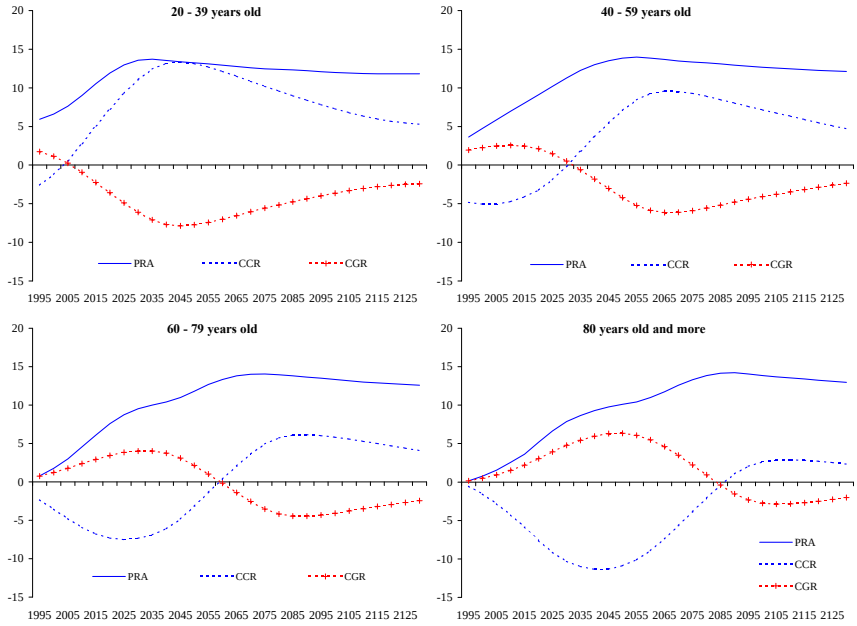
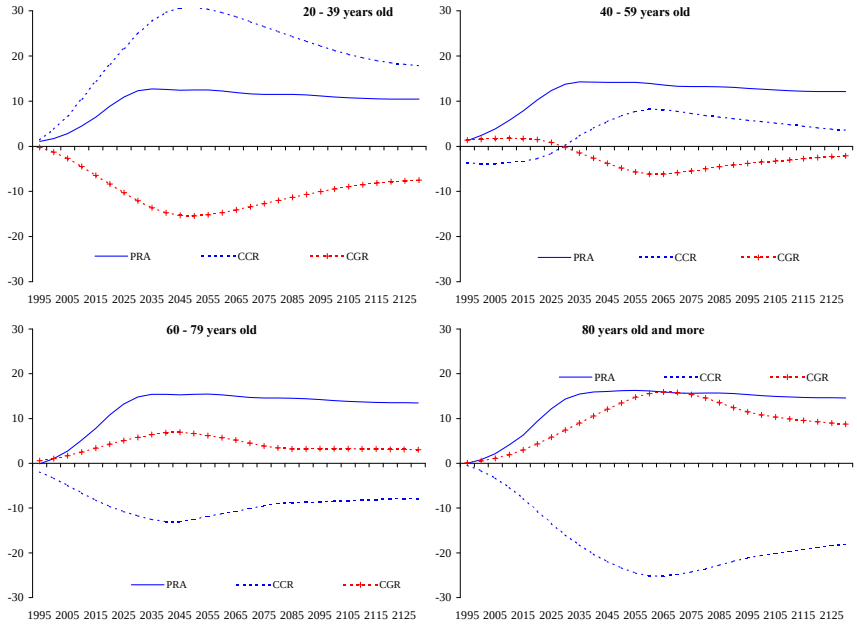


Chart 19: Closed economy: profiles of average consumption (% changes to baseline)



also show in the comparison of the age-profile of a simple criterion of intergenerational equity (Charts 20 and 21) : except for the CCR reform, which appears to generate the least fluctuations in the criterion in the autarkic Europe, all other reforms do yield larger fluctuations in the criterion than the global finance environment. This is a clear demonstration of the need to use such analytical framework, and simply illustrates the double nature of the gains from financial openness: opportunities for investing in countries yielding higher returns and consumption smoothing opportunities.

Chart 20: INGENUE: Criterion of intergenerational equity

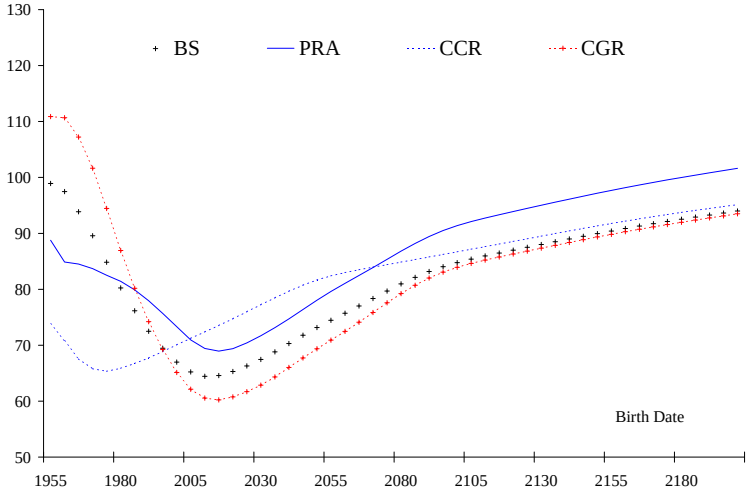
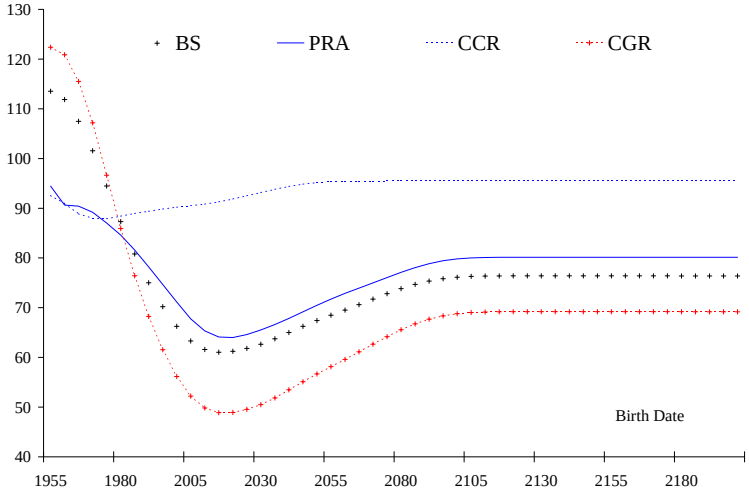


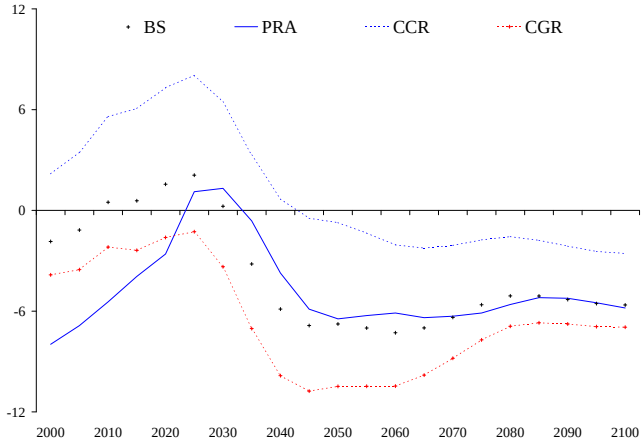
Chart 21: Closed economy: Criterion of intergenerational equity



5.3. INGENUE versus Europe as a small, open economy

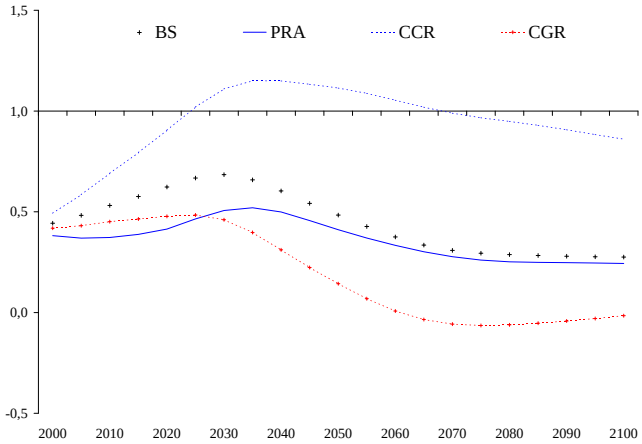
Comparing the outcomes of European pension reforms on European economic variables in the INGENUE model with those obtained by treating the European region of our model as a small, open economy, with no incidence on the world interest, exogenously set at its long-run, world equilibrium level in the baseline scenario, gives an indication of the magnitude of feedback effects from induced developments in the rest of the world; it also shows the advantage of conducting analyses of pension reforms in an integrated, world framework.

Chart 22: Small, Open economy: European current account



Because the interest rate is exogenous, there is no endogenous price in the small, open economy version of the model, so that changes in economic variables are exclusively driven by demographic evolutions in Europe. Hence, most economic variables in the baseline pension scenario and consequences of pension reforms in Europe obtained in the framework of the small, open economy are qualitatively similar to those discussed for the fully integrated INGENUE model, the major differences arising in the case of the PRA reform, inasmuch as the latter alters the size and time profile of the working-age population in Europe, thus having an immediate effect on growth. However, comparing the two environments shows major differences in the financial linkages of Europe with the rest of the world. When treated as a small, open economy, Europe experiences much larger fluctuations in the current account than in the INGENUE setting in all scenarios (Chart 22); and the European current account is almost always negative, except in the CCR reforms scenario, where it remain significantly positive over the first half of the century. Hence, when depicted as a small, open economy, Europe appears, on average over the century, as a low saving region, importing capital from the rest of the world, due to the interplay of demographics and a pension system that is more generous than in other parts of the world; curtailing its generosity (CCR) does increase saving in this setting, but would not prevent an eventual current account deficit. Even the PRA reform scenario, that has many favourable consequences in

Chart 23: Small, Open economy: European ownership ratio



the integrated, world setting, has very negative consequences on the European current account in the small, open economy environment, since it then has most mechanical effects on domestic investment, due to the direct impact of this reform on the size of the labor force. The deterioration of the European current account appears particularly dramatic in the CGR scenario, with a deficit exceeding 10% of European GNP around 2050. As a consequence, the European ownership ratio (Chart 23) is very low in all circumstances in the small, open economy version of the model: it almost always lie below one, except in the PCR reform scenario, where it raises above unity after 2025 and stays higher than 1 for a few decades; conversely, it even becomes negative after 2060 in the pension reform scenario corresponding to an increased generosity (CGR), as European save so little that they have to finance domestic investment with large capital inflows. Once again, because it does not have the feedback effects from the world capital market through interest rate changes, the small, open economy tends to magnify the flow effects of any pension reform scenario.

6. CONCLUDING REMARKS

When analysing the prospects of public, pay-as-you-go pension systems in OECD countries, the emphasis, in most studies over the past two decades, has been on the macroeconomic and inter-generational, distributional consequences of aging populations in the framework of models that have tended not to take into account, or conversely to over-stress the implications of economic and financial globalization on domestic evolutions. Our model has been built to accommodate such analytical needs and this paper has tried to present its major features, its functioning, as well as a number of distinctive results that differ markedly from what would obtain in either autarkic, closed-economy models, or small, open-economy models. The interplay between aging populations displaying different time profiles in the various regions of the world and pay-as-you-go pension systems with varied characteristics yields significant fluc-

tuations and discrepancies in world and regional economic variables, as well as fairly large international capital flows in our baseline scenario and in the various pension reforms studied.

Such large capital flows on average help smoothing the long accumulation cycles that arise from aging and fluctuations in population sizes. Although they may seem excessive, our paper shows that they are significantly smaller in an integrated world model than in models that treat developed countries in isolation as small, open economies. In addition, it should be reminded that large international capital flows of similar relative magnitudes are not entirely unprecedented: though admittedly different in many respects, the last decades of the XIX^{o} century and the *Belle Epoque* have also witnessed considerable international investment flows from aging to emerging countries of the time. The prospects of such large discrepancies between domestic investment and domestic saving, and of consequently large net external positions raises the issue of the sustainability of such developments, hence the questions of the precise forms of capital flows – direct investment, portfolio investment, intermediated lending, etc. – and of the institutional environment and regulation of international finance.

A APPENDIX : DEMOGRAPHIC ZONES

We use the most recent UN demographic projections and assumptions. To divide the world into six demographic areas, a principle of homogeneity is applied, based upon proximity in the demographic structures. More precisely, six criteria have been used: the growth of population, the dependency ratio of young people, the dependency ratio of old individuals, the dependency ratio of very old ones, the ratio of working generations likely to be in debt, and the rate of the working age population. Among the three emerging zones, the main difference between the areas rests on their different relative position in the Demographic Transition Process.
The table below presents all the countries composing each demographic zone[23].

Denomination	Composition
W. Europe	European Union, Switzerland, Norway and Iceland
N. America	United States, Canada, Australia and New Zealand
Japan	Japan
SV	**Emerging Countries with an already aging population** China, Korea Dem. Rep., Hong Kong, Macao, Korea Rep., Singapore, Thailand, Bahrain, Cyprus, Qatar, United Arabs Emirates, Armenia, Belarus, Bulgaria, Georgia, Czech Republic, Hungary, Poland, Moldavia, Romania, Russian Federation, Slovak Republic, , Ukraine, Estonia, Latvia,Lithuania, Bosnia-Herzegovina, Uruguay.
J1	**Emerging Countries just starting their demographic transition** Argentina, Brazil, Chile, Colombia, Guvana, Mexico, Panama, Peru, Suriname, Caribbean zone, Bahamas, Dominia, Jamaica, Trinidad & Tabago, Azerbaijan, Israel, Kuwait, Lebanon, Sri Lanka, Turkey, Albania, India, Indonesia, Brunei, Malaysia, Vietnam.
J2	**Developing countries with high fertility rates** Africa, Mongolia, Afghanistan, Bangladesh, Bhutan, Iran Islamic Rep., Kazakhstan, Kvgrvz Republic, Nepal, Pakistan, Tajikistan, Turkmenistan, Uzbekistan, Cambodia, Eastern Timor, Lao PDR, Mvanmar, Philippines, Gaza strip, Iraq, Jordan, Oman, Saudi Arabia, Syrian Arab Rep., Yemen Rep., Haiti, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Bolivia, Ecuador, Paraguay, Venezuela, Melanesia, Fiji, Papua New Guinea, Vanuatu, Micronesia, Polynesia, Samoa.

[23] Concerning the aggregation of countries by zones, more details are provided in Ingenue (1999).

References

Ando, Albert and Franco Modigliani, Tests of the Life Cycle Hypothesis of Saving: Comments and Suggestions, *Bulletin of the Oxford Institute of Statistics*, 1957.

Auerbach, A.J. and L.J. Kotlikoff, *Dynamic Fiscal Policy*, London: Cambridge University Press, 1987.

____ , ____ , R. Hagemann, and G. Nicoletti, Conséquences du vieillissement démographique pour l'évolution de l'économie : une étude sur le cas de quatre pays de l'O.C.D.E., *Revue Economique de l'O.C.D.E.*, printemps 1989, *12*, 111–147.

Bank, World, *Averting the Old-Age crisis : Policies to protect the old and promote growth* Policy Research, oxford university press editor, World Bank, 1994.

Barro, R. and X. Sala i Martin, Convergence, *Journal of Political Economy*, 1992, *100* (2), 223–251.

Blanchard, O., Debt, deficits and finite horizons, *Journal of Political Economy*, 1985, *93*, 223–147.

Broer, D. Peter and Jukka Lassila, *Pension Policies and Public Debt in Dynamic CGE Models*, physica-verlag in association with etla, helsinki editor, Broer, D. Peter and Lassila, Jukka, 1997.

Buiter, W. H, Time Preference and International Lending and Borrowing in an Overlapping-Generations Model, *Journal of Political Economy*, 1981, *89* (4).

Cazes, S., T. Chauveau, J. LeCacheux, and R. Loufir, *An OG Model of the French Economy: Application to the long-run prospects of the public pension scheme*, Working Paper 92-5, OFCE, Paris 1992.

____ , ____ , ____ , and ____ , Retraites et evolutions démographiques en France : Le long terme, *Revue de l'O.F.C.E.*, janvier 1992, *39*, 93–149.

____ , ____ , ____ , and ____ , Public Pensions in an Overlapping-Generations Model of the French Economy, *Keio Economic Studies*, 1994, *31* (1).

Chauveau, T. and R. Loufir, L'avenir des régimes publics de retraite dans les pays du G7, *Revue de l'O.F.C.E.*, Octobre 1995, *52*, 49–103.

Cortes, Olivier and Jean Pisani-Ferry, Mondialisation, convergence et inégalités, *Economie Internationale*, 1997, *71*.

Diamond, P., National Debt in a Neoclassical Growth Model, *American Economic Review*, 1965, *55*, 1126–1150.

Evans, Paul, How Fast Do Economies Converge?, *Review of Economics and Statistics*, 1997, *79* (2).

Fisher, Bernhard. and Helmut. Reisen, *Réorienter les fonds de retraite vers les marchés émergents*, Cahiers du développement de l'OCDE, OECD, Paris 1994.

i Martin, Xavier Sala, The Classical Approach to Convergence Analysis, *Economic Journal*, 1996, *106*.

Ingenue, *INGENUE : Une modélisation intergénérationnelle et universelle*, Preliminary Report, Institut Caisse des Dépôts, Paris 1999.

____ , *An Applied International Overlapping Generations Model*, Mimeo, CEPII-CEPREMAP-OFCE, Paris October 2000. available upon request.

____ , *INGENUE : une modélisation intergénérationnelle et universelle*, banque de france editor, A. Brender, 2001c.

____ , *Transition démographique, croissance mondiale et équilibres financiers internationaux* Rapport du Conseil d'Analyse Economique, documentation française forthcomming editor, Aglieta, M. and Blanchet, D., 2001d.

____ , *Convergence technologique et institutionnelle entre régions du monde*, Report, Institut Caisse des Dépôts, Paris 2001e.

Jones, Charles, Convergence Revisited, *Journal of Economic Growth*, 1997a, *2* (2).

____ , On the Evolution of the World Income Distribution, *Journal of Economic Perspectives*, 1997b, *11* (3).

Kenc, Turalay and Serdar Sayan, *Transmission of Demographic Shock Effects from Large to Small Economy: An Overlapping Generations CGE Analysis*, Discussion Papers, Bilkent University, Department of Economics, Ankara 1997.

Kotlikoff, Laurence J., Privatization of Social Security at Home and Abroad, *American Economic Review*, 1996, *86* (2).

____ , *Privatization of Social Security: How it Works and Why it Matters*, WP Series, NBER.

Lucas, R.J., Some Macroeconomics for the 21st Century, *Journal of Economic Perspectives*, 2000, *14* (1).

Modigliani, F., Life Cycle, Individual Thrift, and the Wealth of Nations, Nobel Lecture, *American Economic Review*, 1986, *76* (3).

Obstfeld, Maurice and Kenneth Rogoff, *Foundations of International Macroeconomics*, mit press editor 1996.

Perraudin, W and T. Pujol, L'harmonisation fiscale en Europe et l'économie française: une approche en équilibre général, *Revue de l'O.F.C.E.*, Juillet 1991, (37), 245–272.

Pritchett, Lance, Divergence, Big Time, *Journal of Economic Perspectives*, 1997, *11* (3).

Quah, Dany., Empirics for Growth and Distribution : Stratification, Polarization and Convergence Clubs, *Journal of Economic Growth*, 1997, *2* (1).

Raffeluschen, K.B. and A.E. Risa, Reforming Social Security in a Small Open Economy, *European Journal of Political Economy*, 1995, *11* (3).

Reisen, Helmut, *Pensions, Savings and Capital Flows*, Technical Report, OECD, Paris 2000.

Samuelson, Paul, An exact consumption-loan model of interest with or without the social contrivance of money, *Journal of Political Economy*, 1958, *66* (6), 467–482.

Temple, Jonathan R. W., The New Growth Evidence, *Journal of Economic Literature*, 1999, *37* (1).

Turner, Dave, Claude Giorno, Alain De Serres, Anne Vourc'h, and Pete Richardson, *The Macroeconomic Implications of Ageing in a Global Context*, Economic Department Working Papers 193, OECD, Paris 1998.