Pension Reforms In France: Impact On Growth And Inter-Generational Redistributive Effects

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This paper assesses the impact on growth and the inter-generational redistributive effects of some possible pension reforms in France using a dynamic general equilibrium model with overlapping generations. Results suggest that a reform increasing the effective average retirement age by 1.25 years per decade and diminishing the average replacement rate by around 6 percentage points up to 2020 could stabilise social contributions for the youngest, but would gradually foster the poverty rate among pensioners. On the other hand, a reform incorporating a rise in the age of retirement by 1.25 years per decade, unchanged replacement rates and a discretionary increase of all pensions of 2.5 per cent in 2008 would limit the poverty rate among pensioners, but it would weigh down on the growth rate and the welfare of future generations.

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Introduction

This paper assesses the impact on growth and the inter-generational redistributive effects of some possible pension reforms in France.^{1,2} It thus complements the studies assessing the impact of reform scenarios on future deficits.³ This exercise remains illustrative. It measures the main mechanisms involved by Pay-As-You-Go (PAYG) pension reforms in France in a stylised modelling framework.

Pension reforms can have a sizeable influence on growth in the long run because they can modify the dynamics of the labour force (through higher retirement age for instance) or the supply of capital (through lower replacement rates for instance). They also involve strong inter-generational redistributive effects because their welfare cost may not be shared equally between households, depending on their age when the reform is implemented.

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³ For example, COR (2006).

In order to measure the influence on growth and the inter-generational redistributive effects of possible pension reforms, parameters have been set in French data to determine a stylized dynamic general equilibrium model with overlapping generations (GE-OLG). This modelling framework is well suited to measure the impact of pension reforms on growth in an ageing context, as well as addressing inter-generational issues. The model used in this paper is a modified version of a GE-OLG model developed at the Organisation for Economic Co-operation and Development (OECD),⁴ which takes into account some specific features of the French pension system. Different possible pension reforms have been considered and their influence has been assessed to know whether they rely mainly on tax rates, the effective average age of retirement or the replacement rate to balance the PAYG regime in the future.

This paper is divided into two sections. The first section describes the model used in this paper and the pension reforms that are simulated. The second section presents the results and expands on their policy implications.

The model

The model used in this paper is a modified version of a GE-OLG model developed at the OECD.⁵ Appendix describes the model in detail.

As in Oliveira-Martins *et al.*,⁶ working time is exogenous and constant. This assumption can be shown to have very limited consequences on the results.^{7,8} The specification of the model includes some improvements compared with Oliveira-Martins *et al.*^{9,10} The setting of its parameters is close to Cournède and Gonand's¹¹ model. The modelling of public finances includes one pension regime that encapsulates an exogenous variable, measuring the number of years taken into account in the average wage of reference used for computing pensions. It also enables us to measure poverty rates among older individuals, defined as the number of individuals more than 60 years old whose net income is lower than 60 per cent of the average net wage.¹²

The dynamics of the model are exclusively driven by demographics, pension reforms and the behavioural responses of economic agents.¹³

⁴ Oliveira-Martins *et al.* (2005); Cournède and Gonand (2006).

⁵ *Ibid.*

⁶ Oliveira-Martins *et al.* (eds) (2005).

⁷ Gonand (2007).

⁸ While higher taxes or lower replacement rates weigh down on optimal labour supply in a model with endogenous labour market, the favourable effect on net wages of an ageing-driven capital deepening offsets most of this detrimental impact.

⁹ Oliveira-Martins *et al.* (eds) (2005).

¹⁰ In particular, the average individual of a cohort maximizes his/her consumption over his/her real average lifetime, and not over 99 years as in Oliveira-Martins *et al.* (2005).

¹¹ Cournède and Gonand (2006).

¹² As in Blanchet and Crenner (2006).

¹³ The model does not account for effects stemming from the external side of the economy. Accounting for external linkages would smooth the dynamics of the model, but only to a limited extent. Households may want to invest in younger countries to push up the rate of return on their assets; however, the rest of the

A dynamic computable model

As concerns demographics, the model embodies around 60 cohorts each year, depending on the average life expectancy, thus capturing the changes in the population structure in a detailed way. A set of demographic data has been constructed for the period 1910–2158. Historical values were gathered from national sources. Gonand's¹⁴ projections have been used for the period 2000–2158. These projections are very close to French official demographic forecasts. Participation and unemployment rates by age groups are frozen from 2000 onwards in scenarios with unchanged retirement ages. Scenarios with rising retirement ages include corresponding changes in the participation rate of older workers (see Appendix).

The household sector is modelled by a separable, time-additive utility function and an inter-temporal budget constraint. The instantaneous utility function has one argument (i.e., consumption). The average individual of a given cohort decides how much to consume and save, so as to maximise the discounted value of his/her lifetime utility subject to his/her inter-temporal budget constraint. A households' decision to participate in the labour force is exogenous. Households receive wage and pension income and pay proportional taxes on their labour income to finance the PAYG pension regime (see Appendix for more details).

Production is modelled through a standard constant elasticity of substitution (CES) function with two inputs: capital and efficient labour. Exogenous technical progress drives the variation of multi-factor productivity (MFP) over time. In the long-run equilibrium, the growth rate of the gross wage per unit of efficient labour equals MFP gains (i.e., 1.5 per cent per year) because both total labour force and the capital/labour ratio are constant.¹⁵ The price of the goods produced by firms is normalised to one. Inflation is abstracted from, since this is a long run model.

The model is calibrated on an interest rate of 3.5 per cent in the base year, corresponding to the sum of MFP gains and the discount rate, as suggested by the life cycle theory. In contrast with other studies, the model is not calibrated on technical parameters such as the inter-temporal elasticity of substitution to mimic observed variations in the stock of capital around the base year as procedures of this nature can bias the long-run results.

In order to test the robustness of model results to alternative specifications and parameter values, extensive sensitivity analysis has been carried out.¹⁶ Overall, the dynamics of the results proves to be reasonably robust to changes in key parameters.

world, including much of the developing world, is also rapidly ageing and is therefore competing for the same limited pool of capital. Moreover, home bias (the "Feldstein–Horioka puzzle"), exchange rate risks and financial systemic risk also suggest that the possible overestimation of the impact of ageing on capital markets due to the closed economy assumption is very small.

¹⁴ Gonand (2005).

¹⁵ By contrast, during the demographic transition, the dynamic equilibrium is driven by ageing and public finance reforms.

¹⁶ See Gonand (2007).

Scenarios of pension reforms

Five different scenarios are considered in this paper.

In a no-reform, *baseline scenario*, the participation and employment rates among older working individuals remain constant. In line with the 1993 reform, pensions are indexed only on prices and computed by applying a proportional constant rate to an average wage over a period increasing from 10 years for the cohort born in 1933 to 25 years for the individuals born in 1948. Financial pressures stemming from ageing are offset each year in the future by movements of the proportional tax rate only.

This scenario models the situation observed in France up to now (even with the 2003 reform), with no further reform in the future.

In *scenario 1*, the employment rates among older workers increase in line with a rise in the average effective age of retirement of 1.25 year per decade from 2005 on. The number of years taken into account in computing pensions is frozen at 25 years for the cohorts born from 1948 on, as in the baseline scenario. Residual imbalances of the PAYG regime are covered by changes in the tax rate.

This scenario models a successful implementation of the 2003 reform, that is, with an average retirement age and employment rates of older workers effectively increasing over time. In the first years of implementation of the reform, the average age of retirement in France has increased because different schemes allowed for some premature exit from the labour market. However, the impact of these schemes is dissipating and the upward effect of the 2003 reform on the age of retirement is probably beginning to materialise from now onwards.

In *scenario 2*, the employment rates among older workers remain constant as in the baseline. The number of years taken into account in the average wage of reference used for computing pensions increases from 25 to 40 years for the cohorts born in 1963 and afterwards. Thus, the replacement rates diminish over the simulation period. Residual imbalances of the PAYG regime are covered by changes in the tax rate.

This scenario models the effects of a development of pre-funded retirement schemes in the future because lower replacement rates motivate agents to increase their private pension savings to sustain consumption upon retirement.

In *scenario 3*, the average effective age of retirement increases as in scenario 1 and the number of years taken into account in the average wage of reference used for computing pensions rises as in scenario 2. Residual imbalances of the PAYG regime are covered by changes in the tax rate.

Scenario 4 corresponds to scenario 1 with the additional feature of a discretionary and permanent increase of pensions of 2.5 per cent in 2008. This discretionary increase of pensions in 2008 aims at containing the rise of relative poverty for pensioners associated with non-wage-indexed pensions.

Table 1 summarises the main characteristics of the different pension reform scenarios considered in this paper.

There is one financial asset in this model. Accordingly, there is no portfolio strategy modelled here. The model does not address the issue of whether age influences individual portfolio strategies. There is, to date, no broad consensus on the likely impact of age on portfolio strategies. A few comments might be in order here.

Table 1 Four scenarios of future pension reforms

<i>Dynamics from 2008 onwards</i>	<i>Average effective age of retirement</i>	<i>Number of years taken into account in the wage of reference used for computing pensions</i>	<i>Residual imbalances of the PAYG regime covered by changes in the...</i>	<i>Discretionary and permanent increase of pensions in 2008</i>
Baseline	=	=	Tax rate	0
Scenario 1	+	=	Tax rate	0
Scenario 2	=	+	Tax rate	0
Scenario 3	+	+	Tax rate	0
Scenario 4	+	=	Tax rate	+ 2.5%

Ageing could have a major impact on financial markets if the average individual in a population modifies his/her arbitrage between stocks and bonds just because he/she gets older. Samuelson's seminal lifetime asset allocation model¹⁷ suggests that age does not have any impact on portfolio decisions. However, this result relies on strong assumptions. Specifically, taking into account the accumulated labour income (or "non-financial capital") in total wealth significantly alters Samuelson's result.¹⁸ Non-financial capital, computed as the discounted value of future labour income, decreases mechanically with age, while accumulated financial wealth increases. But, assuming that risk aversion remains constant over time, the optimal fraction of total wealth invested in risky assets would also have to remain constant. In consequence, the fraction of financial wealth invested in stocks has to decline over time. This would imply that individuals' portfolio strategies would gradually switch with age from stocks to bonds. However, this effect could be mitigated if risk aversion were to decrease with age.¹⁹ Retirees would be willing to take on more risk because they no longer have to face uncertainty about labour income.

Another issue deals with the impact of an increase in the age of retirement on the participation rate among older workers. Available studies suggest that such a rise may have *per se* a favourable impact on the employment rate among older workers. Hairault *et al.*²⁰ show that the closer the retirement age, the lower the incentives to invest in professional training and/or recruit an older worker. This assumption is implicitly retained in the setting of the reform scenarios considered here, at least for those which incorporate a rise in the age of retirement.

The two most significant French PAYG reforms

Since the 1993 reform, pensions are indexed only on prices. The 1993 reform also increased gradually the number of years taken into account in the average wage of

¹⁷ Samuelson (1969).

¹⁸ Jagannathan and Kocherlakota (1996).

¹⁹ Gollier and Zeckhauser (2002).

²⁰ Hairault *et al.* (2006).

reference used for computing pensions from 25 to 40 years. The period of contribution to the PAYG regime that is necessary to get a full-rate pension had also been raised gradually from 150 to 160 quarters.

The Pension Reform Act (21 August 2003) introduced a mechanism indexing life expectancy to the period of contribution to the PAYG regime that is necessary to get a full-rate pension, diminished the penalties applied to people retiring before having contributed during the minimum required period and created a bonus for those working even if they have contributed sufficiently to get a full-rate pension.

Results provided by four scenarios

The GE-OLG model enables us to assess the impact of possible pension reforms on economic growth and the pension regime, as well as analysing their inter-generational redistributive effects.

Impact of pension reforms on the pension system and growth

Figure 1 shows the impacts in France and up to 2020 of the pension regime and other variables of scenarios 1 and 2, along with the baseline scenario, on the parameters.

In the baseline scenario, replacement rates decline slightly over the simulation period. Employment rates at older ages remain unchanged. In this context, stabilising the PAYG system in an ageing context requires a sizeable increase in the tax rate (around 4 percentage points from 2005 to 2020).²¹ The absence of any indexation of pensions on wages results in an increase in the relative poverty rate among the retired population close to 20 percentage points from 2005 to 2020.²² This order of magnitude is in line with dynamic microsimulations found in Blanchet and Crenner.²³

In scenario 1, the gradual rise of the effective average age of retirement bolsters the future employment rates for individuals over 55. While the replacement rates and the poverty rate are close to those of the baseline scenario, the tax rate is much lower and is almost stabilised. This is a natural reflection of the favourable effect of a higher age of retirement on the dependency ratio and the financial situation of the PAYG system.

²¹ Although exogenous in the model, participation and thus employment rates are negatively affected by tax hikes in practice. A large body of evidence indicates that a higher labour tax wedge reduces participation, especially through its disincentive effect on second earners (Jaumotte, 2003). Tax hikes can also entail additional distortions by the impact of taxation on multi-factor productivity (MFP). Because MFP is exogenous in the model, the simulations do not incorporate the effect of taxes on investment in human capital and research and development activities. Most studies conclude that the effect is negative and strong (Feldstein, 2006). Human capital accumulation and research and development efforts are the main drivers of multi-factor productivity growth which itself is the dominant determinant of long-term growth.

²² More precisely, the relative poverty rate among the retired population is computed as the sum of the population of the cohorts over 60 whose average net income is lower than 60 per cent of the average net income in total population, divided by the population over 60. Computing the poverty rate this way is consistent with the modelling that encapsulates only one representative individual for each cohort.

²³ Blanchet and Crenner (2006).

Figure 1. Impact of scenarios 1 and 2 on some variables of the model.

In *scenario 2*, the gradual rise in the number of years taken into account in the wage of reference used for computing pensions weighs down on the average replacement rate that diminishes by 8 percentage points from 2005 to 2020. The tax rate balancing the PAYG system increases slightly less than in the baseline scenario because pensions are lower. However, it does not stabilise as in scenario 1 as the age of retirement remains unchanged. As pensions paid to retirees are significantly lower, the poverty rate among older individuals surges by 40 percentage points from 2005 to 2020, twice as much as in scenario 1.

Figure 2 shows the impacts on the parameters of the pension regime and other variables of the model in scenarios 3 and 4, along with the baseline scenario, in France and up to 2020.

Figure 2. Impact of scenarios 3 and 4 on some variables of the model.

In *scenario 3* that encapsulates the same increase in the age of retirement as in scenario 1 and the same rise in the number of years taken into account for computing pensions as in *scenario 2*, the tax rate stabilises even though population is ageing. The upswing in the poverty rate among older individuals is relatively strong though more contained than in scenario 2, which does not incorporate any rise in the age of retirement.

In *scenario 4*, the poverty rate among older individuals stabilises, as well as the replacement rates, thanks to the discretionary and permanent increase of 2.5 per cent for all pensions in 2008. However, the tax rate balancing the PAYG system increases by around one percentage point.

Figure 3. Impact on growth of different pension reforms.

Figure 3 shows the effect on potential growth of the four pension reform scenarios. In our stylised GE-OLG model, the French potential growth is assessed as 1.7 per cent per year over the past few years. Ageing will detrimentally affect growth in the future since it materialises, *Ceteris paribus*, in a decelerating labour force. However, the magnitude of this unfavourable impact is strongly related to the characteristics of the pension reform implemented in the next decade (i.e., from 2008 to 2017).

If the pension system is balanced only by tax hikes, as in the baseline scenario, the annual average growth rate in the model declines to 1.5 per cent on average over the next decade in the model.

Increasing the effective average age of retirement by 1.25 year per decade with limited proportional tax increases, as in scenario 1, results in a potential growth rate in the model of 1.6 per cent per year on average over 2008–2017.

Lower replacement rates, as in scenario 2, foster capital deepening, as they motivate agents to increase their private pension savings to sustain consumption upon retirement. However, this increase in optimal saving lowers consumption in the short run. Accordingly, reform scenario 2 does not much enhance the potential growth rate in the next decade in the model, which remains at 1.5 per cent as in the baseline.

In *scenario 3*, which combines the main features of scenarios 1 and 2, the detrimental impact of ageing on growth is offset because this reform bolsters the labour force as well as the supply of capital. The growth rate would thus remain at 1.7 per cent in the model over 2008–2017, even though population is ageing.

In *scenario 4*, which incorporates a discretionary and permanent increase of pensions in 2008, the potential growth rate decelerates to 1.6 per cent per year in the next decade. Compared to scenario 3, the discretionary and permanent rise of all pensions in 2008 does not stimulate the labour force, nor the supply of capital.

Overall, scenario 3 emerges *a priori* as the most favourable reform for growth in the medium run. The impacts on the pension system and growth of scenarios 1 and 4 are very similar. Scenario 2 would fuel relative poverty among pensioners without bolstering growth.

Figure 4. Gain/loss of current welfare for households in scenario 1 compared to baseline.

Inter-generational redistributive effects of pension reforms in France

A commonly used method for assessing inter-generational redistributive effects of pension reforms consists in computing the internal rates of return (IRR) of the PAYG system. This method is simple and useful. However, it remains partial insofar as IRRs do not measure all the effects on households' welfare involved by pension reforms. For instance, scenario 2 involves diminishing replacement rates for future retirees, which weighs down on their IRRs. This does not imply that a lower replacement rate lessens the welfare of future retirees, because economic growth and thus consumption are higher in scenario 2 than in the baseline characterised by tax hikes.

Computing utility levels in a general equilibrium framework helps overcoming this shortcoming of IRRs. Utility levels take into account all the GE mechanisms influencing on households' welfare.

A detailed analysis of the cohorts losing or gaining from reform scenarios is possible by computing Lexis surfaces. A Lexis surface represents, in three dimensions, the level of a variable associated with a cohort of a given age at a given year. The variable considered here is the gain (or loss) of current welfare of a cohort in a reform scenario compared to its current welfare in the baseline scenario.²⁴

Figure 4 shows the gain (or loss) of current welfare for households in scenario 1, when the age of retirement is increased and the replacement rates remain basically unchanged, as compared to the utility level in the baseline, tax-hike scenario. The inter-generational redistributive effects are relatively limited in scenario 1. Compared to the baseline scenario, the welfare loss associated with a shorter period of retirement

²⁴ Current welfare refers here to the instantaneous welfare of a cohort, or equivalently its welfare at a given year, which is computed from the instantaneous utility function of a household in the GE model.

Figure 5. Gain/loss of current welfare for households in scenario 2 compared to baseline.

is more than offset by the favourable impact on consumption of higher economic growth.

Figure 5 shows the gain (or loss) of current welfare for households in scenario 2, associated with an unchanged age of retirement and declining replacement rates, compared to the baseline. The inter-generational redistributive effects are relatively strong in this reform. Baby boomers bear most of the cost of the reform, while younger cohorts born after the mid-1970's and future cohorts clearly benefit from it. These results are intuitive. In scenario 2, future pensions and future taxes are both lower than in the baseline. However, aged working cohorts in 2005 benefit from lower taxes during a few years only, before receiving significantly lower public transfers during their whole retirement period. Accordingly, the reform lessens their permanent income. By contrast, younger and future cohorts cash in on lower taxes during most of their working life, whereas the welfare cost of lower public transfers, which is discounted over several decades, is much lower than for older working individuals in 2005.

Figure 6 shows the gain (or loss) of current welfare for households in scenario 3, associated with an increasing age of retirement and declining replacement rates. Compared to scenario 2, this reform is more favourable for the welfare of all cohorts. Compared to scenario 1, which incorporates a similar rise in the age of retirement but stable replacement rates, scenario 3 is more favourable for young cohorts and future generations but slightly less for individuals born before the mid-1970s, that is, for baby boomers.

The inter-generational redistributive effects of scenario 4, with a rising age of retirement and a discretionary and permanent increase of all pensions in 2008, are very similar to those of scenario 1. Scenario 4 is slightly more favourable to older individuals, while it weighs down on the welfare of younger and future cohorts (Figure 7).

Overall, scenario 3 corresponds to the pension reform that is the most favourable to individuals born after the baby boom and to future generations among the scenarios

Figure 6. Gain/loss of current welfare for households in scenario 3 compared to baseline.

Figure 7. Gain/loss of current welfare for households in scenario 4 compared to baseline.

considered in this model. Scenario 4 benefits to older individuals but is detrimental for the welfare of young and future generations.

Conclusive remarks

This paper assesses the impact on growth and the inter-generational redistributive effects of some possible pension reforms in France. Results suggest that:

A reform increasing the effective average retirement age by 1.25 year per decade and diminishing the average replacement rate by around 6 percentage points up to 2020

may stabilise the potential growth rate over the next decade even though population will be ageing. It could also stabilise social contributions and enhance the welfare of individuals born after the baby boom, including future generations.

In a reform incorporating a rise in the age of retirement by 1.25 year per decade, unchanged replacement rates and a discretionary increase of all pensions of 2.5 per cent in 2008, potential output may decelerate by 0.1 per cent during the next decade while a rise in social contributions of 1 percentage point would be required to balance the PAYG system. The impact on the welfare of younger cohorts and future generations would be detrimental. However, this reform would stabilise the relative poverty rate among pensioners.

The dynamic overlapping generations equilibrium models have some characteristics that provide other original results, as shown earlier. For example, the capital deepening effect appears to have a sizeable impact when the replacement rate scenario holds. The drop in the replacement rate induces households to increase their saving rate (and lower their consumption). This increase in turn depresses the interest rate and weighs down on potential growth.

Raising the number of years taken into account in the average wage of reference used for computing pensions amounts to increasing the contribution that the pension scheme brings. Such an increase in the contribution that the regime brings is, after all, a characteristic of schemes by points (as the current complementary French pension scheme), as well as Notional Defined Contributions (NDCs) regimes.²⁵ Accordingly, considering whether or not to switch to such frameworks appears legitimate.

References

- Acemoglu, D. (2002) 'Directed technical change', *Review of Economic Studies* **69**: 781–810.
- Andersen, P., Klau, M. and Yndgaard, E. (1999) *Higher profits and lower capital prices: Is factor allocation optimal?* working paper no. 65, Bank for International Settlements.
- Aubert, P. and Crépon, B. (2003) 'La productivité des salariés âgés : Une tentative d'estimation', *Economie et Statistique* **368**: 95–119.
- Blanchet, D. and Crenner, E. (2006) *Simulating pensions in France: The DESTINIE model*, working paper, CEPS/ENEPRI seminar "Simulation properties of models of pension reforms", Brussels.
- Börsch-Supan, A., Heiss, F., Ludwig, A. and Winter, J. (2003) 'Pension reform, capital markets, and the rate of return', *German Economic Review* **4**(2): 151–181.
- COR – Conseil d'Orientation des Retraites (2006) *Retraites: Perspectives 2020 et 2050*, (March).
- Cournède, B. and Gonand, F. (2006) *Restoring fiscal sustainability in the euro area: Raise taxes or curb spending?* working paper no. 520, OECD Economics Department.
- Epstein, L.G. and Zin, S.E. (1991) 'Substitution, risk aversion and the temporal behaviour of consumption and asset returns: An empirical analysis', *Journal of Political Economy* **99**: 537–572.
- Feldstein, M. (2006) *The effects of taxes on efficiency and growth*, working paper Series no. 12201, NBER.
- Gallon, S. and Masse, E. (2004) *Arbitrage intertemporel, risque et actualisation*, working paper, Department of the environment, France.
- Gollier, C. and Zeckhauser, R. (2002) 'Time horizon and portfolio risk', *Journal of Risk and Uncertainty* **2**(3): 195–212.
- Gonand, F. (2005) *Assessing the robustness of demographic projections in OECD countries*, working paper no. 464, OECD Economics Department.

²⁵ Holzmann and Palmer (eds) (2006).

- Gonand, F. (2007) *La réforme des retraites, son effet sur la croissance et ses conséquences redistributives*, Doctoral thesis, Ecole Polytechnique, Paris.
- Gourinchas, P.-O. and Parker, J. (2002) 'Consumption over the life cycle', *Econometrica* **70**(1): 47–89.
- Hairault, J., Langot, F. and Sopraseuth, T. (2006) 'Les effets à rebours de l'âge de la retraite sur le taux d'emploi des seniors', *Économie et Statistique* **397**: 51–68.
- Holzmann, R. and Palmer, E. (ed.) (2006) *Pension Reform: Issues and Prospects for Non-Financial Defined Contribution (NDC) Schemes*, Washington DC: The World Bank.
- Jagannathan, R. and Kocherlakota, N. (1996) 'Why Should Older People Invest Less in Stocks Than Younger People?', Federal Reserve Bank of Minneapolis, *Quarterly Review* **20**(3): 11–23.
- Jaumotte, F. (2003) *Female labour force participation: Past trends and main determinants in OECD countries*, working papers no. 376, OECD Economics Department, Paris.
- Klump, R., McAdam, P. and Willman, A. (2004) *Factor substitution and factor augmenting technical progress in the U.S.: A normalized supply-side system approach*, Working paper no. 367, European Central Bank.
- Kotlikoff, L. and Spivak, A. (1981) 'The family as an incomplete annuity market', *Journal of Political Economy* **89**(2): 372–391.
- Miles, D. (1999) 'Modelling the impact of demographic change upon the economy', *The Economic Journal* **109**(452): 1–36.
- Normandin, M. and St-Amour, P. (1998) 'Substitution, risk aversion, taste shocks and equity premia', *Journal of Applied Econometrics* **13**: 265–281.
- OECD (2005) *Pensions at a Glance*, Paris: OECD.
- Oliveira-Martins, J., Gonand, F., Antolin, P., De la Maisonneuve, C. and Yoo, K.-Y. (2005) *The impact of ageing on demand, factor markets and growth*, working paper no. 420, OECD Economics Department.
- Samuelson, P. (1969) 'Lifetime portfolio selection by dynamic stochastic programming', *The Review of Economics and Statistics* **51**(3): 239–246.

Appendix

Description of the model

Demographics

The model embodies around 60 cohorts each year (depending on the average life expectancy), thus capturing changes in the population structure in a detailed way. Each cohort is characterised by its age a at year t , has $N_{t,a}$ members and is represented by one average individual.

The average individual's economic life begins at 20 ($a=0$) and ends with certain death at $\Psi_{t,0}$ ($a=\Psi_{t,0}-20$), where $\Psi_{t,0}$ stands for the average life expectancy at birth of a cohort born in year t .

In each cohort, a proportion $v_{t,a}$ of individuals are working, whereas $\mu_{t,a}$ are unemployed and receive no income. The inactive population is divided into two components. The first component corresponds to individuals who never receive any contributory pension during their lifetime. A proxy for the share of the inactive population that never receives a contributory pension is found in the ratio of inactive people aged 40–44 years to inactive people aged 65–69 years (in 2000).²⁶ Distinguishing between pensioners and inactive people who never receive any pension is not only realistic but also important to get reasonable levels for the contribution rate

²⁶ Cournède and Gonand (2006).

balancing the PAYG regime. The proportion $\pi_{t,a}$ of pensioners in a cohort is then computed as a residual (i.e., $1 - v_{t,a} - \mu_{t,a} - \pi_{t,a}$).

Demographic simulations for France are computed by Gonand²⁷ using official demographic assumptions. These simulations are very close to French official forecasts. They are transformed from 5-year periods (2005, 2010, ..., 2050) and age groups (20–24, 25–29 years ...) into annual data (20, 21, ..., years in 2000, 2001, ..., 2050) using a linear interpolation.

Future paths for the labour force and the working population over the simulation period rely on the assumption that unemployment and participation rates by age groups are frozen from 2000 onwards unless otherwise stated (especially in scenarios involving a rise in the effective age of retirement, see below). The year 2000 is a reasonable starting point, because the output gap was then close to zero in most OECD countries.

Households sector's maximising behaviour

The household sector is modelled by a standard, separable, time-additive utility function and an inter-temporal budget constraint. The utility function has one argument, that is, consumption. The objective function over the lifetime of the average individual of a cohort born ($a = 0$) in year t is:

$$U_{t,0} = \frac{1}{1 - \sigma} \sum_{j=0}^{\Psi_{t,0}} \frac{c_{t+j,j}^{1-\sigma}}{(1 + \rho)^j}$$

where $c_{t+j,j}$ stands for the level of consumption of the average individual representative of a cohort of age j at year $t+j$, σ for the inverse of the intertemporal substitution coefficient and ρ for the subjective rate of time preference (or, equivalently, the psychological discount rate).

The households' inter-temporal budget constraint is:

$$\begin{aligned} y_{t,0} + \sum_{j=1}^{\Psi_{t,0}} \left[y_{t+j,j} \prod_{i=1}^j \left(\frac{1}{1 + r_{t+i}} \right) \right] \\ = c_{t,0} + \sum_{j=1}^{\Psi_{t,0}} \left[c_{t+j,j} \prod_{i=1}^j \left(\frac{1}{1 + r_{t+i}} \right) \right] \end{aligned}$$

where $y_{t+j,j}$ stands for the total income net of taxes of the average individual representative of a cohort, such that $y_{t+j,j} = w_{t+j} \varepsilon_j v_{t+j,j} (1 - \tau_{t+j,p}) + \Phi_{t+j,j}$.

w_{t+j} stands for the gross wage per efficient unit of labour, which is derived from the production function and the optimum behaviour of the producer (see below).

ε_j is a parameter linking the age of a cohort to its productivity or, equivalently, the endowment of the representative individual in an efficient labour unit. Following

²⁷ Gonand (2005).

Miles,²⁸ a quadratic function is used: $\varepsilon_a(a) = e^{0.05*(a)-0.0006*(a)^2}$ which displays an inverted U-shape pattern with a peak at 42 years.²⁹

$v_{t+j,j}$ is the fraction of working individuals in a cohort aged j in year $t+j$.

$\tau_{t+j,P}$ refers to the proportional tax rate financing the PAYG pension regime paid by households on their labour income.

$\Phi_{t+j,j}$ stands for the pension income received by the fraction of a cohort corresponding to retirees.

Up to age (ζ_t) at which an individual is entitled to obtain a full pension,³⁰ the pension is equal to $\Phi_{t+\zeta_t,\zeta_t} = P\pi_{t+\zeta_t,\zeta_t} \sum_{a=1}^{\psi_t} \frac{w_{t-a}\varepsilon_{\zeta_t-a}}{\psi_t}$ where $\pi_{t+\zeta_t,\zeta_t}$ is the fraction of pensioners in a cohort aged ζ_t , $w_{t-a}\varepsilon_{\zeta_t-a}$ stands for the gross wage of the representative individual of this cohort at year $t-a$, and ψ_t is the number of years taken into account in the average wage of reference used for computing pensions. P is a constant of calibration such that the average gross replacement rate for an individual aged ζ_t at the beginning of the period of simulation is close to 62 per cent.³¹

This specification implies that the model does not encapsulate any *decote* (a penalty rate for pension received before ζ_t) nor any *surcote* (a bonus in the opposite situation). Taking these mechanisms into account in the model would not change the dynamics of its variables over the simulation period, notably because the labour market is exogenous.

Above the age at which an individual is entitled to a full pension (i.e., $a+20 > \zeta_t$), the pension is computed as $\Phi_{t+j,j} = \Phi_{t+j-1,j-1}(\pi_{t+j,j})/(\pi_{t+j-1,j-1})$. This implies that the pension of the average representative individual is not wage-indexed, but is adjusted each year by the change in the number of pensioners in each cohort (i.e., $\pi_{t,a}/\pi_{t-1,a-1}$).

The optimal path for consumption stems from the Euler equation using a Lagrangian: $(c_{t,a})/(c_{t-1,a-1}) = ((1+r_t)/(1+\rho))^\kappa$ with $\kappa = \sigma^{-1}$ as the inter-temporal substitution coefficient. The initial level of consumption $c_{t,0}$ (i.e., the level of consumption of a cohort of age 20 at year t) is obtained by plugging the Euler equation back into the budget constraint:

$$c_{t,0} = \left(y_{t,0} + \sum_{j=1}^{\Psi_{t,0}} \left[y_{t+j,j} \prod_{i=1}^j \left(\frac{1}{1+r_{t+i}} \right) \right] \right) / \left(1 + \sum_{j=1}^{\Psi_{t,0}} \left[(1+\rho)^{-j\kappa} \prod_{i=1}^j (1+r_{t+i})^{\kappa-1} \right] \right)$$

This life cycle framework introduces a link between savings and demographics. In this setting, the aggregate saving rate is positively correlated with the fraction of older employees in total population and negatively with the fraction of retirees. When

²⁸ Miles (1999).

²⁹ Although the Ingénue team (2001) also uses this function, recent econometric studies (Aubert and Crépon, 2003) suggest that individual productivity might not decline for older workers. However, sensitivity analysis in the GE-OLG model shows that the impact on macroeconomic variables, especially growth, of the choice between these two productivity profiles is negligible.

³⁰ No pension can be received before the age of 50, however: $[(a+20) < 50] \rightarrow [\Phi_{t,a} = 0]$.

³¹ (cf. OECD, 2005).

baby-boom cohorts get older but remain active, ageing increases the saving rate. When these large cohorts retire, the saving rate declines, *ceteris paribus*.

Having computed the optimal path of consumption for all the cohorts of the model, average individual savings ($s_{t+j,j}=y_{t+j,j}-c_{t+j,j}$) and individual wealth ($\Omega_{t+j,j}=(1+r_{t+j})\Omega_{t+j-1,j-1}+s_{t+j,j}$) can be computed. The annual saving is invested in the capital market, yielding an interest rate r_t . The interest payments are capitalised into individual wealth.

Production function

The supply side of the economy is modelled through a standard CES production function with two inputs, that is, capital and efficient labour:

$$Y_t = \left[\alpha K_t^{1-\frac{1}{\beta}} + (1-\alpha) \left(A_t L_t \sum_a^{\max(a,t)} \left(\varepsilon_a \frac{v_{t,a} N_{t,a}}{L_t} \right) \right)^{1-\frac{1}{\beta}} \right]^{\frac{1}{1-\frac{1}{\beta}}}$$

where α is a parameter characterising the production technology, β is the capital/labour elasticity of substitution, K_t is the stock of productive capital in the business sector, A_t is an index associated with labour-augmenting MFP and L_t is the labour force. The expression $\sum_a^{\max(a,t)} (\varepsilon_a ((v_{t,a} N_{t,a})/L_t))$ is an index linking the average age of the labour force with its productivity (or, equivalently, the endowment in efficient labour unit of the average worker).

The production function can be written in an intensive form as $y_t=f(k_t)=(\alpha k_t^{1-(1/\beta)} + 1-\alpha)^{1/(1-(1/\beta))}$ where $k_t=k_t/[A_t L_t \sum_a^{\max(a,t)} (\varepsilon_a ((v_{t,a} N_{t,a})/L_t))]$ is the stock of capital per unit of efficient labour. Profit maximisation yields optimal factor prices: $r_t=\alpha k_t^{-(1/\beta)} (\alpha k_t^{1-(1/\beta)} + 1-\alpha)^{1/(\beta-1)}$ for capital, and $w_t=A_t(1-\alpha)(\alpha k_t^{1-(1/\beta)} + 1-\alpha)^{1/(\beta-1)}$ where w_t is the real wage per unit of efficient labour, gross of social contributions.³² The price of the goods produced by firms is normalised to one. Inflation is abstracted from it since this is a long run model.

Aggregation and convergence of the model

In the aggregation block, capital supplied by households is $W_t=\sum_a \Omega_{t,a} N_{t,a}$. In other words, the representative stock of capital of every cohort is weighed by the size of each cohort in total population. The capital supply is normalised to one in the base year (i.e., 1989). Total efficient labour supply is aggregated in the same way, taking into account the number of working individuals in each cohort at a given year and is also normalised to one in 1989.

The inter-temporal equilibrium of the model is dynamic: modifying the equilibrium variable (i.e., the endogenous interest rate or wage) in a given year changes the supply and demand of capital in that year and in any other year in the model, after as

³² In the long-run equilibrium, the growth rate of w_t equals Total Factor Productivity (TFP) gains because both total labour force and the capital-labour ratio (in efficiency units) are constant. There is no depreciation of capital. Including this parameter would not change the dynamics of the model since equilibrium conditions stem from saving behaviour net of depreciation of capital.

well as before the change. Numerical convergence applies respectively to both the demand and supply of capital per unit of efficient labour. When the convergence process is completed, the equilibrium stock of capital per unit of efficient labour defines the equilibrium r_t and w_t associated with $W_t=K_t$ and L_t each year. With capital and labour markets clearing, Walras' law ensures that the market for goods is cleared too.³³

Pension reforms scenarios

Five scenarios are considered:

In a no-reform, *baseline scenario*, the participation rates among older working individuals remain constant. In line with the 1993 reform, pensions are indexed only on prices and computed by applying a proportional constant rate to an average wage over a period increasing from $\psi_t=10$ years for the cohort born in 1933 to $\psi_t=25$ years for the individuals born in 1948. Financial pressures stemming from ageing are offset each year in the future by movements of the proportional tax rate $\tau_{t,P}$ only.

This scenario models the situation observed in France up to now (even with the 2003 reform).

In *scenario 1*, the employment rates among older workers increase in line with a rise in the average effective age of retirement of 1.25 year per decade from 2005 onwards. As the labour market is exogenous, it was assumed that age-specific participation rates of workers above 50 years of age increase in line with the changes in the age of retirement. For instance, in 2045, participation rates of 60-year old workers are the same as those of 55-year old workers in 2005, and so on. The number of years taken into account in computing pensions is frozen at 25 years for the cohorts born from 1948 onwards, as in the baseline scenario. Residual imbalances of the PAYG regime are covered by changes in the tax rate ($\tau_{t,P}$).

This scenario models a successful implementation of the 2003 reform, that is, with an average effective retirement age and employment rates of older workers ($v_{t,a}$), increasing over the simulation period.

In *scenario 2*, the employment rates among older workers remain constant, as in the baseline. The number of years taken into account in the average wage of reference used for computing pensions (ψ_t) increases from 25 to 40 years for the cohorts born in 1963 and afterwards. Thus, the implied replacement rates diminish over time. Future lower replacement rates motivate agents to increase their private pension savings to sustain consumption levels upon retirement. Residual imbalances of the PAYG regime are also covered by the changes in the tax rate ($\tau_{t,P}$).

In *scenario 3*, the average effective age of retirement increases as in scenario 1, and the number of years taken into account in the average wage of reference used for computing pensions rises as in scenario 2. Residual imbalances of the PAYG regime are covered by changes in the tax rate.

³³ This result is ensured in the model because it requires respecting national account identities (i.e., investment equals saving and total value added equals the sum of the remunerations of production factors).

Scenario 4 corresponds to scenario 1 with the additional feature of a discretionary increase of pensions of 2.5 per cent in 2008.

Reforms 1–4 were announced in 2008 and households responded immediately. For each cohort, consumption before 2008 was the same as in the baseline scenario where households anticipated that PAYG system reforms rely on tax hikes. When announced in 2008, households adjusted their optimal consumption path over their lifetime. Thus, the reform entails new optimal inter-temporal paths for consumption for each cohort over its remaining lifetime. For a cohort aged a in 2008, the new optimal consumption path begins in 2008 at:

$$c_{2008,a} = \frac{(1 + r_{2008})\Omega_{2007,a-1} + y_{2008,a} + \sum_{j=a+1}^{\Psi_{2008-a,0}} \left[y_{2008+j-a,a} \prod_{i=a+1}^j \left(\frac{1}{1+r_{2008+i-a}} \right) \right]}{1 + \sum_{j=a+1}^{\Psi_{2008-a,0}} \left[(1 + \rho)^{-(j-a)\kappa} \prod_{i=a+1}^j \left(\frac{1}{1+r_{2008+i-a}} \right)^{\kappa-1} \right]}$$

Setting parameters, calibration and sensitivity analysis

The main exogenous variables in the model are the demographic data, for which the model needs a data set covering the period 1910–2158. For the simulation period, the demographic simulation model of Gonand³⁴ is used. The results are very close to national official forecasts.

The average life expectancy at birth for the cohorts born in France ($\Psi_{t,0}$) is assumed to have increased by two years per decade during the 20th century, reaching close to 79 years in 2000. The growth in life expectancy decelerates in line with national projections of member countries over the projection period. After 2050, average life expectancy remains stable at 84 years.

The model is back to its long-run steady state in 2080.³⁵ In this situation, GDP *per capita* growth is exclusively determined by the exogenous growth in TFP. By contrast, during the demographic transition, the dynamic equilibrium is driven by ageing and public finance reforms.

In the production function, K_t , L_t , w_t and A_t are normalised to one in the base year of the model (1989). As in Miles,³⁶ there is no depreciation of capital, an assumption that has no consequence for the dynamics of the model and the net equilibrium interest rate. The annual growth rate of A_t associated with TFP gains incorporated in labour productivity in the long run³⁷ is set to 1.5 per cent for all countries. Lastly, the model does not attempt to trace effects of ageing on TFP and possible endogenous growth effects.

The elasticity of substitution between capital and labour is assumed to tend to one. Thus, the production function in the model is a Cobb Douglas function. A wide but

³⁴ Gonand (2005).

³⁵ Sensitivity analysis shows that the results are robust to the date chosen for the long-run steady state. For instance, pushing it back to 2,100 does not alter the results much.

³⁶ Miles (1999).

³⁷ Acemoglu (2002).

still inconclusive empirical literature has attempted to estimate the elasticity of substitution between capital and labour in the CES production function. On average, these studies suggest a value close to one.³⁸

The parameter α , which corresponds to the profit share of capital in the value added, is set at 0.3 for all countries. In models incorporating a depreciation rate,³⁹ the value for this parameter is usually higher (for example 0.4) corresponding approximately to the ratio (gross operating surplus/value added including depreciation) in the business sector. Assuming this figure of 0.4 and a standard depreciation rate as a per cent of added value of 15 per cent yields a net profit ratio of around 0.3. This is close to Miles,⁴⁰ who uses 0.25.

The households' psychological discount rate was set at 2 per cent per annum, in line with much of the empirical literature. Different methods can be used to estimate this parameter. Analytical models, such as that by Gallon and Masse,⁴¹ suggest using a discount rate between 2 per cent and 3 per cent in real terms. Alternatively, econometric models like that of Gourinchas and Parker⁴² suggest a value close to 3 per cent.

The variable ς_t is used in the model as a proxy for the length of the average working life and is approximated here by the average retirement age in France at year t .⁴³ The average effective age of retirement in France is currently close to 59 years.⁴⁴

The inverse of the inter-temporal substitutability coefficient (σ) in the utility function is assumed to be equal to 1.33 (implying an inter-temporal substitution elasticity of 0.75). A standard result in financial and behavioural economics is to consider this parameter as indeed greater than one.⁴⁵ Börsch-Supan *et al.*⁴⁶ use a risk aversion parameter of 2.7, but this choice results from the specific calibration of their model to reproduce observed orders of magnitude around the base year. Such a high value might account for the relative insensitivity of saving behaviour to interest rate

³⁸ Andersen *et al.* (1999) use a panel of 17 OECD countries from 1966 to 1996 to estimate a value of 1.12. This study estimates a CES production function with a Hicks-neutral technical progress, whereas in this model, the function has a labour-augmenting technical progress. Yet no estimates for a wide range of countries of the elasticity of substitution of a CES function with a labour-augmenting technical progress are available (see Klump *et al.*, 2004).

³⁹ Börsch-Supan *et al.* (2003).

⁴⁰ Miles (1999).

⁴¹ Gallon and Masse (2004).

⁴² Gourinchas and Parker (2002).

⁴³ Strictly speaking, ς_t is defined in the model as the age at which an individual who begins to work at 20 years will be able to obtain a full pension at year t . Yet, finding an aggregate value for ς_t thus defined would require ignoring potentially important microeconomic factors.

⁴⁴ More precisely, 59 is the average age at which workers leave the labour market in the model and stop paying contributions to the pension regime. However, the average age at which people begin receiving a pension is close to 61 years in France. Between 59 and 61 years, most people who are neither active nor retired receive social contributions. Accordingly, the model assumes that the amount of these contributions received between 59 and 61 are close to the average level of a pension. Such an assumption seems reasonable since, for instance, the average replacement rate of the unemployment regime is close to the average replacement rate of pension regimes.

⁴⁵ See Kotlikoff and Spivak (1981).

⁴⁶ Börsch-Supan *et al.* (2003).

variations in their model and thus might bias the results. Kotlikoff and Spivak⁴⁷ use 1.33. Epstein and Zin⁴⁸ suggest values between 0.8 and 1.3, whereas Normandin and Saint-Amour⁴⁹ use 1.5.

The model is calibrated on an interest rate of 3.5 per cent in the base year, corresponding to the sum of TFP gains and the discount rate, as suggested by life cycle theory. Contrary to other studies, the model is not calibrated on some technical parameters (for example, the relative aversion to risk) so as to reproduce broadly observed variations in the stock of capital around the base year. This procedure can indeed bias the results, as mentioned above.

In order to test the robustness of model results to alternative specifications and parameter values, extensive sensitivity analysis was carried out. Overall, the dynamics of the results appear relatively robust to changes in some key parameters (the capital share in value-added α , the risk aversion coefficient σ , the age individual productivity function ε_a , the elasticity of substitution between capital and labour β and the discount rate ρ). Joint sensitivity analysis was also carried out. A complete sensitivity analysis of a version of the model close to the one used in this paper can be found in Gonand.⁵⁰

About the Authors

Frédéric Gonand, former student of the “Ecole Nationale d’Administration” (France) and PhD in Economics (Ecole Polytechnique, Paris), worked for the Ministry of Economic Affairs, Finance and Industry and then for the Organisation for Economic Co-operation and Development (OECD). The main focus of his work relates to pension schemes, public expenditure effectiveness and budgetary policy.

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⁴⁷ Kotlikoff and Spivak (1981).

⁴⁸ Epstein and Zin (1991).

⁴⁹ Normandin and Saint-Amour (1998).

⁵⁰ Gonand (2007).