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Demographic Uncertainty in Europe

Implications on macro economic trends and pension reforms

An investigation with the INGENUE2 model

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DEMOGRAPHIC UNCERTAINTY IN EUROPE
Implications on macroeconomic trends and pension reforms
An investigation with the INGENUE2 model

SUMMARY

The worldwide overlapping generation model INGENUE2 has been designed to investigate the economic consequences of ageing. A benchmark scenario has been built as a basis of various simulations aiming at exploring alternative assumptions regarding structural changes. Particular attention has been devoted to Western Europe where ageing will make it difficult to preserve retirement benefits in public pensions resting on constant replacement ratios. However all investigations before the present study were performed under deterministic assumptions regarding fertility and mortality rates that shape the evolution of the age group structure and the size of population in the ten regions of the world identified in the model.

Nonetheless substantial uncertainty impacts population forecasts. In Western Europe alone, they have been revised upward significantly both by the UN and by Eurostat since the mid-1990's. Studies dedicated to providing insight on the interplay between demography and economy in the long run cannot ignore uncertainty in demographic projections. Uncertainty is best dealt with in using stochastic population paths drawn from confidence intervals in fertility and mortality rates established by demographers. In the first part of the paper we estimate the range of likely variation in total population of Western Europe until 2050 with 80% probability.

In the second part, we run simulations with INGENUE2 to figure out the impact of demographic uncertainty on the world economy. We present the results for Western Europe. The main finding is that uncertainty in the growth rate is due to variations in the size of the working age population: errors in forecasting fertility rates from the early decade of the century show up in the potential labour force from 2025 onwards. In 2050 the growth rate is within a confidence interval between 0.3 and 1.1% at 90% probability. Such a range in growth rates has significant bearing for saving and wealth accumulation. It should not be ignored in shaping pension policies.

The third part of the paper addresses the consequences on pension reform of making allowance for demographic uncertainty. It is well-known that benefit-preserving of public pension in an environment of low growth would be very costly in rising contribution rates until the mid-century. In the worst occurrence of the lowest likely growth it might become unbearable. It is wise to prepare to such occurrence in the next two decades in providing incentive to save more and institutions to diversify financial wealth worldwide. We study the economic consequences of one such policy defined as a compulsory funded system designed to substitute to pension contribution increases.

ABSTRACT

Ageing is a main concern in Western Europe for the present half century. It impinges heavily upon the financing of retirement because a shrinking labour force will entail decelerating growth. Moreover, contrary to popular opinion and to most prospective studies which rely on deterministic demographic projections, the determinants of population size and structure are stochastic. The present paper makes use of the INGENUE2 model to assess the economic impact of demographic uncertainty in Western Europe.

Demographic uncertainty affects saving, financial conditions and growth significantly from year 2025 onwards. Worst case scenarios can have crippling effects on the financing of public pension under present retirement policies. It makes all the more necessary to study alternatives. We simulate a policy that involves the development of a funding system to substitute to part of the projected increase in the contribution rate, both under deterministic and stochastic demographic forecasts

Classification JEL: C68, F21, D91, J11

Keywords: Computable General Equilibrium Models, International capital flows, Life cycle models and saving, Demographic trends and forecasts.

INCERTITUDE DÉMOGRAPHIQUE EN EUROPE
Conséquences pour les tendances macroéconomiques et les réformes des retraites
Une exploration avec le modèle INGENUE2

RÉSUMÉ

Le modèle mondial à générations imbriquées INGENUE2 a été conçu pour explorer les conséquences économiques du vieillissement en économie ouverte. Un scénario de référence a été construit pour servir de base à des simulations visant à étudier différentes hypothèses de changements structurels. Une attention particulière a été portée à l'Europe de l'Ouest où le vieillissement va rendre difficile la préservation des taux de remplacement en vigueur pour les prestations de retraites publiques. Toutes nos analyses, jusqu'à la présente étude, ont retenu des hypothèses déterministes concernant les taux de fécondité et de mortalité à l'origine de la déformation de la pyramide des âges et de la taille de la population totale dans les dix régions du monde définies dans le modèle.

Or les projections de population sont affectées par une incertitude importante. En Europe occidentale, elles ont été révisées vers le haut à la fois par les Nations Unies et par Eurostat depuis le milieu des années 1990. Les études qui cherchent à éclairer les interactions à long terme entre démographie et économie ne peuvent ignorer l'incertitude dans les projections démographiques. Cette incertitude est traitée par les démographes en simulant des trajectoires stochastiques de population à partir de tirages aléatoires à l'intérieur des intervalles de confiance pour les taux de fécondité et de mortalité. Dans la première partie de cette étude, nous estimons l'amplitude probable de la variation de la population de l'Europe occidentale dans l'intervalle de confiance de 80 % et 90 %.

Dans la seconde partie, des simulations sont réalisées avec le modèle INGENUE2 pour estimer l'impact de l'incertitude démographique sur l'économie mondiale. Les résultats sont présentés pour l'Europe occidentale. Le principal d'entre eux est que l'incertitude sur la croissance économique est due aux variations de la taille de la population d'âges actifs : les erreurs de prévision du taux de fécondité au début du siècle se retrouvent dans la force de travail à partir de 2025 environ. En 2050 le taux de croissance se trouve dans l'intervalle de confiance compris entre 0,3 et 1,1 % avec une probabilité de 90 %. Une telle plage de variabilité dans les taux de croissance a des implications importantes sur l'épargne et sur l'accumulation de richesses. On ne saurait les ignorer en concevant les réformes de retraite.

La troisième partie du texte s'intéresse à une réforme des retraites qui prend en compte les risques induits par l'incertitude démographique. Il est bien connu que préserver les taux de remplacement des pensions dans une économie de croissance basse serait très coûteux pour

les personnes actives en terme d'augmentation des taux de contribution jusqu'au milieu du siècle. Dans la pire occurrence des plus bas taux de croissance probables, le coût pourrait devenir insupportable. Il est sage de s'y préparer dans les deux prochaines décennies en offrant des incitations à épargner plus et en développant des institutions capables de diversifier la richesse financière dans des placements mondiaux. On étudie les conséquences économiques d'une telle politique conçue comme le déploiement d'un système obligatoire de retraites par capitalisation pour se substituer au relèvement des taux de contribution.

RÉSUMÉ COURT

Le vieillissement est une préoccupation essentielle en Europe occidentale pour le demi-siècle actuel. Il pèse lourdement sur le financement des retraites parce que la diminution de la population en âge de travailler va peser sur la croissance. En outre, contrairement à une opinion commune et à de nombreuses études prospectives qui s'appuient sur des projections démographiques déterministes, la taille de la population et sa structure par âge sont des variables hautement incertaines. Il en résulte que les projections de population sont affectées par une incertitude importante dont ne peuvent pas rendre compte les projections déterministes. Les projections stochastiques de population permettent pour leur part de prendre en considération cette incertitude liée aux paramètres déterminants de la dynamique démographique (taux de fécondité, taux de mortalité, immigration).

L'incertitude démographique affectera l'épargne, les conditions financières et la croissance de manière significative à partir de l'année 2025. Les scénarios les plus défavorables peuvent avoir des effets dévastateurs sur le financement des retraites publiques pour les politiques en vigueur actuellement. L'étude de réformes alternatives en est rendu d'autant plus utile. Nous simulons une politique qui implique le développement d'un système par capitalisation pour substituer en partie un surcroît d'épargne à l'augmentation des taux de cotisation selon des projections démographiques déterministes et stochastiques.

Classement JEL : C68, F21, D91, J11.

Mots Clés : Modèles d'équilibre général calculable, mouvements internationaux de capitaux, modèle de cycle de vie et épargne, projections démographiques.

DEMOGRAPHIC UNCERTAINTY IN EUROPE
Implications on macroeconomic trends and pension reforms[1]

Michel AGLIETTA[2] and Vladimir BORGY[3]
with the INGENUE TEAM*

I. INTRODUCTION

Studying the economic consequences of ageing so that one can provide insights to policy makers involved in pension reforms is a purpose of the INGENUE project. For that matter a worldwide, computable general equilibrium model, embodying overlapping generations, has been built. The more advanced version INGENUE2[4] is now operational to simulate various scenarios. They are performed to outline long-run macroeconomic paths due to alternative assumptions regarding structural changes in different regions of the world economy. However, while those scenarios were built up, no alternative assumptions were considered in featuring the demographic transition. We simply used and aggregated UN central projection of population for individual countries by age groups.

Nevertheless assumptions upon the overall size and age structure of population in different regions of the world fifty years ahead are no less hazardous than economic assumptions. Therefore there are risks both upbeat and downbeat for policies dedicated to meeting the challenge of ageing. The range of variations due to alternative assumptions on demographic structural parameters must be assessed and the subsequent economic impact must be displayed. Scenario building is a method less than satisfactory however because it cannot attach definite probabilities to deviations from the baseline scenario.

[1] This paper is based on research carried out in the EU 5th framework funded research project 'Demographic Uncertainty and the Sustainability of Social Welfare Systems' (DEMWEL), QLK6-CT-2002-02500. The authors gratefully acknowledge European Commission funding under the DEMWEL project. We would like to thank Juha Alho for his help and advice concerning the implementation of the stochastic population forecasts and Nico Keilman for providing us data on demographic forecasts. We are grateful to Pablo Antolin, Agnès Bénassy-Quéré, Martine Carré, Xavier Chojnicki and Valérie Mignon for their useful suggestions and comments. This paper reflects the opinions of the authors and does not necessarily express the views of the institutions they belong to.

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[4] INGENUE2 is the second version of the INGENUE model.

A better approach is available, thanks to the work of demographers that treat the demographic transition as a stochastic process[5]. Ageing in different parts of the world is neither following a region-specific deterministic trajectory, nor is it a picture of equivalent scenarios in their occurrence. If an underlying probability distribution might be estimated via stochastic simulations, the information drawn from the INGENUE2 model, using the values of those demographic parameters as inputs and computing the macroeconomic impact is much enhanced.

This paper portrays such an exercise. While focusing on Europe to draw lessons on pension reforms, it studies the macroeconomic consequences of demographic uncertainty at the world level. In the first part the reasons to consider population change as a stochastic process are discussed. Mean population forecasts and standard deviations are portrayed for the world and the INGENUE regions. In the second part the INGENUE2 world model computes the extent of the uncertainty around the baseline scenario due to random population forecasts[6]. The economic meaning of the results are analysed for Western Europe, focusing on the most significant macroeconomic variables. In the third part pension reforms in Europe are introduced for the central scenario. Then the risks of misjudging the effects of the reforms because of errors on population trends are discussed.

II. HOW DOES DEMOGRAPHIC UNCERTAINTY AFFECT POPULATION FORECASTS?

II.1. Characteristics of the UN central scenario for the INGENUE world regions

In our baseline scenario, population evolution is calculated according to a standard population projection method on the basis of historical and prospective UN data until 2050. We use our own demographic model thereafter. We aggregate the population structure across the countries of each region with UN data from 1950 to 1995[7]. We project fertility and mortality trends (for both sexes) at the region-aggregate level so that our own demographic profiles fit with UN central projection 1998 until 2050. Then our trends converge to a stationary population structure in the very long run in each region.

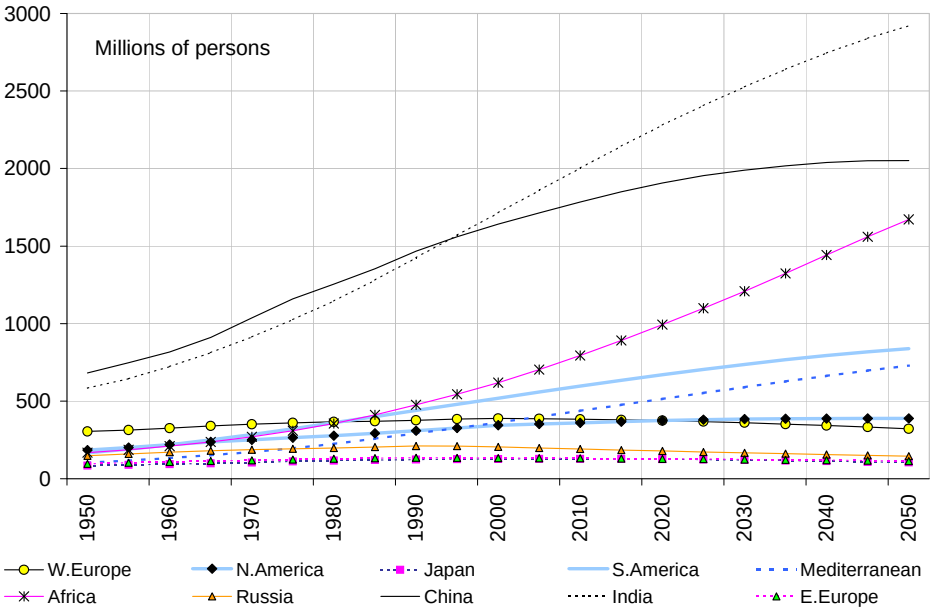
[5] For a presentation of the technical features of stochastic population simulations, see Alho and Spencer (2005).

[6] For an analysis of the macroeconomic consequences of different assumptions regarding interregional correlations of forecasts errors in the INGENUE 2 framework, see Alho and Borgy (2008).

[7] In the INGENUE 2 model, the world is divided in 10 regions according mainly to geographical and demographic criteria. These regions are labelled : Western Europe, Eastern Europe, North America, Latin America, Japan, Mediterranean World, Chinese World, Africa, Russian World and Indian World. The content of each region is detailed in Appendix.

According to these demographic forecasts, the world population reaches 9,3 billions in 2050. Population of the Indian world grows at a sustained pace and reaches 2,9 billions of persons in 2050 (31% of the world population against 28,3% in 2000). Population of the "Chinese world" increases at a very low pace between 2030 and its culmination in 2050 (see Figure 1).

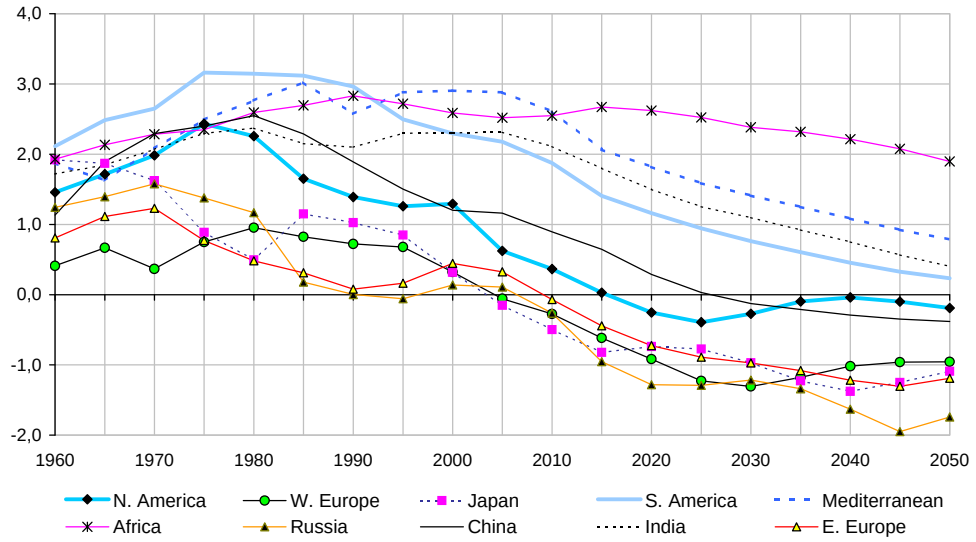
Figure 1 - Population by regions in the INGENUE2 model (1950-2005)



One must note that the population of the African region is growing at the highest pace in our projections. This comes from the high fertility rates that still characterize the countries included in this region. Conversely the population of Western Europe will culminate around 400 million people in 2005-2010, and then decline gently as much as in Eastern Europe. The population of Japan and Russia has already started declining.

The contrast between the INGENUE2 world regions is more pronounced for the change in the labour force (see Figure 2). The rate of growth of the working age population is decelerating everywhere. But the labour force will still be growing in South America, Indian world and the Mediterranean countries (outside Europe) and Africa where it will be hardly slowing down. Conversely it will decline throughout the half century in the Russian world (very fast), Eastern Europe, Western Europe and Japan. It will decline more moderately in North America (after 2010) and China (after 2020).

Figure 2 – Working age population annual growth rate 1960-2050

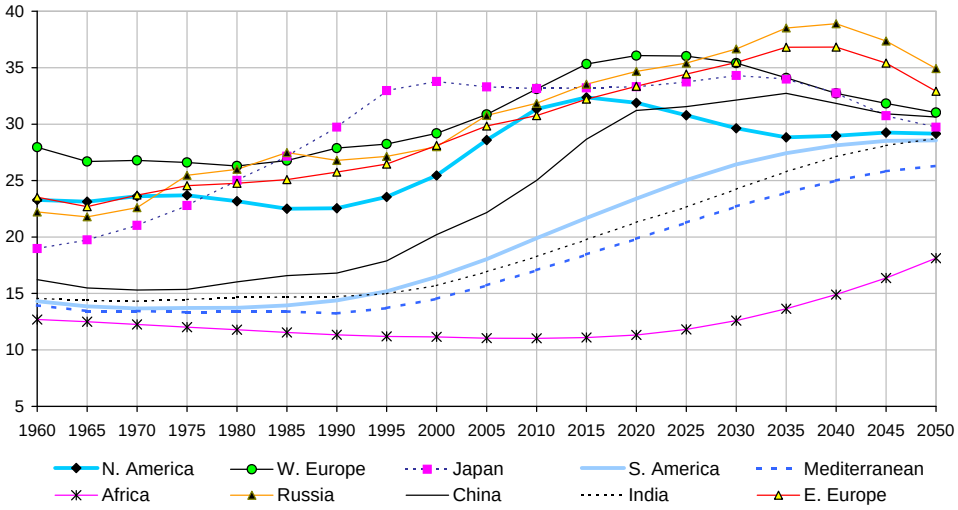


The conjecture is that the size and the dynamism of the population in large continental countries will become the preponderant factor in domestic development. The reason is that governments, mostly in Asia, have embarked in policies designed to enhance the productive power of the labour force. They are aware of the need to invest in infrastructure, health and education. What are still lacking are the financial institutions able to channel the abundant saving into public long-term investment and well-functioning bond markets to manage the risks and attract foreign capital.

As the leading OECD countries concentrate the largest part of world capital, the growth regime will depend on international capital rather than labour mobility. An intergenerational transfer of resources via capital export from the rich aging countries to the labour force growing countries will make the world regions strongly interdependent. Figure 3 illustrates why this intergenerational exchange will arise.

One can see that the proportion of high savers in total population follows a wave pattern that propagates from one region of the world to the next through the decades. The ratio culminates first in Japan as soon as 1995 and remains on a high plateau until 2030. Then North America will have its maximum in 2015 and Western Europe in 2020, Eastern Europe, the Russian world and the Chinese world in 2035. They are regions where the labour force will decline and thus hamper growth in the future. On the contrary, the regions found on figure 2 as the potentially fast-growing regions will see a progressive aging leading to an increase of the high savers ratio which will not culminate before 2050. It follows that saving should flow from early high savers to late high savers in the coming decades.

Figure 3 – High Savers Ratio (age group 45-69 yrs in percentage of total population) 1960-2050

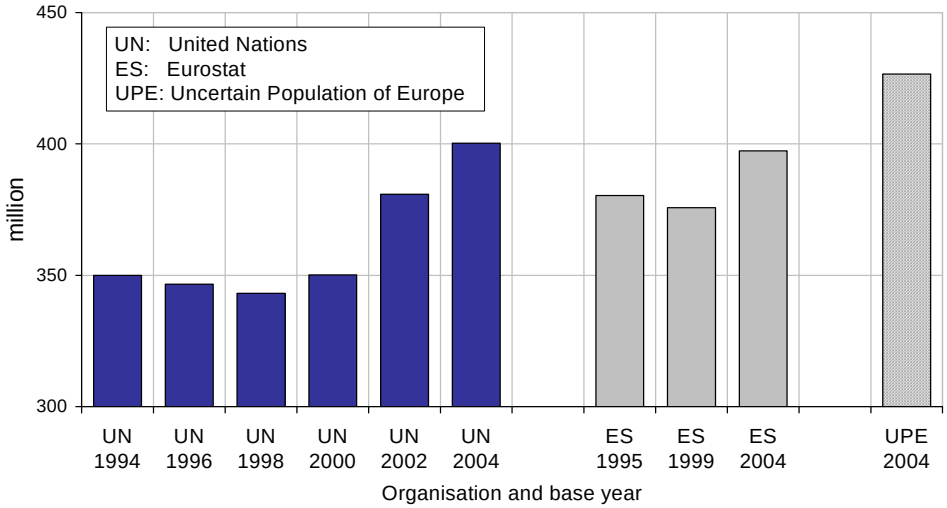


II.2. Changes in views over time as the basis for stochastic population forecasts

Revision of forecasts over time is common practice. Population forecasts do not escape this fate as on can see on Figure 4. For instance, in 1994, the UN predicted a total population in Western Europe (EEA+) of 350 million people in 2050. The number was slightly lowered to 340 millions in the 1998 projections. Then the UN undertook a sharp upward revision, delivering a forecast of 400 millions in its latest 2004 projection. Eurostat gave an almost identical number the same year. However an alternative forecast performed by independent demographers on the basis of stochastic population forecasts gives the much higher number of 427 millions[8]. The economic consequences of one or another occurrence will be substantially different. For this reason economists must be able to understand why the differences arise.

[8] See Alders, Keilman and H.Cruijsen (2006).

Figure 4 – Forecasts of total population size for EEA countries in 2050



The ground of population forecasts is a table of population numbers by age and gender in the basis year. The table is updated for future years by applying assumptions on:

- Death rates for each combination of age and gender;
- Birth rates specific for ages of women in childbearing years;
- International migration added up in each future year;

In INGENUE2 migrations across regions of the model are not considered in the baseline scenario. Therefore uncertainty comes from the structural parameters of demographic change, i.e. death and birth rates. Be they deterministic or stochastic, the forecasts are carried out similarly. But in stochastic forecasts, the structural parameters are random variables whose probability distribution is assumed normal in log-scale. The probabilistic cohort-component demographic model being non-linear in terms of the random rates, repeated simulations with stochastically varying rates are run. They give predictive intervals for the distribution of population by age and gender at future times.

Surprisingly the sharpest differences between alternative forecasts do not come from birth rates, rather from death rates.

The crucial assumption impinging on births accrues to the total fertility rate (TFR). The TFR for a certain year determines how many children a woman would have on average if age-specific fertility rates in that year would remain constant over time. The UN assumed

TFR much under replacement rate in 1996 and a target of 2.1 in 2050. But it gave little justification for this assumption of the assumed convergence to replacement level.

A lot of social, ethical and economic factors account for differences in fertility rates. They lead to a clear division in Europe. Northern countries, the UK and France have TFR of 1.8 per woman presently, German-speaking and Mediterranean countries converge to 1.4. If it is assumed that the divide will pervade throughout the half-century to 2050, it is tantamount to an average TFR of 1.65, close to the Eurostat 2004 scenario but at odds with the UN assumption of convergence to full replacement.

The main discrepancy is with mortality measured by means of life expectancy. This is the number of years an individual might expect to live if age-specific death rates remain constant over time. UN forecasts assumed in 1994 a maximum life expectancy of 87.5 years for women and 82.5 years for men in, 2050. Actual life expectancy was predicted at 79 years for men and 85 years for women. The lengthening of actual life expectancy slows down as much as the level approaches the maximum. In the 2004 UN forecast the maximum climbed to 92.5 for women and 87.5 for men. Predictions of actual life expectancy in 2050 were 81 years for men and 86.5 for women.

The revisions mean that those UN forecasts consistently under predicted life expectancy gains in the past, especially because it assumed that the gender gap would not diminish much. Alternative assumptions by independent demographers are based upon the observation that the gender gap has declined and will continue to decline substantially. These assumptions lead to higher forecasts in life expectancy of almost 85 years for men and 88.5 years for women.

II.3. Stochastic population forecasts

Demographers use commonly a deterministic (or scenario-based) model, where a point forecast is surrounded by a high and a low variant. Nevertheless, such a scenario-based approach to forecasting has several important shortcomings.

First, as explained above, there is uncertainty about assumptions concerning future fertility rates, mortality rates and net-migration numbers. In order to mimic this uncertainty, a high and low variant are constructed next to the point forecast of the total population. The high variant results from high fertility, low mortality and high net-migration, whereas the low variant has the opposite values in these parameters. The area between the high and low variant is simply interpreted as “uncertainty” of the point forecast. Therefore, the forecaster cannot assign a probability to a specific trajectory and subsequently the user cannot assess the likelihood of the underlying assumptions. Thus, scenario-based projections are not able to provide a probability distribution of future population structures.

Second, the high and low variants both have perfect (positive or negative) correlation between the crucial parameters, as well as perfect correlation over age and time. As a result we get extreme variants and, since the crucial fertility and mortality rates cannot fluctuate

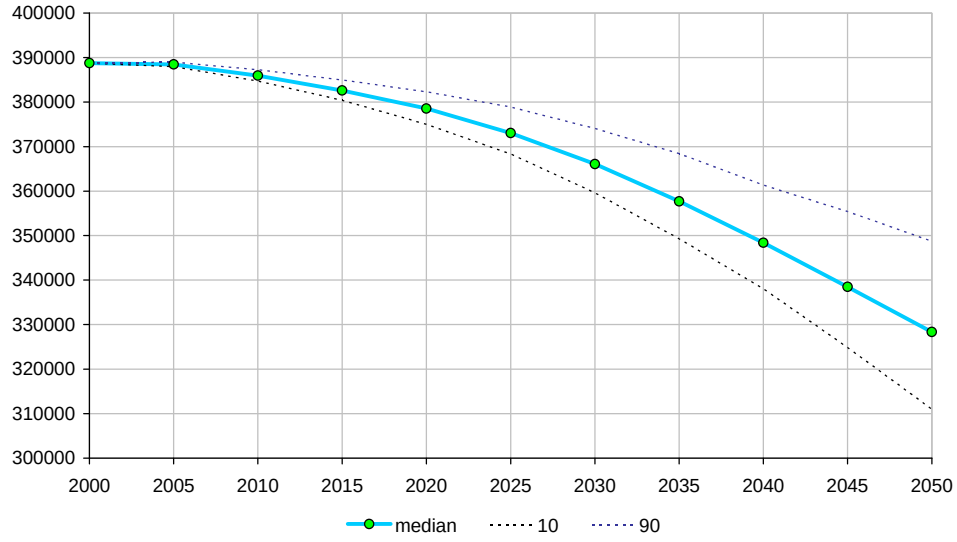
by assumption, the method tends to overestimate (at least in the short run) the uncertainty of population growth.

Third, the pairing of assumptions may not capture correctly the uncertainty either in the age structure or in the total population. Consider the high variant for population growth, with a low mortality rate combined with high fertility. The population of elderly will expand, so will the labour force and total population. The low variant, with high mortality rate and low fertility rate will give the opposite results: both fewer elderly and fewer working age people. Hence, the crucial variable for the economic impact of ageing, e.g. the old-age dependency ratio will not vary that much, resulting in an underestimation of that uncertainty. If instead one makes a young and an old variant, the first with high fertility, high mortality and high net-migration, the second with opposite values of the variables, to illustrate the range of variation in the dependency ratio, one now gets a narrower band for population growth and hence an underestimation of the uncertainty for the total population. Either way, the deterministic approach will result in internal inconsistency. Consequently stochastic forecasts are inescapable whether one wishes to get an unbiased view of uncertainty in population processes.

In order to run the stochastic population forecasts in the 10 regions of the INGENUE 2 model, we use the PEP (Program for Error Propagation) program developed by Juha Alho. We perform 200 population forecasts for the 10 regions of the model. The uncertainty scale parameters for the 10 regions of the model used for the stochastic simulations are calibrated on the basis of the coefficients of variation estimated by Juha Alho for 2050. The stochastic population paths are then used as an input for the INGENUE2 economic model.

Figure 5 depicts the point forecast of the population in Western Europe surrounded by the 80% confidence region. According to the point forecast, total population will decrease from 390 millions in 2000 to approximately 330 millions in 2050. From the confidence intervals, it seems that there is a 10% probability that the total population will decrease much less, reaching 350 million in 2050, but there is also a 10% probability that population will be much lower in 2050, reaching 310 million. We observe that uncertainty increases throughout the whole forecast period, and in 2050 there is a 80% probability that total population will lie between 310 and 348 million people.

Figure 5 – Stochastic population forecast : Western Europe



Source: authors'calculations.

III. IMPACT OF DEMOGRAPHIC UNCERTAINTY ON THE BASELINE SCENARIO

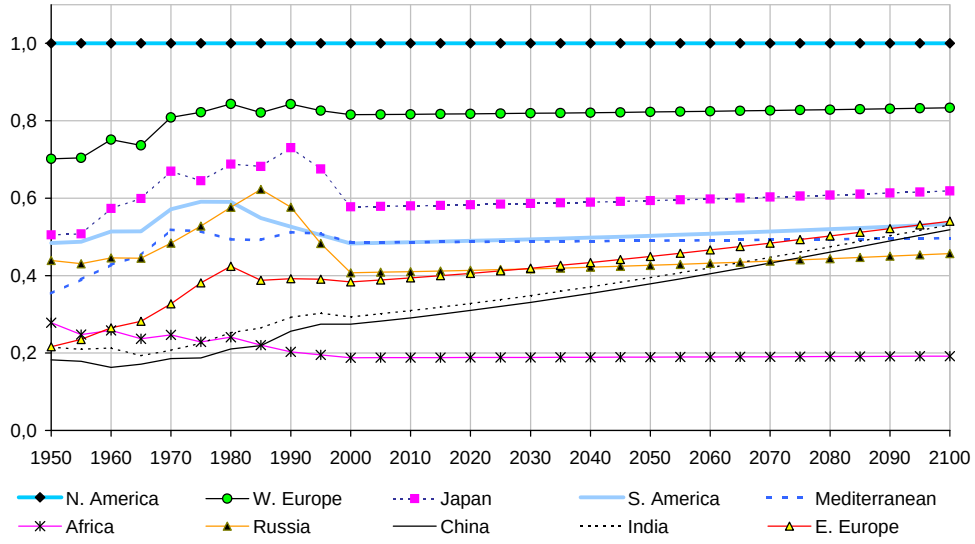
Beside changes in the population structure, growth in the world economy and subsequently in Western Europe is shaped by trends in the diffusion on technological progress. Because we want to focus on economic consequences of demographic uncertainty and because little is known in the interplay between population and technological development, we assume no uncertainty in trends of total factor productivity (TFP) growth. Nonetheless uncertainty in the pace of technological progress should be investigated in a future study.

To model the diffusion process of technological knowledge, we make a conservative hypothesis in the baseline scenario. We assume that North America will remain the technological leader and will revert to its long-run growth trend after absorption of the IT revolution. For the rest of the world there is a region-specific catching-up process in TFP. The differential speed of catching up reflects the discrepancies in the social and institutional conditions of assimilating innovation conceived elsewhere, combined with the levels of TFP already reached.

Figure 6 gathers the profiles of TFP relative to North America, which is assumed in the baseline scenario for the world regions of the INGENUE2 model. It shows that Western Europe and Japan resume their slow catching-up, meaning that they absorb the IT revolution after North America. The takeoff in China and India, which started in the 1990's, gains momentum. The rise of these continental countries to the status of prominent powers attracts whole regions (Chinese and Indian worlds) into commercial and financial

integration. Eastern Europe is also a fast-growing region due to its participation to the European Union. We take a dimmer view of the other regions. A relatively slow catching up is assumed in South America and the Mediterranean countries where there are perennial difficulties in establishing efficient market institutions, in promoting a large class of entrepreneurs and in generating non-corrupt and competent governments. The same arises more seriously in the Russian world where the catastrophic decline of the population is a further handicap. Finally we are more pessimistic about Africa where we assume no catching-up in level of TFP. Yet the rise in TFP at the same rate of the leading region, even if it entails no catching-up, is a marked improvement on the last quarter of a century which has seen no progress at all and thus a setback relative to the rest of the world.

Figure 6 – Total Factor Productivity: 1950-2100
(percentage of "North America" level)



Source: Ingenue.

The dynamic paths portrayed in the next figures depict the projections made with the overlapping-generation rational expectations general equilibrium model INGENUE2. The trajectories of the selected variables are shown for Western Europe only. But they are consistent with a world dynamic equilibrium. A short non-technical overview of the model is outlined in box 1.

Box1. Non-technical overview of the INGENUE2 model

The world is compounded of 10 regions: *North America* (including Australia and New Zealand), *Western Europe, Japan, Eastern Europe, Russian World* (including Ukraine Bielorussia and Central Asia), "*China world*" (China and other East Asian countries excluding Japan*),"Indian World*" (India, Indonesia, Pakistan, Bangladesh, Sri Lanka), *"Latina world*" (South and Central America and the Caribbean), *Mediterranean (*Non-European Mediterranean countries, Near and Middle East countries), *Africa* (Sub-Saharan Africa).

Overlapping generations: 21 generations overlap. Unit time 5 years, hence the maximum life span is 105 years.17 cohorts of adults and 4 cohorts of young (under 20). Cost per child proportional to the consumption of their parents. Exogenous labour supply adjusted for an age-specific participation ratio in each region.

Macroeconomic framework:

- *Household behaviour*: life cycle hypothesis and voluntary bequest left to children at age T subject to survival until that age. In the budget constraint, the expenditure side encompasses the consumption (costs of children included) and saving of each individual of age a at period t. On the income side there is the financial income on accumulated saving (if the individual of age a-1 at time t-1 has survived between t-1 and t) corrected by the survival probability of generation age a-1. This adjustment amounts to the mechanism of a perfect annuity market that pools death risk due to the uncertain lifetime of individuals. There is also a non-financial income which depends on the age of the individual respective to threshold ages: net labour income (after social security taxes) modulated by an age-efficiency profile for people in full labour activity; a mix of labour income and pension benefits for people partially retired (reduced labour activity); full pension benefits for people entirely retired. The lifetime utility program is maximized under the intertemporal budget constraint, taking prices, social contributions and benefits as given. [Modigliani, 1986]

- *Public sector*. It is confined to a public Pay As You Go (PAYG) pension scheme in all regions. It operates under a defined-benefit rule. It pays a proportion of the current net wage (replacement ratio) to retirees. It is financed by a payroll tax on labour income. The exogenous parameters are the retirement age and the replacement ratio. They are region-specific. The contribution rate is determined so as to balance the budget period by period.

- *Production system.* Goods are heterogeneous. In each region, there is an intermediate goods sector. It uses labour and capital to produce a region-specific intermediate good with a constant return-to-scale Cobb-Douglas production function. The final goods sector is the product of a CES combination of a domestic intermediate good and a foreign intermediate good imported by the region from a world market (Backus and alii, 1995). This homogenous world good is "produced" by a fictive world producer as the output of a CES combination of all intermediate goods exported by the regions. All production functions are augmented by TFP coefficients.

- *Firm behaviour*. In each type of sector, firms act on competitive markets. They maximize their profit under their production constraint, taking prices as given. In the domestic intermediate good sector the constraint is intertemporal, since the production function depends on the stock of capital which is depreciated and accumulated. Intermediate goods producers thus maximize net present value of future cash flows, i.e. production value minus wage cost and capital cost. The latter depends on the depreciation rate, which is itself affected by international capital market imperfections. The depreciation rate is higher in debtor regions. More precisely the higher their net foreign debt ratio to their stock of capital, the higher the depreciation rate in those regions. As a consequence, such a specification introduces a risk premium related to the debtor position of the region. Therefore this debt constraint increases the required gross rate of return on capital in debtor regions, which in turn lowers the demand for capital and thus the equilibrium capital / labour ratio resulting from the first-order condition. Other type producers face a more simple maximization problem. Domestic goods producers and the world producer maximize current profit subject to their CES production functions

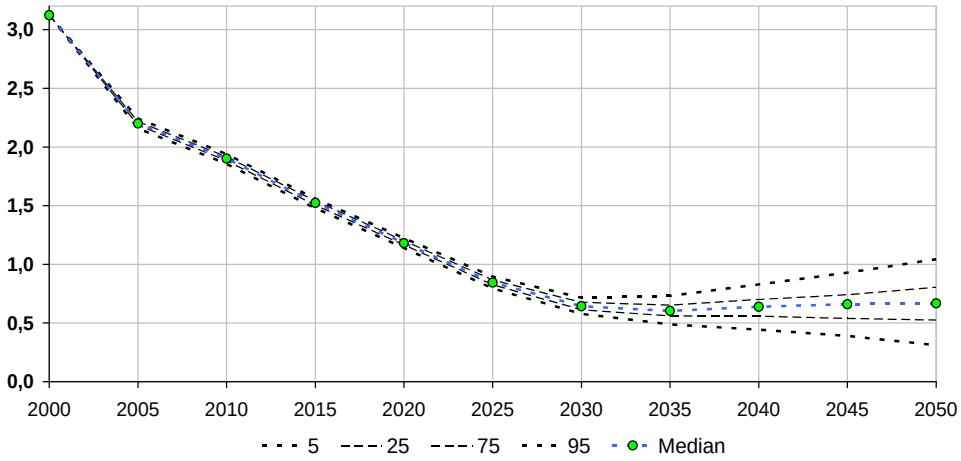
- *General equilibrium.* The capital stock in each region, the age distribution of saving in each region, the initial prices of domestic commodities are the initial conditions. .Exogenous variables and parameters are: the demographic profiles in each region that are outputs of the demographic upstream model, the coefficients of the TFP determination in intermediary and final sector of each region, the social security policy parameters in each region. The competitive world equilibrium stems from five set of equations: intertemporal utility maximization of households, intertemporal profit maximization of firms in intermediate goods sectors, period profit maximization of firms in final goods sectors, period profit maximization of the world producer, market clearing conditions. The markets for intermediate goods, final goods, labour in each region and the market for the world intermediate good are cleared in each period . These equations determine all relative equilibrium prices expressed in a common numeraire, which is the price of the intermediate good in North America set equal to one. This convention allows us to express values in constant dollars. Finally Walras's law implies that the world financial market equilibrium is the redundant equation. This market is automatically cleared.

III.1. Growth and saving in Western Europe

From year 2000 to about 2030 the growth rate of potential GDP slows down continuously, in line with the decline of the working age population. The mean growth rate of the European labour force starts declining in 2005-2010 to reach a minimum of –1.3% annual growth in 2025-2030. Then it recovers slowly to –1.0% in the mid-century. Therefore the mean growth rate of GDP slows down from 3.2% in 2000 to 0.7% in 2030, combining the impact of the decline in the labour force and a diminishing rate of gross productive investment (Figure 7). It rests roughly at 0.7% until 2050.

Throughout the period 2000-2030 the uncertainty in birth rates has a modest impact on the size of the working age population. Therefore the growth rate of GDP stays in a close range around its mean with a 95% probability. The picture changes dramatically thereafter. High or low fertility rates are conveyed into the labour force twenty years after. Furthermore a larger labour force entails more consumer spending and thus more productive investment. It is why the confidence interval in growth rates widens from 2025-2030 onwards. All in all, Figure 7 portrays a GDP growth rate in the 0.5 to 0.9% confidence interval with a 50% probability and a 0.3 to 1.1% interval with a 90% probability. Such a confidence interval is very significant for wealth accumulation. It should not been ignored when shaping policies dedicated to pension reforms.

Figure 7 – GDP growth rate in Western Europe (2000-2050)



Source: authors' calculations.

The consequence of demographic uncertainty on net domestic saving shows a more evenly distributed pattern (Figure 8). Net saving in each region is the aggregate of individual savings in the life cycle. It depends on the demographic structure (high savers ratio and dependency ratio), on the expectation of future income and on the parameters of the PAYG pension systems. Demographic determinants are prevalent. Regions with the fastest-increasing dependency ratios are the ones with the fastest decreasing net saving rates. Western Europe is one of them.

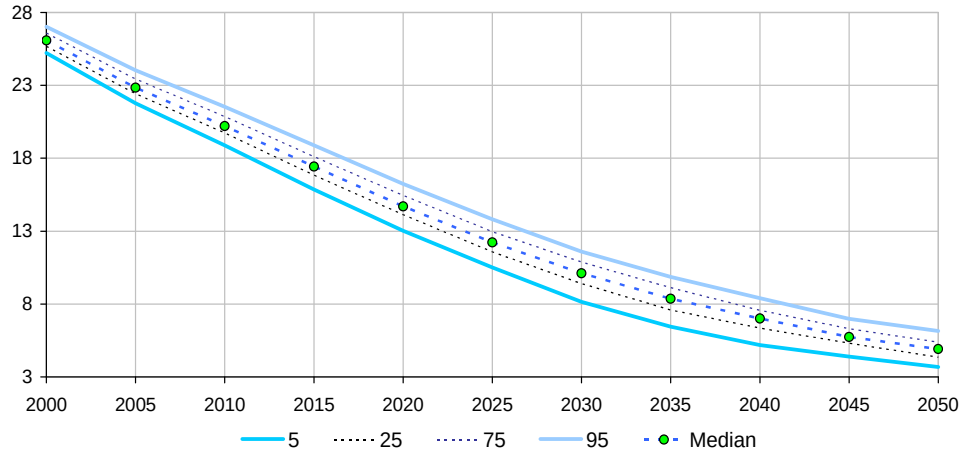
The reason rests with the profile of individual saving over the life cycle and with the aggregation at a given date of savings from people of different ages, which stem from overlapping generations. Because they expect higher future income and because they incur child-raising expenditures, young people indulge in debt. When people get into the 40-60 or 65 age bracket, they become high savers to redeem their former indebtedness and to build financial wealth in provision for future retirement income. In the last stage of their life

people save less because their income is diminished and they might even disave while pension funds and life insurance accounts are drawn down.

In Western Europe declining income growth on the one hand, and raising dependency ratios on the other hand, make the mean aggregate saving ratio decline continuously throughout the half-century. Uncertainty impinges upon saving both via fertility and mortality rates. A total fertility rate higher than the one predicted in the UN central scenario increases the child dependency ratio for years ahead. A generation later it raises the proportion of young people in the total population. Therefore a higher fertility rate reduces the saving ratio for decades. An increase in life expectancy raises the old-age dependency ratio (the proportion of retirees in total population). The consequence is also a reduction in the overall saving rate. The opposite occurs with a lower fertility ratio and with a shorter life expectancy.

In reading Figure 8, one must be careful not to identify the upper and the lower limit of the 90% probability zone in the saving rate to well-defined variants of the central scenario. A probabilistic reasoning is in the order. What the figure measures is the confidence interval on the absolute value of the ratio at 90% probability of occurrence. The range of variability in the saving rate widens from 1.8pp in 2000 to a little more than 3pp in 2025. Then it shrinks to 2.5pp in 2050. But, in relative value, the picture is quite different because the mean value of the ratio declines dramatically in the half-century. The percentage of variation is 7 in 2000, 25 in 2050, 50 in 2050.

Figure 8 – Net Saving: Western Europe
Baseline scenario



Source: authors' calculations.

III.2. Current account balance and exchange rate in Western Europe

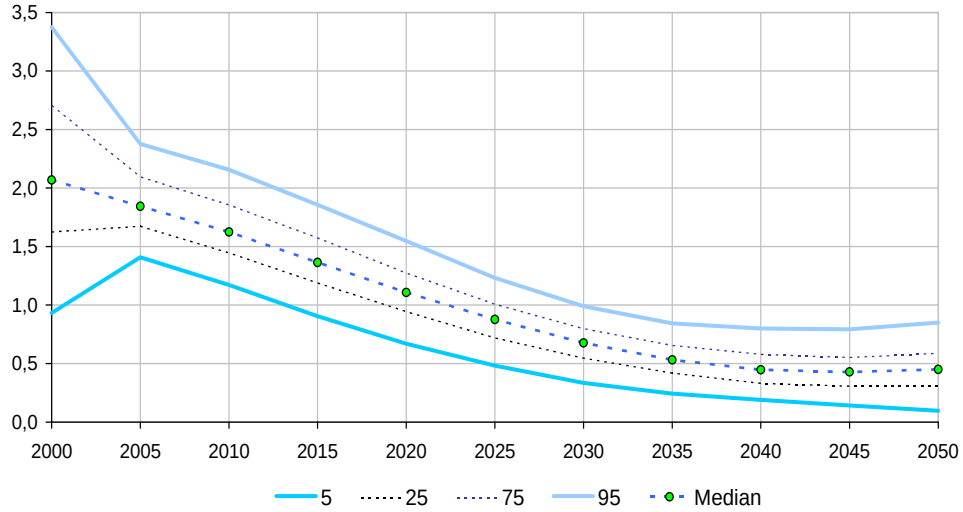
In INGENUE2 capital markets are wholly integrated. Despite the general interdependence of prices one can roughly say that the world interest rate is the price that equilibrates the world financial market as a whole, matching total aggregate wealth and world capital stock.

The world real interest rate declines over the fifty-year period. This is due to global ageing. More regions move into a larger proportion of high savers and investment growth slows down with the world labour force. It follows that the world saving investment equilibrium is tilted more and more toward a lower equilibrium interest rate. This downward trend provides the general profile of regional real interest rates. The hierarchy of regional real interest rates is linked to the rate of change of the real exchange rates. The real interest rates regulate investment and saving flows. The gap between investment and saving is the current account balance of each region. It is financed by capital flows whose amounts are such that yield differentials between different regions cancel out in every period.

Therefore the world financial equilibrium allocates capital flows that finance current account imbalances modulated by real exchange rate changes. Net foreign assets affect exchange rates. They move with the net financial positions of the regions to create future surpluses or deficits, so that current accounts are balanced in the very long run, i.e. there is no more accumulation of net foreign assets or debts.

In Western Europe the current account is systemically in surplus in the central demographic scenario (Figure 9). It wanes from 2% of GDP in 2000 up to 0.5% in 2040 and stays put thereafter. The structural creditor position is mainly the result of parsimonious investment needs. The shrinking of the current account surplus comes from the larger proportion of retirees in total population, whose saving rate is lower, and from the lesser size of the high saver stratum. Correlatively the sustained creditor position entails an appreciation of the mean European real exchange rate against North America and for that matter against all other regions but Japan (Figure 10).

Figure 9 - Current Account Balance (% GDP): Western Europe



Source: authors' calculations.

Because real exchange rates are consistent with real interest rate parities, the appreciation of the European real exchange rate is tantamount to a real interest rate lower than the world and the American interest rate, because Europe is such a low-growth region.

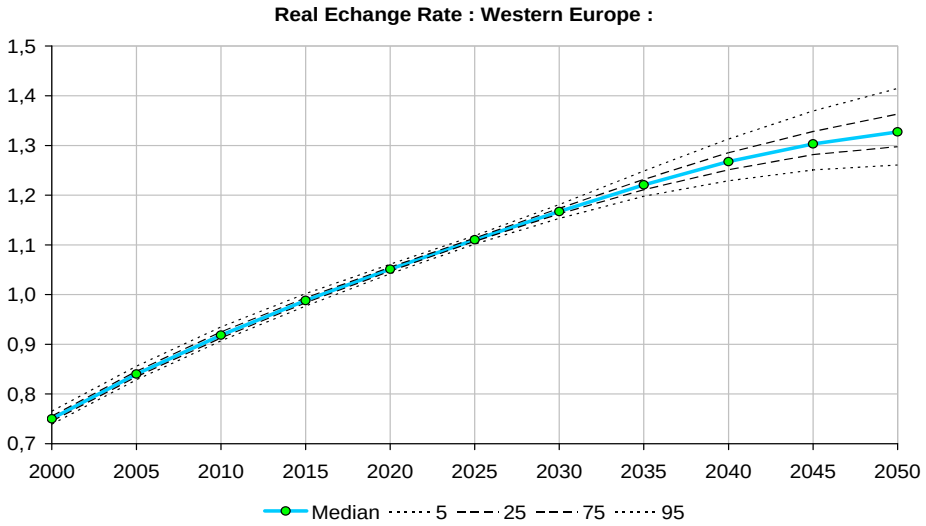
The impact of uncertainty

Population uncertainty has a strong influence on the current account surplus and, thus, on the accumulation of foreign assets by European households. A revision of forecasts appears as an unexpected shock. Households are supposed to be rational expectation agents, who resort to dynamic programming to determine their inter temporal consumption profile and their related wealth accumulation. When an unexpected shock occurs, they revise their optimal plan because they embody the innovation. It ensues that consumption jumps up or down according to the nature of the revision, while production change is shackled by the inertia of the capital stock. Therefore, if the shock is large enough, there is an overshooting in the current account. For instance a large increase in consumption, because households expect higher future incomes than beforehand, drives production upward with a delay. In the first period after the shock, excess demand is covered by a temporary surge of imports leading to a much lower current account surplus. Subsequently this move is partly offset by a rise in domestic production.

Figure 9 depicts such a pattern. If population growth has been grossly underestimated and is revised upward, higher income growth can be anticipated in the future. Simulating an upward revision in year 2000, which leaves a 5% probability for an even higher population, the model computes an immediate slump in the current account surplus from 2 to 1% of GDP. This abrupt change is partly reversed in the next period to 1.4%. Then the profile of

the current account closely follows the one of the net saving analysed above: a steady diminution until 2035-2040 and a levelling off thereafter.

Figure 10 – Real Exchange Rate : Western Europe



Source: authors' calculations.

Comparing Figure 7 and Figure 10 one can observe that population uncertainty affects the real exchange rate as much as it affects the growth rate. It has been explained above that the effect of uncertainty on growth comes from the size of the labour force, which conveys variations in fertility rates a generation later. Therefore uncertainty in birth rates in the early years of the 21st century shows up on working-age people a generation later. Whether growth is higher than its mean, capital accumulation is stronger and real interest rate upper than the interest rate compatible with the baseline scenario. Because the real interest rate in Europe is declining less than in baseline relative to world rate, the real exchange rate appreciates less. Conversely growth rates lower than in baseline convey a larger appreciation. For an average appreciation of more than 75% over the half-century, the range of uncertainty at a 90% probability is 20%.

III.3. Conclusion on European growth and financial equilibrium

In the next half-century Europe is likely to be a low-growth region, because of its adverse demographic profile and its slow progression in total factor productivity. Nevertheless it will benefit from the advance of globalisation. Being one of the two regions (with Japan) where real interest rates are persistently the lowest, Western Europe will be a permanent creditor, accumulating net foreign assets for the whole half-century. Its real exchange rate will also appreciate consistently. Therefore European households will gain from

globalisation in both income drawn from the yield of their foreign assets and in purchasing power over its imported goods relative to other regions. As a consequence consumption per capita measured at PPP will rise in sympathy with real exchange rate appreciation.

Demographic uncertainty may entail adverse risks to which public policy should be prepared. Worst scenarios would come from a much lower growth of the labour force due to lower than expected fertility rates. In the worst case scenario, GDP growth might almost stall after 2030 and the appreciation of the real exchange rate would be significantly stronger than in baseline. If simultaneously life expectancy was to expand faster than expected on average, the old-age dependency ratio would get crippling for the financing of public pension at constant replacement rate of labour income. Since the dire economic consequences would show up after 2030, time is left for pension reform that would enhance wealth accumulation before that deadline. Such reform is underlined in the next session.

IV. CONSEQUENCES FOR PENSION REFORM IN EUROPE

In the baseline scenario, the European pension system is characterised by two major features throughout the 21st century: a low legal retirement age (62.5 years on average) and a fairly high replacement rate (45%). With the help of INGENUE2 we now investigate the consequences of a pension reform in Europe, keeping the institutions in other regions of the world identical to baseline.

IV.1. Pension reform with deterministic population forecasts

In the baseline scenario; the replacement rate is kept constant, which induces a marked increase in the contribution rate that reaches 32% by mid-century and stabilises around 25% in the very long run, in the aftermath of the baby-boom shock. Conversely the reform that is explored is a levelling-off of the contribution rate (CCR). The European pension contribution rate is supposed to be kept constant at the level it reached at the end of the 20th century (18%). The result is a progressive and significant decline of the replacement rate, as the European population ages. In 2050 it would be reduced by 55%.

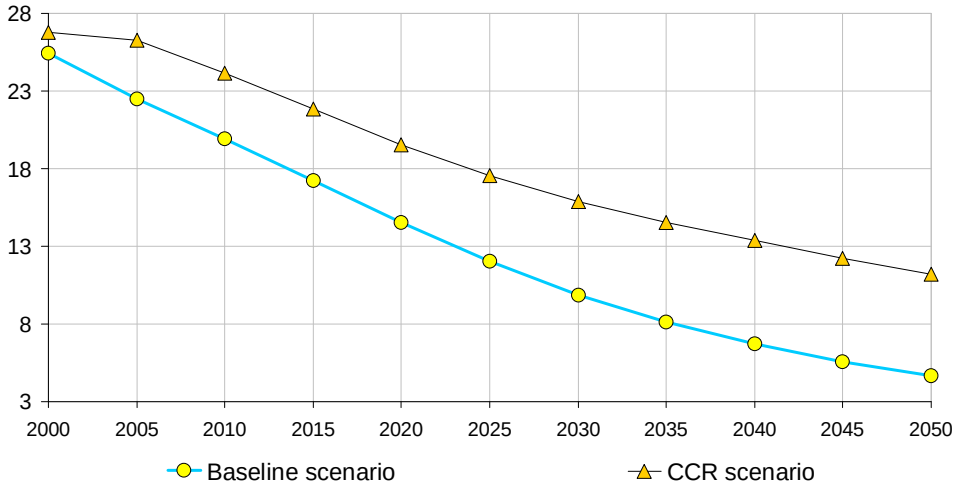
Because this reform is assumed to be perfectly anticipated as soon as it is announced (at the start of the 21st century), its major direct and most immediate effect impinges upon individual saving behaviour, and hence on aggregate saving.

Unsurprisingly, compared to the baseline scenario, the CCR reform raises the saving rate of Western Europe all along the half-century (Figure 11). As the public pension system is made less generous, European households save and accumulate more in order to compensate for the effect of lower pensions on consumption after retirement. This reform is thus an incentive for the development of private pension funds.

Because labour supply is exogenous, this saving effect is the only direct effect on households, and it stems from a change in the time profile of their budget constraint. As a

consequence, consumption per capita is below its level in the baseline scenario. Restriction in consumption lasts until 2035, so that households accumulate enough wealth to offset their reduced future social income. Thereafter consumption recovers because enough wealth has been accumulated by ageing household who can enjoy more capital income (figure 12).

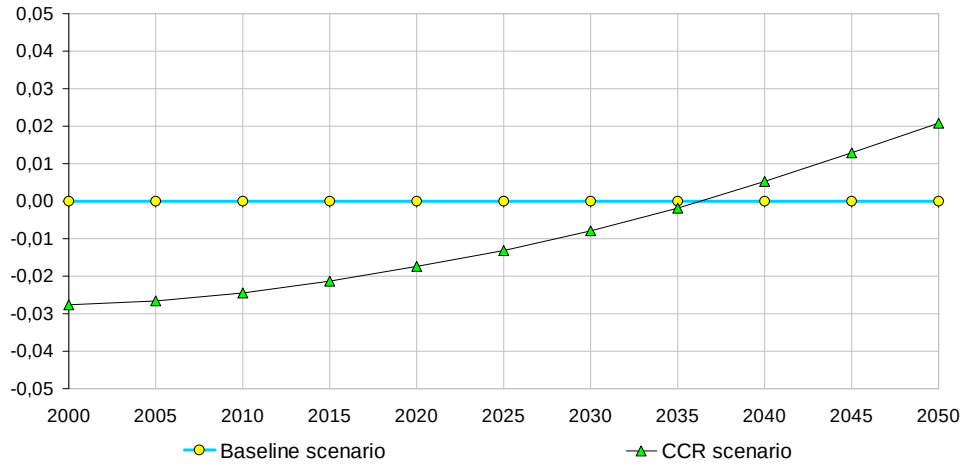
Figure 11 – Western Europe: Saving rate



Source: authors' calculations.

While the adjustment is underway, the reduced consumption tends to lower the price of the final goods in Europe relative to the rest of the world. The change in relative final goods prices leads to a depreciation of the real exchange rate. The latter induces an increase of the trade balance surplus in comparison with the baseline scenario, since European exports (as a share of GDP) are sustained until 2030.

Figure 12 – Western Europe : consumption per capita (level)
(difference from baseline)



Source: authors' calculations.

After that time the wealth accumulated beforehand transforms the saving investment balance. The capital invested in the three decades to 2030 has raised labour productivity. Household wealth is high enough to deliver a future stream of income that will complement the reduced public pensions of retirees. Therefore consumption per capita gets above its baseline level and the real exchange rate gets higher than in the baseline scenario[9]. Correlatively, the accumulated saving makes Western Europe a larger permanent exporter of capital to the rest of the world than in baseline.

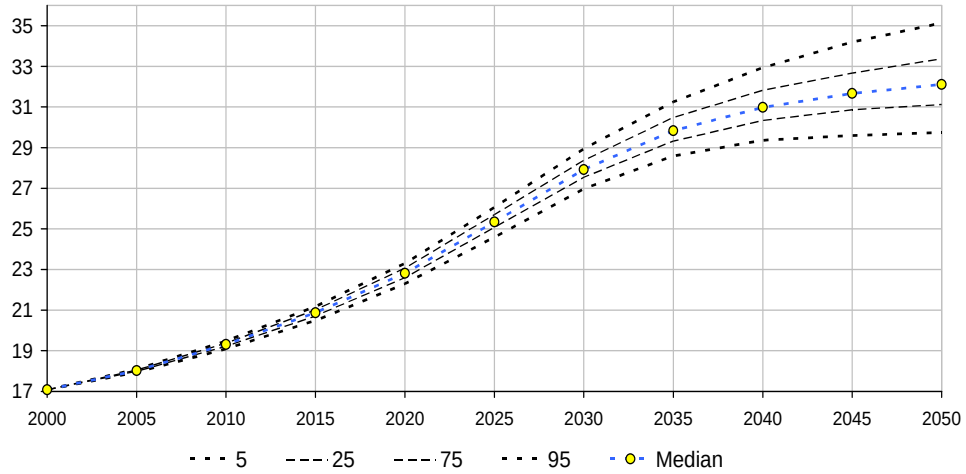
IV.2. How do stochastic population forecasts impact the distributive consequences of pension reform?

The implementation of a pension reform that encourages more saving in Western Europe is all the more relevant from the viewpoint of policymakers than adverse population changes are to be feared. The range of increase in the contribution rate to sustain a steady replacement ratio with population uncertainty is illustrated on Figure 13. In any case, keeping the benefits of present-day retirement policy entails a sharp increase in the contribution rate. It must adjust at each period in order to get a time to time balanced budget. In the baseline case, the contribution rate increases from 17% in 2000 to 32% in 2050. The distribution associated to stochastic population forecasts highlights the fact that the increase in the contribution rate could even be higher. There is a 5% probability that the

[9] The deviation from baseline of the real exchange rate has a profile similar to consumption per capita.

contribution rate could reach 35% in 2050[10]. To manage the risk in the worst occurrence, policymakers should induce policies that encourage pension plans, especially in countries where compulsory saving dedicated to future retirement income has not been developed yet.

Figure 13 – Contribution to the Public Retirement System: Stochastic Population Forecasts

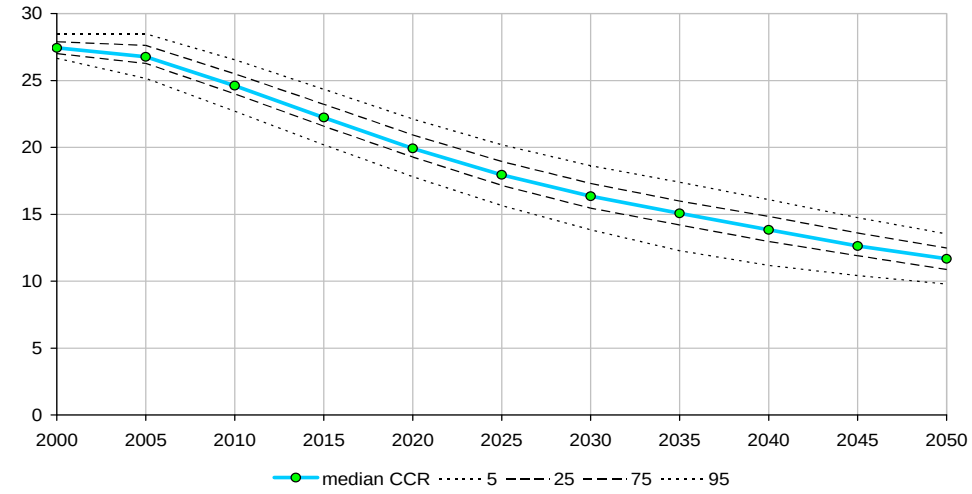


Source: authors' calculations.

The likelihood of a broad pension reform has bearing on long-run financial investors via its effect on the saving rate and the subsequent impact on financial prices. The probability distribution in the saving rate, associated with the stochastic population forecasts, can be compared for the alternative policies. Figure 8 depicts saving rates with the retirement benefit-preserving policy and Figure 14 with the contribution-capping policy. As mentioned above, the latter policy induces a substantial increase in the saving rate. The range of variations in the saving rate for the extreme population forecasts never overlap when the profiles are compared for both policies. The saving rate is consistently higher under the contribution-capping policy.

[10] One must note that there is also a 5% probability that the increase could be lower than in hte median case, the contribution rate reaching only 29.7%.

Figure 14 – Saving in Westerne Europe: CCR reform



Source: authors' calculations.

The higher saving rate will lead to lower interest rate in Europe. It will entail an incentive to more diversification of household wealth.

What are the consequences for the current account surplus and the appreciation of the exchange rate in the contribution-capping vis-à-vis the benefit-preserving policy? The higher the saving rate in Europe, the more European households invest in assets produced in faster-growing regions, the higher the current account surplus of Western Europe.

The positive relationship between the saving rate and the current account surplus is illustrated in the following stochastic simulations where demographic uncertainty is supposed to be independent in the different regions of the world[11]. On Figures 15 and 16 the positive relationship between the distribution of saving rates and the one for current account surpluses is computed both for the benchmark scenario and the contribution-capping scenario. The much higher saving in the latter case is reflected into a higher current account surplus. In the contribution-capping scenario, where people save more to keep up with their desired future pension, the average relationship explains much more of the variance and the slope is higher. It means a higher a propensity to invest abroad whenever income from capital makes a higher share of pension income.

Then the comparison between the benchmark and the CCR scenario is depicted for the relationship between the current account surplus and the real exchange rate. The relationship is almost non existent in the benchmark scenario. For the range of variation in

[11] For an analysis of the key role played by different assumptions regarding interregional correlations of forecasts errors in the INGENUE 2 framework, see Alho and Borgy (2008).

the saving rate, the dispersion in the current account surplus is large relative to the mean. The opposite arises in the CCR scenario. When the population is such that the saving rate is higher, the current account surplus is also higher. Meanwhile consumption expenditure in the final good is lower. Therefore the price of the final good in Western Europe relative to North America, e.g. the real exchange rate in Western Europe, is lower while the saving rate is higher. A negative relationship between the surplus in current account and the real exchange rate ensues. It is much more significant in the CCR scenario (Figure 18) than in the benchmark scenario (Figure 17).

Figure 15 - Western Europe:
Current Account (vertical) and Saving (horizontal) – 2025
Baseline scenario

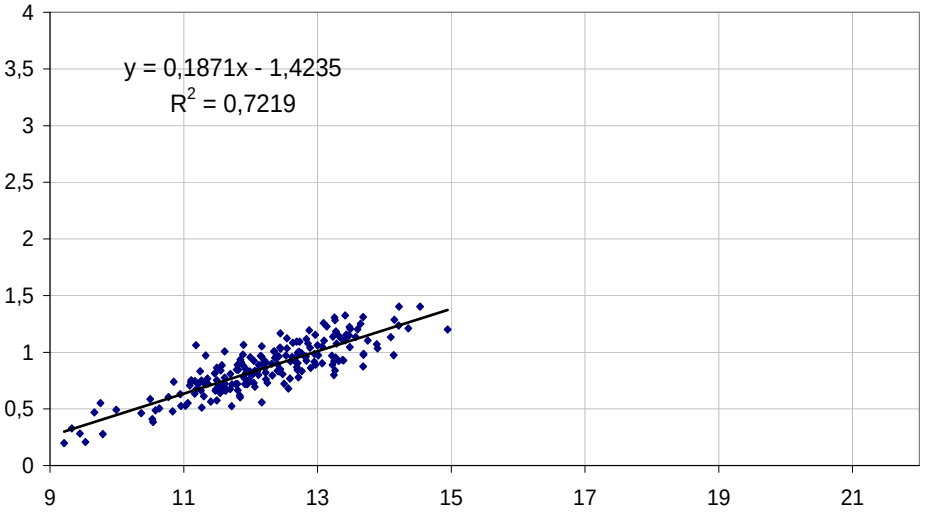
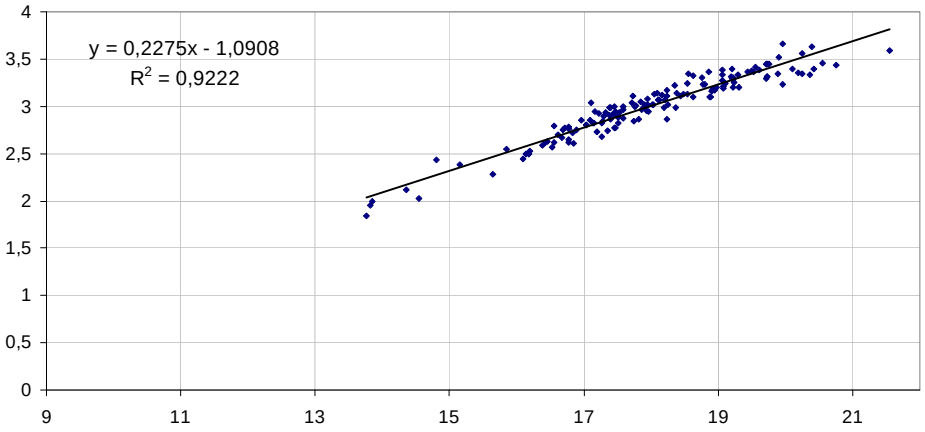


Figure 16 – Westerne Europe:
Current Account (Vertical) and Saving (horizontal)
CCR Scenario



Source: authors' calculations.

Figure 17 – Current Account (Vertical) and Real exchange rate (Horizontal)
Baseline Scenario - 2025

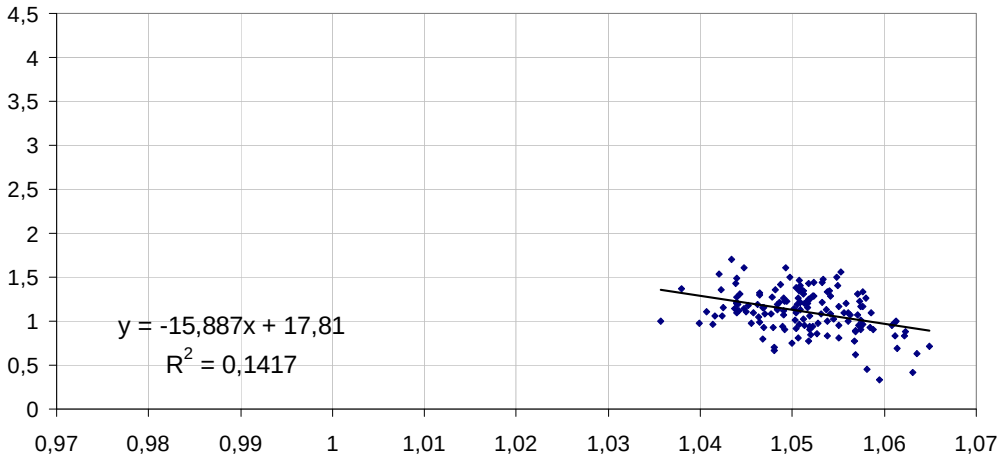
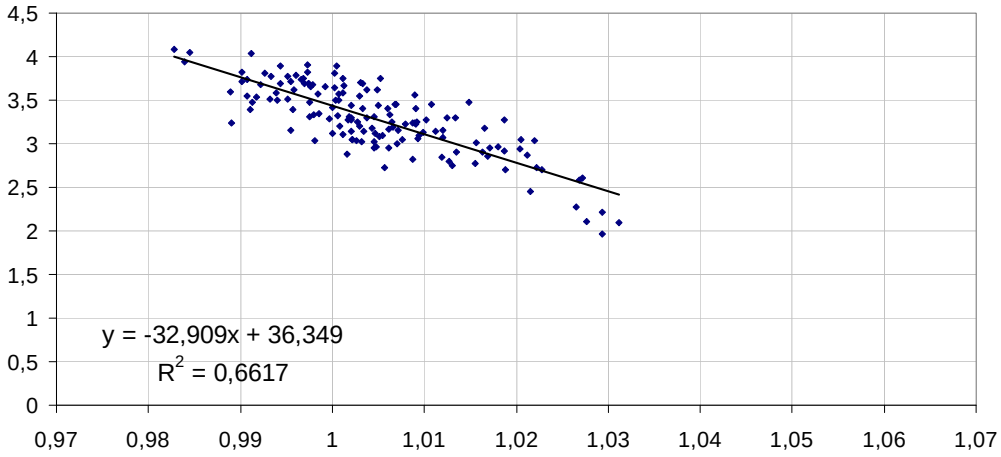


Figure 18 – Current Account (Vertical) and Real exchange rate (Horizontal)
CCR Scenario - 2025



Source: authors' calculations.

V. CONCLUSION

The demographic transition is a long-range and powerful structural process. It is also enthralled by uncertainty. Assumptions on the underlying stochastic process can be made in observing the pattern of forecast revisions by the authoritative international institutions. Using the INGENUE2 worldwide computable general equilibrium model, it is possible to study the economic consequences of population uncertainty. This paper has focused on Western Europe where the population is ageing fast and where pension reforms are at stake.

The economic consequences of population uncertainty arise mainly on saving and growth. Demographic uncertainty is much larger on the dependent people at both extreme strata of the age pyramid. The working age population, hence the growth rate, is affected a generation later. It is why the range of variation in the growth rate gets larger from 2030 onwards. On the contrary, uncertainty on the ratio of retired population/ high-saving working population, which is crucial for the saving rate, arises throughout the half-century. Because it interacts with the passing of the baby boom wave, it leads to a distribution of saving rates that is wider around 2025-2030.

Interest rates and exchange rates on the one hand, current account balance and net foreign assets on the other hand, carry on the uncertainty in the saving and growth rates. The stochastic simulations provide confidence intervals for the variations of those financial prices that are of importance for the strategic allocation of saving.

Europe will be a region with high but declining saving and mediocre economic performance. Its low growth and low real interest rate would get worse in the worst-case scenarios. Such a setting gives a strong incentive for international diversification. Therefore

European households will be permanent capital exporters via the strategic allocation of institutional investors.

Furthermore population uncertainty interferes with pension policy. The probability of a worsening of the dependency ratio much higher than the mean forecast makes the case for reform more compelling.. The paper has illustrated the policy problem in contrasting two regimes: a retirement benefit-preserving regime on the one hand and a social contribution-capping regime on the other hand. With the latter policy, wealth accumulation is larger whatever the stochastic population change. There is more opportunity to invest abroad because the domestic real interest rate is lower. If the policy shift is made now, it will take at least three decades of wealth accumulation and reduced consumption to recover and improve the standard of living relative to the status quo.

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APPENDIX: THE REGIONS IN THE INGENUE 2 WORLD MODEL

In the INGENUE 2 model, the World is divided in 10 regions according mainly togeographical and demographic criteria. These regions are labelled : Western Europe, Eastern Europe, North America, Latin America, Japan, Mediterranean World, Chinese World, Africa, Russian World and Indian World. The content of each region is detailed below.

"Western Europe": 'Channel Islands', 'Denmark', 'Finland', 'Iceland', 'Ireland', 'Norway', 'Sweden', 'United Kingdom', 'Greece', 'Italy', 'Malta', 'Portugal', 'Spain', 'Austria', 'Belgium', 'France', 'Germany' (East and West), 'Luxembourg', 'Netherlands', 'Switzerland'.

"Eastern Europe": 'Estonia', 'Latvia', Lithuania', 'Bulgaria', 'Czech Republic', 'Hungary', 'Poland', 'Romania', 'Slovakia', 'Slovenia', 'Albania', 'Bosnia and Herzegovina', 'Croatia', 'TFYR Macedonia', 'Yugoslavia'.

"North America": 'Canada', 'United States of America', 'Australia', 'New Zealand', 'Melanesia', 'Fiji', 'New Caledonia', 'Papua New Guinea', Solomon Islands', 'Vanuatu', 'Micronesia', 'Guam', 'Polynesia', 'French Polynesia', 'Samoa'.

"Latin America": 'Argentina', 'Bolivia', 'Brazil', 'Chile', 'Colombia', 'Ecuador', 'French Guiana', 'Guyana', 'Paraguay', 'Peru', 'Suriname', 'Uruguay', 'Venezuela', 'Belize', 'Costa Rica', 'El Salvador', 'Guatemala', 'Honduras', 'Mexico', 'Nicaragua', 'Panama', 'Bahamas', 'Barbados', 'Cuba', 'Dominican Republic', 'Guadeloupe', 'Haiti', 'Jamaica', 'Martinique', 'Netherlands Antilles', 'Puerto Rico', 'Saint Lucia', 'Trinidad and Tobago'.

Japan

"Mediterranean World" : 'Algeria', 'Egypt', 'Libyan Arab Jamahiriya', 'Morocco', , 'Tunisia', 'Western Sahara', 'Armenia', 'Azerbaijan', 'Bahrain', 'Cyprus', 'Georgia', 'Iraq', 'Iran', 'Israel', 'Jordan', 'Kuwait', 'Lebanon', 'Occupied Palestinian Territory', 'Oman', 'Qatar', 'Saudi Arabia', 'Syrian Arab Republic', 'Turkey', 'United Arab Emirates', 'Yemen', 'Turkmenistan', 'Uzbekistan' 'Kyrgyzstan'.

"Chinese World": 'China', 'Democratic People's Republic of Korea', 'Mongolia', 'Republic of Korea', 'Brunei Darussalam', 'Cambodia', 'East Timor', 'Lao People's Democratic Republic', 'Myanmar', 'Philippines', 'Singapore', 'Thailand', 'Viet Nam'.

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