IMF Working Paper

WP/98/12

INTERNATIONAL MONETARY FUND

European I Department

French Public Finances: Modeling Long-Term Prospects and Reform Options

Prepared by Karl F. Habermeier and Fabrice Lenseigne[1]

Authorized for distribution by C. Maxwell Watson

February 1998

Abstract

Over the coming decades, demographic developments will lead to a significant increase in public outlays on pensions and health care, relative to national income. This study extends earlier work by considering the adverse effects of taxation on the determinants of economic growth -- in particular, investment, productivity growth, and labor force participation. Available empirical evidence suggests that these adverse effects could well be sizable, and that conventional estimates of the adverse effects of population aging probably severely underestimate their impact on the public finances and economic performance. The paper uses stochastic simulations to examine the robustness of the results to changes in parameter values. It also provides quantitative simulations of various reform options, including mainly an increase in the effective retirement age and flanking labor market measures.

JEL Classification Numbers: H1, O4, J2.

Keywords: Population Aging, Economic Growth, Public Finance, Pensions, Health Care, Stochastic Simulations

Authors' E-Mail Addresses: khabermeier@imf.org and flenseigne@imf.org

---

[1]The authors would like to thank their colleagues in the International Monetary Fund for many helpful comments, and take full responsibility for any remaining errors.

Contents **Page**

Appendix Tables

SUMMARY

Over the coming decades, demographic developments in France will lead to a significant increase in public outlays on pensions and health care, relative to national income. Most conventional estimates suggest an increase equivalent to about 6 percent of GDP by 2020, and 15 percent of GDP by 2050.

This study extends earlier work by considering the effect of taxation on the determinants of economic growth -- in particular, investment, productivity growth, and work incentives. Available empirical work suggests that such negative feedbacks could well be sizable, and that conventional estimates of the effects of population aging may severely underestimate its impact on public finances and economic performance. Taking such feedbacks into account suggests that economic growth could eventually come to a standstill, while the share of public expenditure in GDP could rise by some 35 percentage points by 2050. Stochastic simulations are used to examine the robustness of these results to changes in parameter values.

Quantitative scenarios suggest that reforms can render the impact of the population aging manageable, provided they are initiated at an early stage. Nothing short of a sizable rise in the effective retirement age (by some 5 to 10 years)—or a correspondingly large cut in benefits—would appear to be sufficient to address the economic and fiscal problems of aging. Other measures, such as reduced benefit indexation and more trenchant health care controls, can help alleviate the problem, but any such policy changes that are likely to be politically sustainable would have an impact that, with an unchanged retirement age, would be insufficient. As an important corollary, steps to raise the effective retirement age will need to be accompanied by labor market reforms to encourage and enable productive work (full or part-time) by older persons.

I. Introduction

Recent years have seen a growing recognition of the burden that will be placed on the public finances by aging populations. Most industrial countries can expect serious pressures on public expenditure in the early decades of the next century. Moreover, this outlook needs to be faced, in many cases, with public debt ratios and tax burdens that are already at a high level. On average, the European G-7 countries had a debt-to-GDP ratio of over 70 percent in 1996, and public revenue equivalent to some 45 percent of GDP.

France is no exception to this general situation. Projections by INSEE, among others, confirm that the population over 60, relative to the population of working age, is likely to double over the next few decades. The impact of this needs to be assessed against the background of a public debt ratio that has risen to 55 percent of GDP, a primary general government surplus that currently is too low to stabilize the debt ratio even at 60 percent of GDP, as well as a revenue burden that, at 50 percent of GDP, is the highest among the seven major industrial economies.

Assessing the macroeconomic consequences of an aging population is inherently difficult. Obvious uncertainties exist, for example, in extrapolating costs of medical care or the age at which people will want to retire. Moreover, small changes in assumptions about economic performance make a substantial difference to fiscal outcomes over the period under consideration.

These uncertainties are especially pronounced when one takes into account the feedback between social and fiscal policies and the determinants of long-run economic growth, such as incentives for work, investment, and innovation. Two types of feedback are likely to be the most important. First, persons of working age will be obliged to pay an ever greater proportion of their income to finance social security; and the extent to which they participate in the formal labor market could decline—an unwelcome development against a background where the number of persons of working age is already shrinking. Second, higher taxes and public deficits will distort the allocation of resources in other ways, dampening investment and leading ultimately to a slowing of productivity growth in the economy. As the economy slows or even begins to contract, the difficulty of providing social security to the aged and infirm will become ever greater; and the financial position of the public sector becomes increasingly precarious.

This paper aims to contribute to an assessment of these issues, under alternative assumptions about parameters and policies, by analyzing the problems relating to population aging within a model of macroeconomic growth. The insights gained in this way may in turn open the door to designing policy approaches that can help to secure more satisfactory outcomes in terms of social security integrity and fiscal sustainability.

The plan of the paper is as follows. The next section briefly summarizes the standard view of how demographic forces will drive public expenditure over the coming decades. This is followed by a discussion of the principal interactions between public expenditure policies and economic performance in the long run. Quantitative scenarios are then used to illustrate the possible implications of these linkages for the future course of the economy and the public finances. The final section discusses some reform options, again supported by quantitative scenarios. An Appendix provides further detail on the model and simulation methods used in the paper.

II. Demographic Developments and Long-Run Expenditure Trends

Over the next 50 years, the population in France, as in most other advanced countries, is likely to age significantly. Official demographic projections (taking into account the trend decrease in mortality) show the following profile for the old-age dependency ratios:

Dependency Ratio	2000	2010	2020	2030	2040	2050
20–60/over 60	2.62	2.32	1.88	1.58	1.43	1.21
20–65/over 65	3.66	3.50	2.74	2.23	1.91	1.83

Source: INSEE.

Thus, at the current retirement age of 60, there will be 2.6 persons of working age for every person of retirement age in 2000, but only 1.2 persons in 2050. The change is still pronounced, albeit significantly less so, if the dividing line between working age and old age is drawn at 65 instead of 60.

The well-known implication of these demographic developments is that spending on pensions is likely to rise markedly, and that—because relatively fewer people will be working—the contribution rate to pay-as-you-go pension systems would need to increase even more. Health care spending is also likely to increase sharply, owing to the fact that older people consume significantly more health services per capita than do younger people.

A. Pensions

Despite the reforms undertaken in recent years, the pension system in France remains one of the most generous in the industrial countries. The standard retirement age is 60, and the replacement rate of pensions in the principal schemes for private sector employees is equivalent to 70 to 80 percent of the last wage. The 1993 reform of the *régime général* (which provides basic pensions for private sector employees) comprised, among other things, a lengthening of the contribution period from 150 to 160 quarters over 10 years, an extension of the period over which the reference wage is calculated (from the 10 best years to the 25 best years), and a shift in indexation from gross wages to the CPI. The 1996 reform of the supplementary pension schemes increased the contribution rate and indexed payments to the

CPI less 1 percentage point; the financial impact of this reform will be relatively small when measured against the outlays of the pension system as a whole.

Available studies of the pension system, which take into account the reforms through 1993, suggest that their long-term financial prospects remain problematic. The most recent official French study (*Perspectives à long terme des retraites,* 1995) shows that the average contribution rate needed for financial balance rises from 18.9 percent of labor income in 1990 to 48 percent in 2040. With labor income amounting to about 60 percent of GDP, the share of pension expenditure in GDP would increase by 17½ percentage points over the same period. The study by Chand and Jaeger (1996) finds that the net present value of pension liabilities in France amounts to 114 percent of 1995 GDP, the highest in the sample of countries examined (Table 1).

The studies cited above, and most others, use what may be termed an "accounting" methodology in which the main macroeconomic variables are exogenous. Given any set of rules governing a pension program, it is possible to derive the time path of expenditure for the program. Typically, studies of this type are carried out using a variety of demographic scenarios, and several different assumptions about the rate of increase in labor productivity. As indicated earlier, a central purpose of this paper is to explore the implications of endogenizing macroeconomic developments by introducing feedback from fiscal to real variables.

B. Health Care

Future increases in health care expenditure are more difficult to project. Unlike pension entitlements, where benefits are clearly defined in terms of well-understood and easily measured economic variables such as prices, wages, and years of contribution, the consumption of health benefits is driven to a considerable extent by the choices of individual consumers, health care providers, and insurers.[2] These choices are strongly influenced by advances in medical technology, which have often been accompanied by significantly and unpredictably higher unit costs of treatment. Moreover, decisions on the consumption of medical services are typically made in an environment of incomplete information and one in

---

[2]See "Health Expenditure", Section I of France - Selected Issues (SM/96/249) for a detailed discussion of these issues.

Table 1. Net Pension Liabilities and Sustainability of Fiscal Stance
(In percent of GDP)

	Net Public Debt at end 1994 1/	Net Pension Liability, 1995-2050 2/	Combined Net Debt Liability	Primary Balance 1995 3/	Sustainable Primary Balance Required to: Stabilize net public debt in 1995 4/	Sustainable Primary Balance Required to: Stabilize net public debt and prevent buildup of pension debt 5/	Adjustment Needed in Primary Balance for Fiscal Sustainability 6/
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Major industrial countries	57.2	60.0	117.2	0.7	1.0	2.9	2.2
United States	63.3	25.7	89.0	0.4	1.1	1.9	1.5
Japan	33.2	106.8	140.0	-0.2	0.3	3.6	3.8
Germany	52.5	110.7	163.2	2.4	1.1	4.5	2.1
France	42.4	113.6	156.0	-0.3	0.7	4.0	4.3
Italy	112.9	75.5	188.4	3.3	2.1	4.6	1.3
United Kingdom	37.7	4.6	42.3	0.4	0.7	0.8	0.4
Canada	71.6	67.8	139.4	0.2	2.7	4.7	4.5
Sweden	54.5	20.4	74.9	-5.1	0.1	1.0	6.1

Source: Chand and Jaeger (1996).

1/ Adjusted for net assets of public pension fund at the end of 1994. Estimate of net public debt for Germany includes unification debt as of the end of 1994.
2/ Net present value of difference between projected primary expenditure and revenue of public pension fund during 1995-2050, adjusted for net asset position of public pension systems at the end of 1994.
3/ May 1995 WEO projections of structural primary balance of general government.
4/ Primary balance required to stabilize net public debt in 1995.
5/ Sustainable primary balance in column (5) plus contribution gap from column (4) of Table 9.
6/ Difference between columns (6) and (4).

which neither consumers nor providers are internalizing the full costs of their choices, leading to overconsumption.[3]

In France, health care expenditure since 1980 has increased at an annual rate 0.7 percentage points greater than that of nominal GDP. The OECD estimates that about 0.4 percentage points of this excess can be attributed to population aging. Cumulatively, aging by itself would tend to increase the share of health expenditure in GDP by about 3 percentage points by 2050. However, the increase could amount to 5 percentage points or more if spending continues to develop in line with historical trends.[4]

III. Entitlement Expenditure, the Public Finances, and Economic Performance

An important disadvantage of the "accounting" approach to assessing the long-term fiscal outlook is that it neglects the interactions among entitlement expenditure, the public finances as a whole, and economic performance. This section traces out some of these interactions, considers their empirical and policy relevance, and lays the basis for the long-term fiscal scenarios presented in Section D.

A. Analytical Framework

As outlined above, the share in national income of pension and health care expenditure will rise markedly over the coming decades, not just in France, but in most of the advanced economies. In analyzing the macroeconomic impact of these developments, one would in principle want to consider their effect on saving, investment, and economic growth in a global context using an intergenerational general equilibrium model. Key parameters in such an analysis would be the degree to which higher entitlement spending reduces domestic saving, the extent to which foreign saving can substitute for domestic saving, and the responsiveness of investment and labor supply to the higher taxes or deficits needed to finance entitlement spending.

Most previous work on the macroeconomics of population aging and pension reform has focused on the implications for saving, though mostly in a closed-economy context (see

---

[3]Indeed, it is difficult to explain satisfactorily even past developments in health care spending. While factors such as population aging, greater insurance coverage, and higher real income play a role, there is also a substantial residual (or trend) item, which reflects a variety of technological and institutional factors.

[4]On the other hand, future generations may be healthier and consume relatively fewer health care services at the same age than earlier generations.

OECD 1997 for a survey).[5] The tentative conclusion of this line of inquiry has been that a reduction in the generosity of the public sector pension system would increase national saving and hence future potential output, though the estimated size of the effects has tended to be small. Some of these studies have also suggested that it matters little or not at all whether the generosity of entitlement programs is reduced through increases in taxation or cuts in benefits (though it does matter whether such programs are pre-funded or pay-as-you-go).

The approach in this paper differs from previous work on the macroeconomics of population aging in that it focuses on investment and labor supply as the prime movers of long-run economic growth. It takes as its point of departure the commonly held view that the long-run increase in real per capita GDP reflects the accumulation of capital, the expansion of the labor force in both numbers and skills, and technological change. Against this background, it marshals research suggesting that long-run economic growth, and the factors determining it, are strongly affected by economic policies or institutions, and in particular by the share of taxation and public spending in the economy.[6]

B. Taxation and Economic Growth—Theoretical Considerations

How will the higher taxes needed to finance mounting pension and health care spending affect economic growth? The answer to this question depends on many factors, including the type of taxes being increased, the type of expenditure being financed by those taxes; but also on how high the overall tax burden is before the increase.

A simple model presented by Barro and Sala-i-Martin (1996) may help to illustrate the last point. In this model, capital has a constant social marginal product, but a diminishing private marginal product; and public goods (such as the maintenance of law and order) raise aggregate productivity, but with diminishing marginal returns. Government spending on public goods is financed by a flat tax on gross output; and the government runs a balanced budget. It is shown that under these conditions, the rate of economic growth is an inverse u-shaped

---

[5]Very little work has been done so far on the consequences that population aging and entitlement reform would have on the balance of payments and net foreign asset positions of countries. One important question would be whether in the absence of pension reform, the net foreign asset position of the aging advanced economies should be expected to deteriorate in the course of coming decades.

[6]Other variables have also been shown to have an influence on long-run economic growth, notably public sector deficits, inflation, educational policy, political stability, political and civil liberties, the rule of law, the exchange market regime, and trade protection. Barro and Sala-i-Martin (1996) provide an overview, both of theory and the empirical evidence.

function of the tax rate.[7] For low tax rates, the benefit of additional public goods outweighs the distortionary effect of the tax. However, beyond a certain point, the negative effect of taxation on the after-tax marginal product of capital is larger than the positive effect of additional public goods on productivity, and the growth rate begins to decline. These results also hold in a more realistic model in which public goods are not entirely non-rivalrous in consumption, but subject to congestion.

Different types of taxes will of course have somewhat different effects on economic growth. Milesi-Ferretti and Roubini (1995), building on work by Jones, Manuelli, and Rossi (1997), use a model in which the growth process is driven by the accumulation of human and physical capital to examine the channels through which income and consumption taxes are transmitted to the economy. They show that income taxes are unambiguously growth-reducing, as such taxes discourage the accumulation of human and physical capital. The effect of consumption taxation is indeterminate and depends critically on the elasticity of labor supply, and hence on the labor-leisure tradeoff. When labor supply is sufficiently elastic, a consumption tax reduces time spent on education and work. Other authors, for example Stokey and Rebelo (1995) have found possible positive effects of consumption taxes on economic growth. However, Stokey and Rebelo also conclude that restructuring the tax system (toward a greater emphasis on flat rate income and consumption taxes) would have only relatively small positive effects on economic growth.

As indicated above, the adverse effects of taxation on economic growth can be offset, at least in part, by the productive effects of spending on public goods. Of course, the provision of directly productive public goods accounts for only a small part of overall government outlays: social transfers of many kinds make up the largest part of public spending in France and most other advanced economies. A critical question is then how economic growth is affected by the government's combined tax and expenditure policies; and in particular, how it is affected by social transfer payments.

The effects of social spending on economic growth are complex and highly differentiated. The traditional viewpoint is that transfer payments have no effect on incentives and rests on the assumption that such transfers typically take the form of pure lump-sum redistribution.[8] Another argument for the neutrality of social transfers stresses substitution: if the public sector were not providing pensions, for instance, individuals would be obliged to

---

[7]Profit maximization by firms in this model implies that the wage rate is set equal to the after-tax marginal product of capital, and that the rental rate of capital is set equal to the after tax-marginal product of capital.

[8]In general equilibrium theory, a pure lump-sum transfer is defined as a (one-time) redistribution of initial endowments of goods, before markets open.

accumulate greater retirement savings of their own.[9] Much recent work, by contrast, has emphasized the incentive effects of government transfer payments. For example, OECD (1996) notes that there is a negative relationship between job search and the replacement rates for unemployment insurance and minimum social benefits. It has also been argued that social transfers to the poor may reduce the incentive of poor persons to engage in criminal or other destructive activities (Sala-i-Martin 1996).

In conclusion, the theoretical literature suggests a number of channels through which public revenue and expenditure policies can influence long-run economic growth, mainly by way of investment and productivity, but also by way of the labor market. However, the size and direction of the net effect cannot be determined on theoretical grounds alone, but must be established empirically.

C. Empirical Evidence from Cross-Country Studies

Empirical studies of differences in economic growth across countries have typically considered a wide range of policy and institutional variables. As most of the theoretical models predict that countries at an earlier stage of development would grow more quickly than more advanced countries (other things remaining equal), real per capita GDP in a base period is routinely included as an explanatory variable. In many of these studies, the regressions are estimated using instrumental variables to allow for the possible endogeneity of the explanatory variables.

The key question for the purposes of this paper is whether an increase in pension and health care spending financed by higher taxes has a negative effect on investment, labor supply, and thereby on economic growth. The available empirical studies have not addressed precisely this question. However, studies have found a negative association between the aggregate tax burden and economic growth. Many studies have also found a negative relationship between the share of public spending in GDP and economic growth. The latter result should not be too surprising given that the shares of revenue and expenditure in GDP are closely correlated.[10]

The most directly relevant results from the empirical literature include the following:

---

[9]The work surveyed in OECD (1997), however, suggests that the substitution of private old-age saving for public pensions is not one-for-one, but considerably less.

[10]It is interesting that expenditure tends to be correlated somewhat more strongly and robustly with economic growth; possibly, this reflects the fact that expenditure is the sum of revenue and deficits, and may reflect the negative effects of both better than either variable alone.

• Cashin (1995), in a panel data set of 23 countries and four multi-year time periods, finds that taxation exercises a strong negative influence on growth, which is partly offset by positive effects of government spending, for an overall effect that is negative.

• Easterly and Rebelo (1993), using a data set comprising some 50 countries, estimate regressions that, in addition to standard conditioning variables (the level of per capita income in a base period, school enrollment, political stability), include a variety of fiscal variables. They find that growth is negatively correlated with government consumption, overall government expenditure, government deficits, and marginal tax rates. The size of the coefficients ranges from a low of 0.05 for the marginal tax rate to 0.24 for overall government expenditure.[11]

Though the following two studies do not directly address the effect of taxation on economic growth, they do provide an indication of how strongly growth is affected by the size and composition of the public sector:

• Sala-i-Martin (1996), in a cross section of 75 countries covering 1970-95, finds that both government consumption and government investment have a negative effect on economic growth (0.1 and 0.2 percentage points), but that social security spending has a positive effect (0.1 percentage points), for an overall effect that is still negative.

• Barro and Lee (1994), using a sample of 87 countries for 1965-75 and 97 countries for 1975-85, find that a 1 percentage point increase in the ratio of government consumption to GDP reduces real GDP growth by 0.1 percentage points.[12] Their regressions also include a wide variety of other indicators of political and economic structure.

The empirical work cited above deals with the effect of public revenue and expenditure on the growth rate of real per capita GDP. Considerably less systematic attention has been given to the channels through which fiscal variables exercise their effect on growth. Studies that consider these channels include Easterly and Rebelo (cited above), who report that private investment is negatively correlated with government consumption, domestic taxes, and total government expenditure.[13] Some work has also been done on the relationship between

---

[11]Thus, a 1 percentage point increase in the share of government expenditure to GDP would reduce the long-run growth rate by ¼ percentage point.

[12]This result is consistent with the theoretical view, articulated in Barro (1990), that a considerable fraction of government consumption spending is directly unproductive.

[13]Fischer (1993) examines the transmission of a wide variety of macroeconomic policies to growth by way of investment, productivity growth, and labor supply. However, the budget

(continued...)

tax and spending policies and labor market performance, though without examining the implications for economic growth. For example, Layard, Nickell, and Jackman (1994) have found that unemployment in the industrial countries is related, among other things, to the replacement ratio of social benefits, as well as to the duration of unemployment benefits. Several of the papers collected in Henry and Snower (1996) have found a negative effect of the tax wedge and other measures of the size of the public sector on employment, as well as indirect effects of higher taxes (through the net wage) on labor force participation.[14]

The results obtained in the labor market literature are not directly transferable to the model used in this paper, which expresses labor market performance in terms of the broader concept of the employment rate.[15] The cross-section regression presented in the Appendix addresses this issue (Table A4). On the basis of data for 18 industrial countries, it shows that the employment rate depends negatively on the overall tax burden in the economy, and positively on the degree of wage differentiation and the share of women in the workforce. Ceteris paribus, a 1 percentage point increase in the ratio of general government revenue to GDP would decrease the employment rate by between 0.3 and 0.5 percent.

To summarize, empirical work provides support for the view that higher shares of government revenue or expenditure in the economy (as well as higher fiscal deficits) have a negative effect on long-run economic growth, by dampening investment, productivity growth, and employment. As a broad quantitative approximation, the empirical studies as a whole suggest that, controlling for the influence of other policy variables, a 1 percentage point increase in the ratio to GDP of government revenue (or government expenditure) would reduce the growth rate of real per capita GDP by about 0.1 to 0.2 percentage points.

---

[13](...continued)
deficit is the only fiscal variable considered in this study.

[14]Another strand of the literature is concerned with the impact of marginal income tax rates on hours of work; for a recent assessment, see MaCurdy (1992). Many of these studies find that higher marginal rates have a fairly small effect. However, as was pointed out more than a decade earlier by Rosen (1980), the effects on the labor market of tax and spending policies are by no means fully captured by relationships between hours of work, income, and after-tax wages. Social security provisions, the overall tax burden, and other variables are likely to be important as well.

[15]The employment rate is defined as the ratio of employment to population aged 15 to 64. The non-employment rate, defined as 1 less the employment rate, takes account of both measured unemployment and non-participation in the labor force.

D. Application to France

In analyzing the macroeconomic consequences of rising entitlement spending related to population aging in France, it is necessary to parametrize a growth model for France in a manner that is broadly consistent with the cross-country empirical results discussed above. As is standard, a production function relates real GDP to inputs of labor and capital, and to total factor productivity. The production function is assumed to have the Cobb-Douglas form, so the shares of capital and labor in GDP are constant over time. Feedback from the rising share of revenue on growth are transmitted through their effects on labor supply and investment; moreover, the accumulation of capital is related to the growth of total factor productivity.

A simple investment function is estimated in which the change in the capital stock depends on the marginal product of capital adjusted for taxation. A critical assumption in this function is how to set the level of the tax/GDP ratio beyond which net investment becomes negative. Estimates of this threshold value derived from French time series data range from a low of 50 percent to a high of 100 percent of GDP (see the discussion in the Appendix). An intermediate value of 80 percent was adopted for the simulations in this paper. The chosen calibration implies that a 1 percentage point increase in the general government revenue ratio would reduce the growth rate of the capital stock by 0.1 percentage points (from an initial rate of 2.5 percent annually). Such a slowdown in the growth of the capital stock would, ceteris paribus, directly reduce the annual growth rate of real GDP by 0.04 percentage points.

Furthermore, the model assumes that the contribution of capital to aggregate output consists of two parts: one which is appropriated by (or internal to) business enterprises, and another that is not appropriated (external). The analytical foundations for this approach were developed by Romer (1986) in his seminal article on endogenous economic growth. In calibrating the model in this paper, measured total factor productivity is related to the capital stock. The estimation yields an external production elasticity of capital of about 0.4; adding this to the internal production elasticity derived from the share of capital income in GDP yields an overall (social) production elasticity of 0.8. Combined with the investment equation discussed above, the conclusion is that a 1 percentage point increase in the general government revenue ratio would slow the growth of real GDP by 0.08 percentage points.

In addition to the investment and productivity channels, the model also allows for the transmission of tax and spending policies to economic growth via the labor market. In light of the estimation results obtained in Tables A4 and A5 in the Appendix, the effect of a 1 percentage point increase in the general government revenue ratio on the employment rate is set, rather conservatively, at ¼ percentage point. Thus, a 1 percentage point increase in the revenue ratio would lower the level of real GDP by about 0.18 percent. If the revenue ratio were increasing by ½ percentage point per year, the drag on the growth rate coming from the labor market would amount to about 0.09 percentage points.

It is important to emphasize that this is a highly stylized representation of the feedback from fiscal policy to real economic activity, i.e., one that does not take into account the composition of public revenue and expenditure. However, the overall magnitudes involved are not implausible when seen against the background of the extensive cross-country studies of fiscal policy and economic growth that were reviewed earlier. Moreover, in light of the results obtained by Stokey and Rebelo, the role of compositional effects seem to be relatively minor, at least for public revenue.

IV. Model Simulations of the Long-Term Fiscal Outlook

The model of economic growth outlined above was combined with projections of public expenditure and revenue to assess the long-term fiscal outlook. Two versions of the model were used: one without feedback from fiscal to real variables, and one with feedback. In the version without feedback, labor supply and total factor productivity are exogenous, with the former being a fraction of the population that is not retired, and the latter growing at a constant rate throughout the simulation period. In the investment equation, the tax variable is held constant at its base year level. By contrast, the version of the model with feedback from fiscal to real variables uses the investment, total factor productivity, and labor supply equations discussed in the previous sub-section.

The fiscal accounts in the model disaggregate expenditure into four categories: pensions, health, interest payments, and other.[16] In order to capture the effect of population aging, health expenditure in turn is divided between young and old persons. Revenue is not disaggregated by category.

Pension spending is computed on the basis of annual cohort data drawn from official demographic projections through 2050, and the path of wages and prices generated in the model. Using disaggregated demographic data makes it possible to account precisely for the effects of changes in key parameters of the pension system, such as replacement rates, retirement ages, and indexation rules.[17] Health spending in each demographic group (young, old) grows in proportion to gross wages and an additional factor which captures the historical excess in the growth of health care spending over what can be explained by income and demographics. Interest payments are related to average of the beginning-of-period and end-of-period stocks of debt.

The fiscal accounts are closed by introducing an exogenous target for the ratio of the general government balance to GDP, and by rules for adjusting revenue and primary

---

[16]All public finance variables are expressed in current price terms to facilitate inflation accounting and ensure continuity with historical series.

[17]This type of accounting is particularly important in representing changes in the effective retirement age, discussed in the following section. With a standard retirement age of 60, there is a distribution of ages at which individuals retire, ranging from 55 to 65. An increase in the retirement age gradually shifts this distribution upwards.

expenditure other than on pension, health care, and debt interest. These adjustment rules are such that the actual deficit moves toward the target but only reaches it in the course of time. The parameters that govern the speed of the adjustment are a measure of the strength of the adjustment effort and of its composition. In the model, and broadly in line with historical experience, it is assumed that adjustment equivalent to about one-quarter of the deviation from the deficit target is undertaken each year, and that the bulk of the adjustment is achieved by increasing revenue. The values of these parameters were set so as to avoid an excessive accumulation of debt (which would have made it necessary to model inflation); consequently, the ratio of public revenue to GDP increases very markedly by the end of the simulation horizon.

A. Baseline Simulations under Certainty

The baseline scenario assumes that policies affecting the pension system are unchanged, and that health spending develops in accordance with demographics and past trends. When the scenario was run without feedback between fiscal and real variables, the results were similar to those obtained by the most recent official study (discussed in Section B).[18] Real GDP grows by about 2 percent in the long run, pension spending increases by about 6 percentage points of GDP by 2020 and 13 percentage points by 2050 (Chart 1), while health care spending increases by 1½ and 4 percentage points, respectively, over the same periods. Mild expenditure restraint in other areas allows the share in GDP of non-pension, non-health care primary expenditure to decline somewhat, thus holding down slightly the rise in overall general government outlays, which increase to over 60 percent of GDP by 2020 and to just under 70 percent by 2050.[19] Even so, general government expenditure increases at a steady and rapid pace—more than ½ percentage point of GDP per annum—right from the beginning of the simulation period. Unless offset by measures to contain expenditure, or new revenue measures, the structural deficit would also increase by this amount every year.

Strikingly different results obtain if feedback from rising taxes and deficits on labor force participation and productivity growth is included in the model. Even if the feedback effects are quite mild, they set in motion a cumulative process that causes the growth of real GDP to slow markedly during the first two decades of the next century, with a contraction beginning around 2035 (Chart 1). In these circumstances, pension expenditure would rise to

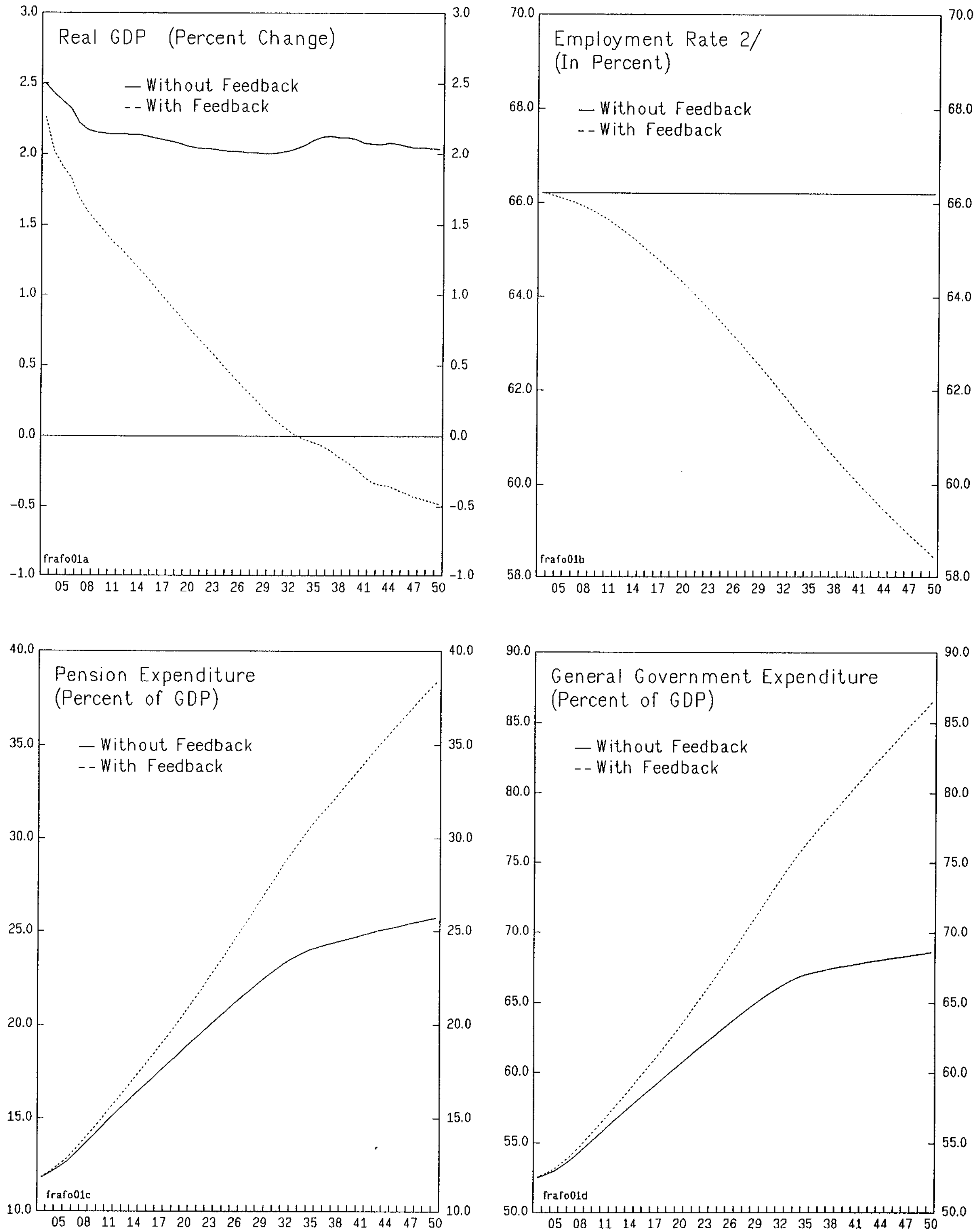
---

[18]It should be noted that even though the results are similar, the model used in this paper endogenously generates the rate of economic growth over time, rather than assuming it to be exogenous as is done in accounting-type studies.

[19]The average annual growth rate of real non-pension, non-health primary expenditure amounts to about 1¾ percent. This reflects the operation of the expenditure adjustment mechanism described in the Appendix.

CHART 1
FRANCE

Baseline Scenarios With and Without Feedback 1/



Source: Staff calculations.
1/ Assuming unchanged policies.
2/ Employment as a percent of working-age population.

almost 40 percent of GDP in 2050, and general government expenditure to almost 90 percent of GDP. The speed at which general government expenditure increases in the absence of policy action is substantially higher—about ¾ percentage point of GDP per year. In contrast to the scenario without feedback, this rate of increase does not level off once the worst of the demographic shock is past, around 2030. Rather, the accumulated damage to the real economy continues to take its toll.

In assessing the credibility and policy relevance of these results, it may be helpful to consider three issues. First, as a general rule, projections looking 50 years into the future (or even 10 years, for that matter) need to be treated with caution. There is no crystal ball in economics. Second, the severity of the impact that is envisaged would doubtless trigger policy reactions. Thus, the projections are not forecasts. Third, the model does show that on current policies, demographic developments are likely to exercise considerable pressure on the public finances by the end of the present decade. Given the compounding effects of the feedbacks among taxation and economic growth, early action to contain expenditure would be very effective, while delay is likely to cause harm.

B. Stochastic Simulations

Adding random shocks (to productivity, investment, and health care spending) provides additional insights into the range of outcomes that the model is capable of generating if current entitlement policies are not reformed. The methodology employed allows for an assessment of the entire probability distribution of outcomes for all variables in the model.[20] The relevance of the results will of course depend on whether the means and standard deviations of the random variables were chosen appropriately; and whether the model used for the simulations adequately represents the economic process being examined.

The main sources of uncertainty in the stochastic simulations are annual shocks to total factor productivity, investment and health care spending, and uncertainty about the magnitude of certain key parameters (in particular about those governing the strength of the feedback from taxation to investment and labor supply). A sample size of 1000 was chosen for the simulations to allow adequate convergence. Summary statistics of the distributions for some key variables are shown in Table 2.

---

[20]All random variables were assumed to be normally distributed with means and standard deviations derived from regressions on historical data. For the sake of simplicity and tractability, it was assumed that the various sources of uncertainty are statistically independent of one another. However, this assumption also motivated the decision to limit, to just a few key variables, the sources of uncertainty in the model.

Table 2. France: Long-Run Effect of Current Policies - Stochastic Simulations

	Minimum	Maximum	Mean	Standard Deviation	Lower quartile 1/	Upper quartile 1/
Without fiscal-macro feedback						
Real GDP						
Average growth rate						
1997-2050	1.9	2.6	2.2	0.1	2.1	2.2
2040-2050	1.5	3.0	2.1	0.2	1.9	2.2
Level in 2050 2/	10395	14928	12234	608	11822	12602
Present value 3/	145.0	166.1	155.4	3.2	153.1	157.6
Employment rate in 2050 4/	66.2	66.2	66.2	0.0	...	...
General government expenditure 5/	63.7	77.8	68.6	2.0	67.3	69.7
of which: Pensions 5/	23.3	27.3	25.7	0.5	25.4	26.0
Health 5/	7.1	19.3	11.1	1.8	9.8	12.1
Public debt 5/	44.5	85.8	62.0	5.7	58.3	65.4
Unfunded pension liability 6/	246.6	263.2	254.5	2.7	252.6	256.2
With fiscal-macro feedback						
Real GDP						
Average growth rate						
1997-2050	0.3	1.2	0.8	0.1	0.7	0.9
2040-2050	-1.2	0.5	-0.3	0.3	-0.5	-0.1
Level in 2050 2/	4550	7223	5813	449	5493	6112
Present value 3/	120.9	139.9	129.6	3.4	127.2	131.9
Employment rate in 2050 4/	54.7	60.3	58.4	0.8	58.0	59.0
General government expenditure 5/	76.4	104.2	86.3	4.0	83.5	88.5
of which: Pensions 5/	34.1	43.5	38.1	1.5	37.1	39.1
Health 5/	8.1	23.5	12.6	2.1	11.2	13.8
Public debt 5/	111.3	240.7	159.5	18.9	146.6	170.9
Unfunded pension liability 6/	255.4	276.5	265.5	3.6	263.0	267.8

Source: Staff calculations. Sample size was 1000.

1/ 25 percent of the simulation results lie below (above) the lower (upper) quartile.
2/ In billions of 1980 francs. For purposes of comparison, the 1997 figure is F 3800 billion.
3/ In trillions of 1980 francs. Discounted using a real rate of 3.5 percent per annum.
4/ In percent of working-age population.
5/ In 2050; percent of GDP. The ratios to GDP in 1996 are 54.5 percent for total expenditure, 12.5 percent for pensions, and 6.9 percent for health.
6/ In percent of 1996 GDP; discounted at a real rate of 3.5 percent per annum.

In the absence of feedback between real and fiscal variables, the outcomes in the stochastic simulations tend to fall in a relatively narrow range. For example, in 50 percent of all cases, the annual growth rate of real GDP toward the end of the period under consideration is between 2.1 and 2.2 percent, while the share of pension expenditure in GDP lies between 25 and 26 percent.[21] With the rather rigorous deficit target (1 percent of GDP) and high revenue adjustment parameter, the public debt ratio rarely exceeds 65 percent of GDP, and the average over time of the growth rate of real GDP almost always remains positive.

As in the non-stochastic simulations, the results are rather different when allowance is made for feedback between real and fiscal developments. In more than half of all cases, the economy is shrinking toward the end of the forecast horizon; and general government expenditure becomes very high, relative to GDP. The elevated levels of taxation also induce a considerable fraction of the available workforce to opt out of the labor market.

It is conceivable that there might be resistance to the tax increases needed to hold the deficit and public debt to an acceptable level. This can be modeled by assuming that a relatively smaller fraction (one-eighth) of deviations from the deficit target are eliminated in any given year.[22] [23] Though employment is almost 10 percent higher than in the basic scenario with feedback (as taxes are lower), there is a 25 percent probability that the public debt would exceed 180 percent of GDP, and a 10 percent probability that it would exceed 220 percent of GDP. While the model does not endogenously model inflation, there would be pressure to dissipate by one means or another the real value of obligations at the very high levels of public debt that could well arise as a result of resistance to ever-higher taxation.

The risks outlined in this section argue for strong efforts to contain the growth of entitlement spending. The following section outlines some of the possible reform options and discusses their likely economic consequences.

V. Options for Reform

Against the background of the baseline simulations, the control of pension and health care entitlements appears as an important condition for maintaining incentives for work, investment, and innovation; and indeed as necessary for the preservation of effective social security. Needless to say, they may be usefully complemented by objectives for the general government balance that promote a sustainable debt trajectory, and by labor and product market policies that favor a more robust growth of incomes and employment.

---

[21]Compared with Chand and Jaeger (1996), the unfunded pension liability is considerably higher, at 250 percent of GDP.

[22]Compared with about one-quarter in the basic scenario.

[23] One could also assume that the deficit target gradually drifts upward.

As illustrated in the previous section, the problems caused by aging are most pronounced in the area of pension expenditure. Pension reform is consequently given the most attention in what follows. With higher life-expectancy and adverse demographics, pension systems will need to lower the implicit rate of return they offer to their participants. This can be achieved in many different ways, for example by raising the contributions paid by those who are working, increasing the age or contribution period needed to obtain a full pension, cutting the replacement rate of current or future recipients, or reducing the indexation of pensions. For the sake of tractability, only two basic types of pension reform are examined in what follows: (1) a change in indexation rules and (2) an increase in the age of eligibility for a full pension from 60 to 65 years, and a corresponding increase in the period of contribution, spread over a period of 10 years.

Consideration is also given to the potential impact of health care reform, though this is more difficult to quantify. As was noted earlier, health care expenditure had tended to rise more quickly than GDP, even once the effect of population aging has been allowed for. Viewed this way, the objective of health care reform would be to reduce the excess in the growth rate of health care spending.

A. Pension Indexation

Different indexation rules for pensions have rather different implications for the fiscal accounts, generational fairness, and incentives. In terms of fiscal consequences, indexation on prices is usually considered to be the most economical. However, indexation well below the CPI could prove unsustainable if the standard of living of retired vis-à-vis active workers deteriorates too much over time—a development that could be seen as breaking the intergenerational commitment between generations.[24] Indexation on gross wages tends to be both the most costly and least fair: not only do workers have to support significantly higher pension expenditure, but there is a second-round increase in pensions when contribution rates are raised; thus, the standard of living of workers is decreasing over time vis-à-vis retirees. Finally, indexation on net wages results in greater burden sharing between retirees and active workers and helps to maintain the balance in the standards of living balance between working and retired persons.

Currently, indexation rules in France vary from scheme to scheme. Pension schemes for the private sector now index pensions on prices (in the *régime général*) or to prices less 1 percentage point (in the complementary schemes ARRCO and AGIRC since 1996). By

---

[24]A system in which a pensioner would experience an erosion, in real terms, of his initial pension by 2 percent per year for, on average, 20 or 25 years may lack credibility. Questions have also been raised about sustained indexing to retail prices only, because of the very wide income differentials that develop among different cohorts of pensioners. In this context, it should be noted that the shift from gross wage to price indexation introduced in 1992 in the *régime général* must be re-examined in 1999.

contrast, public sector pension schemes are indexed on gross wage increases; and there are no explicit rules for the pension schemes of the self-employed.

The most recent official report on the pension system (*Perspectives à long terme des retraites*) assesses the savings generated through 2010 by the 1993 reform of indexation in the *régime général*. It is noteworthy that this change was the most important feature of the 1993 reform, as shown below (figures in billions of 1993 francs):

Change in indexation (from gross wages to prices)	128
Extend averaging period for pension base	25
Increase in duration of contributions (from 37.5 to 40 years)	11

It should be pointed out that the other two measures will bear most of their fruits well beyond 2010, as the grandfathering of current workers gradually expires.

Model simulations were used to assess the effect of changes in indexation rules on the trend of pension expenditure and on macroeconomic performance. Two indexation rules were considered: (1) indexing all pensions on CPI less ½ percentage point; and (2) indexing all pensions on net wages.

In the absence of fiscal-macro feedback, the ratio of pension expenditure to GDP in 2050 is about 1 percentage point lower in the first case, and 5 percentage points higher in the second case (Chart 2). The latter result reflects the fact that net real wages continue to increase.

When there is fiscal-macro feedback, reduced inflation indexation generates substantially larger savings, with a ratio of pension expenditure to GDP in 2050 some 4 percentage points lower than in the baseline. This outcome is attributable mainly to the relatively greater importance of scaling back acquired nominal entitlements in a shrinking real economy, but it also reflects the positive feedback effect on growth of lower taxes (Chart 3). Indexation on net wages is an even more effective cost-saving measure than reduced indexation; it lowers the pension expenditure ratio in 2050 by some 7 percentage points. This result stands in marked contrast to the outcome in the model without feedback, and is explained by the decline in net real wages when there is feedback (the marked increase in taxes that is needed to finance pension spending reduces the growth of both output and gross wages). GDP growth and the employment rate are marginally higher with net wage indexation than with CPI-less-½-percentage-point indexation.

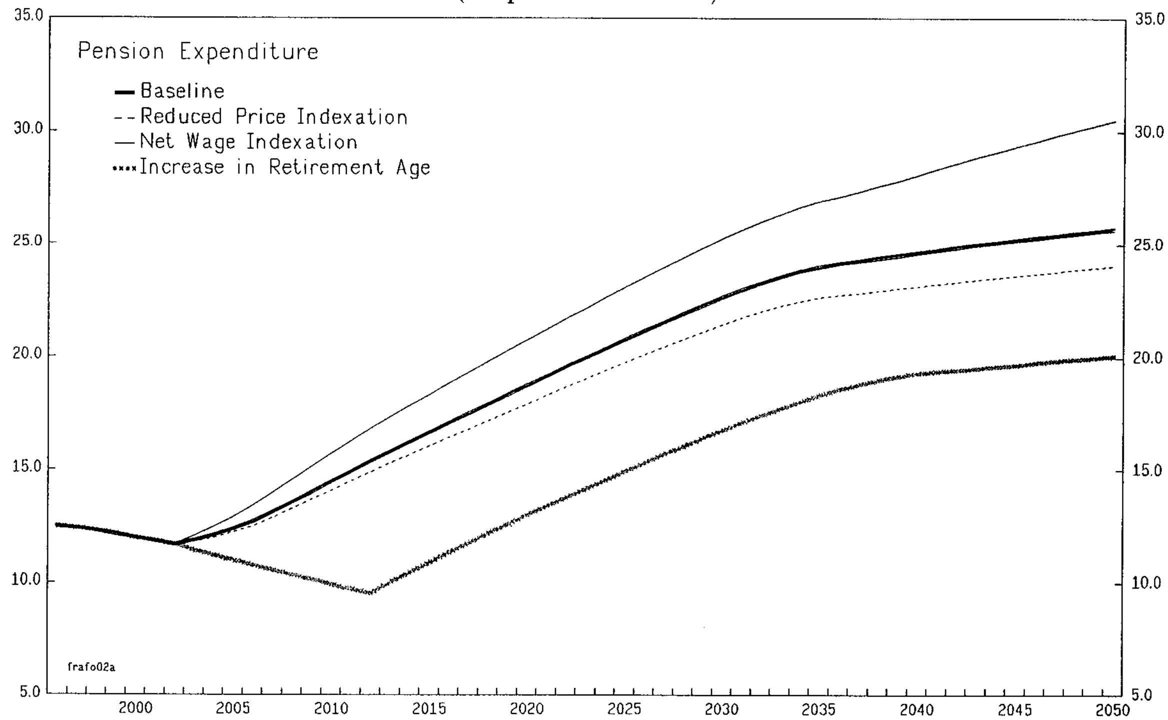
B. Increase in the Retirement Age

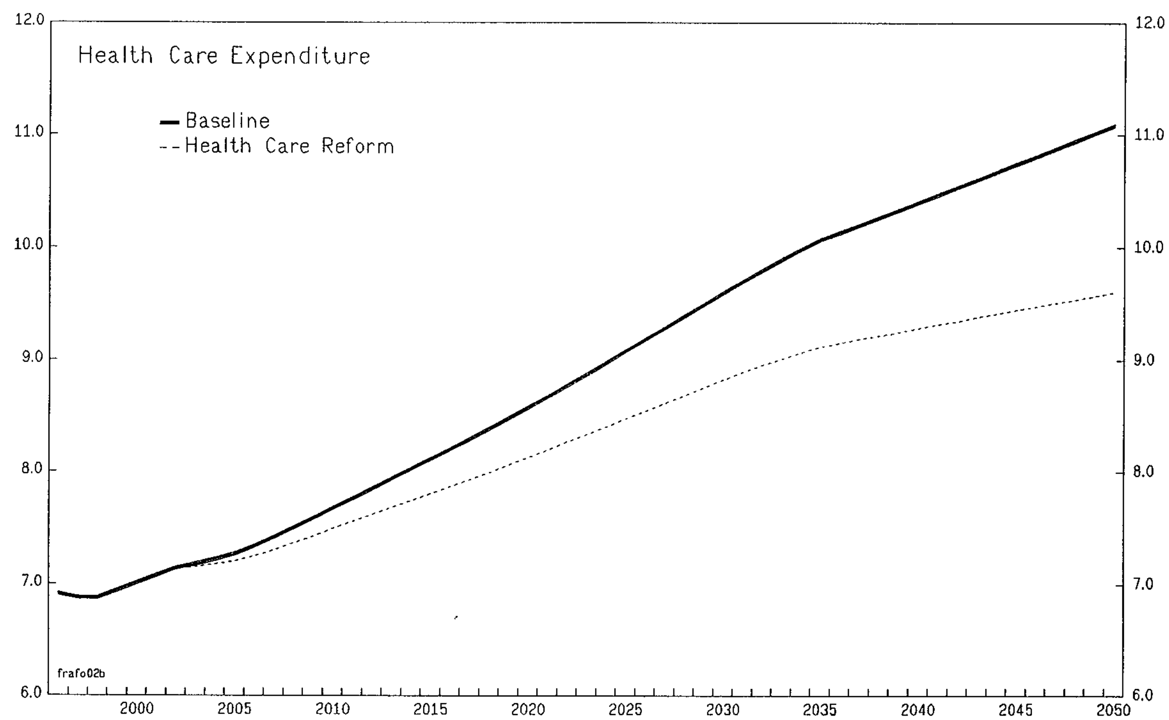
An increase in the retirement age (defined as the age of eligibility for a full pension) has four principal effects: it delays, on average, the time at which a pension begins to be paid; it increases the average time during which contributions are paid; it reduces the average length

CHART 2
FRANCE

Projected Expenditure, Without Feedback

(In percent of GDP)



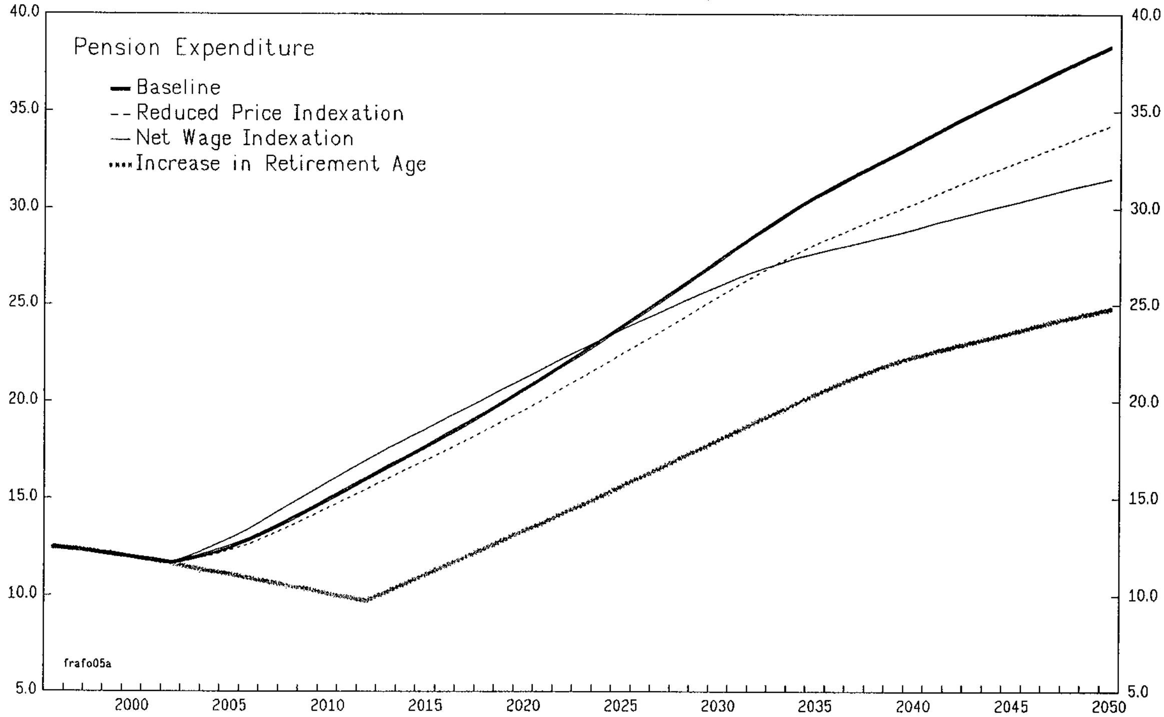


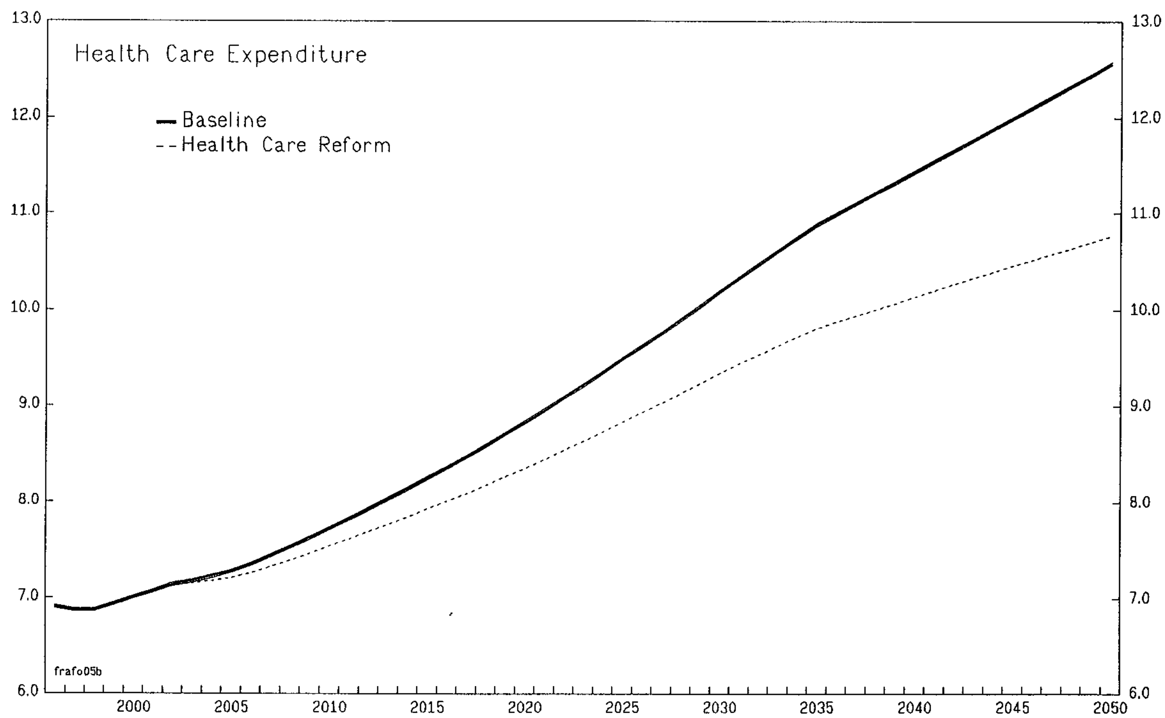
Source: Staff calculations.

CHART 3
FRANCE

Projected Expenditure, With Feedback

(In percent of GDP)





Source: Staff calculations.

of time for which a pension is paid; and it increases the supply of labor in the economy. It also tends to shift the political balance of power away from interest groups representing retirees and toward taxpayers.

Conceptually, the effective retirement age is distinct from the legal retirement age, which is only one of the factors by which it is determined. Other influences on the effective retirement age include (1) the replacement rate of pensions and the way in which it depends on age and length of service, (2) the extent and generosity of pre-retirement schemes (which may cause moral hazard and reduce the employment of older workers), (3) rules under which firms manage the work force (relying more or less on elder workers), and (4) the average age at which persons enter the labor market.

Over the last two decades, France has experienced a marked decline in the effective retirement age, a development that can be attributed largely to changes in policy: the lowering of the legal retirement age in the early 1980s (for the most part to 60, and currently one of the lowest among the industrial countries), the development of extensive pre-retirement schemes as a means of reducing measured unemployment, and a growing reluctance to use older workers (owing mainly to their relatively lower level of education and pay systems based on seniority).[25] Together, these policies have contributed to a strong withdrawal of workers aged 55 and above from the labor market. Moreover, this withdrawal took place against the background of an ongoing increase in life expectancy. Altogether, France now exhibits one of the highest non-employment rates among the major industrialized countries, especially among the young and the old:[26]

Non-employment Rates—International Comparison

	15 to 24	25 to 54	55 to 64
Canada	47	24	56
France	78	23	66
Germany	52	23	62
Italy	74	35	73
Japan	55	21	36
United Kingdom	55	23	52
United States	42	20	45

Source: OECD Employment Outlook, July 1996. Figures refer to 1995.

[25]The various early and pre-retirement schemes, including DRE provisions in unemployment benefits and arrangements for an early pension in the *régimes spéciaux*, pose a serious moral hazard problem, as they allow firms to eliminate older workers at virtually no cost to themselves (or to the workers).

[26]Among the young, the high non-employment rate has been caused mainly by a minimum wage that is in excess of the productivity of many inexperienced workers.

Policies to foster an increase in the rate of employment in France to the same level as in the United States or the United Kingdom (around 55 percent for young persons and 50 percent for old persons) would raise the active population by some 3 million in 1995, an increase of well over 10 percent.

A change in policy would also be needed to reverse the decline in the effective retirement age. One possibility would be to raise the legal retirement age, say from 60 to 65 in the course of 10 years, or possibly further.[27] Another possibility would be to take a more "actuarial" approach and increase the duration and amount of contributions needed for eligibility for a full pension (a first step was already made in the reform of the *régime général* in 1993), dropping any reference to a legal retirement age.

Indeed, the latter may be preferable by allowing for greater flexibility in the transition between labor and retirement and reducing the incentives workers have to withdraw prematurely from the labor market.[28] Indeed, should it become necessary to broaden the tax base by encouraging labor force participation, workers up to a certain age (perhaps as high as 70) might be rewarded with a higher than actuarially balanced pension if they chose to postpone retirement (while there would be a penalty for choosing early retirement). Another advantage of basing pensions on the length of contributions is that it results in a fairer distribution between workers who entered the labor market early (and who have a lower life expectancy) and those who delayed their entry into working life (and who acquired more human capital and increased their life expectancy).[29] It may also be argued that working until a

---

[27]An interesting calculation is to adjust the retirement age so that the old-age dependency ratio remains constant at its 1995 level (for this purpose, one calculates the ratio of people from 20 to retirement age to people above retirement age). The results are the following:

Year 2000: retirement age stabilizing the "dependency" ratio= 61
Year 2010:----------------------------------= 62
Year 2020:----------------------------------= 65
Year 2030:----------------------------------= 68
Year 2040:----------------------------------= 69
Year 2050:----------------------------------= 70

[28]A fixed retirement age may also reduce the employability of older workers by signaling to employers that investments in on-the-job training and experience may not be worthwhile, raising the risk of a vicious circle: dropping older workers creates pressures to institutionalize a lower effective retirement age, which in turn leads employers to drop workers even earlier.

[29]Life expectancy at the time of retirement is still increasing and entry into the labor market is being further and further delayed by schooling (taking into account unemployment and participation by age, the duration of work over the life cycle for an average wage-earner in

(continued...)

higher age imposes fewer hardships than in the past owing to the progressive disappearance of heavy physical labor.[30]

Simulations illustrate the effect of an increase in the effective retirement age from 60 to 65 over the course of 10 years, beginning in 2002 (Charts 2 and 3). Such an increase would have a considerably larger effect on the growth of pension spending than the changes in indexation contemplated earlier. In the absence of fiscal-macro feedback, the ratio of pension spending to GDP would be almost 6 percentage points lower than in the baseline. The effects are even more pronounced once the second-round effects on labor supply and economic growth are taken into account: real GDP growth remains substantially stronger, most notably during the transition to the higher retirement age but also thereafter; and the employment rate is significantly higher (this translates into an even bigger increase in the absolute value of employment as the working-age population is gradually redefined to allow for the increase in the effective retirement age).

C. A Comprehensive Adjustment Package: Pensions and Health Care

Thus far, the effects of different reform options have been examined separately. None of the possibilities examined was by itself sufficient to produce satisfactory outcomes. Moreover, in a context where there is feedback between real and fiscal variables, the beneficial effects of policies to restrain expenditure and deficits are more than the sum of their parts.

Against this background, a comprehensive reform package was examined, consisting of the following elements: (1) an increase in the retirement age from 60 to 65 years, phased in over a decade; (2) indexation on prices less ½ percentage point; and (3) a health care reform package that reduces the non-demographic annual trend rate of growth in spending by 0.3 percentage points.[31]

---

[29](...continued)
France ranks ninth out of 14 among the principal OECD countries, largely owing to low participation rates for both young and old persons).

[30]Even so, many older people may not be able to work productively at a full-time job, or at the most demanding jobs. Allowing older people to draw a partial pension while continuing to work part-time (and continuing to contribute to the pension system) could be a remedy. It will also be important to reform labor market institutions to facilitate part-time work by older persons, for example by providing fiscal incentives for training of older persons (possibly financed by the elimination of pre-retirement schemes), and stronger laws against age discrimination in employment.

[31]The last objective could presumably be achieved by implementing some or all of the following measures: (1) closing underutilized hospitals; (2) creating regional medical centers
(continued...)

The consequences of implementing such a package appear beneficial (Charts 4 and II-5). When there is feedback from fiscal to real variables, the ratio of general government expenditure to GDP is some 22 percentage points lower at the end of the simulation period, the level of real GDP is more than 60 percent higher, and the employment rate improves by some 5 percentage points. Nonetheless, the expenditure ratio, at over 60 percent of GDP, is still very much on the high side; and the employment rate is substantially lower than in 1997. A possible conclusion is that the effective retirement age would need to rise further, to 67 years or more. In addition, if there is sufficiently strong negative feedback from taxation to economic growth, pensions might be indexed to net wages instead of prices.

Moreover, it would appear that every effort will need to be made to hold down the growth of other public expenditure, to perhaps one-half the rate of real GDP. To achieve this, public employment would need to be reduced substantially over time, for example through attrition. By contrast, prolonged public sector wage restraint would probably not contribute much to reducing personnel outlays, as it could lead to the emergence of differentials between public and private sector pay that cannot be credibly sustained.

Stochastic simulations were carried out in order to gain a better understanding of the sensitivity of this projection to changes in parameter assumptions and random shocks. Compared to the unchanged policy scenario with feedback (Table 2), the outcome is unambiguously improved (Table 3). Notably, the growth rate of real GDP is ½ percentage point higher, and even more so toward the end of the period under consideration. Almost as importantly, the standard deviation of many variables declines markedly, implying that adjustment also reduces the riskiness of the outlook.

---

[31](...continued)
to improve capacity utilization for expensive equipment and improve health outcomes by allowing staff to gain greater experience in difficult procedures; (3) making more use of generic medicines (this presupposes strict quality standards to maintain confidence); (4) periodically reinforcing the controls imposed by the 1996 health care reform on the practices of individual physicians; (5) limiting the number of university places and licenses for new physicians; and (6) subjecting new medical technology to a strict cost-benefit analysis, with public financing being made available only for the adoption and use of technology that meets this test. See "Health Expenditure", Section I of France - Selected Issues (SM/96/249) for a detailed discussion of these issues.

VI. Conclusions

This paper has examined some of the possible implications of population aging for the public finances. It has extended earlier studies by embedding the fiscal accounts in a model of aggregate supply in which fiscal policy can affect the prospects for economic growth. A review of the theoretical and empirical literature on long-run economic growth suggests that distortions created in financing rising entitlement spending can have a negative and cumulatively significant effect on economic prosperity.

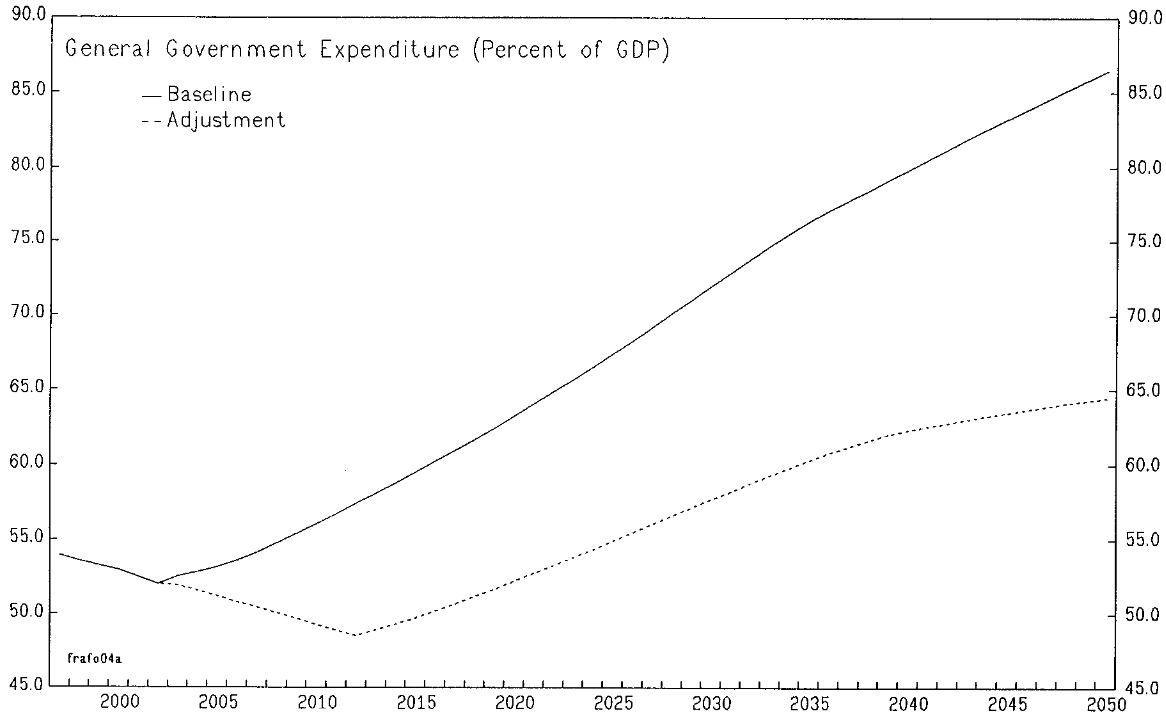
The paper begins by confirming the conclusion reached in other studies: absent measures to restrain the growth of spending, public outlays on pensions and health care would rise very substantially by the end of the present decade, owing to the anticipated aging of the population. When there is no feedback from the fiscal burden to long-run economic growth, the ratio of general government expenditure to GDP increases by about ½ percent of GDP per year, each year, for at least the next 30 years. Thus, keeping the general government deficit within Maastricht bounds would require the adoption of substantial adjustment measures at regular intervals.

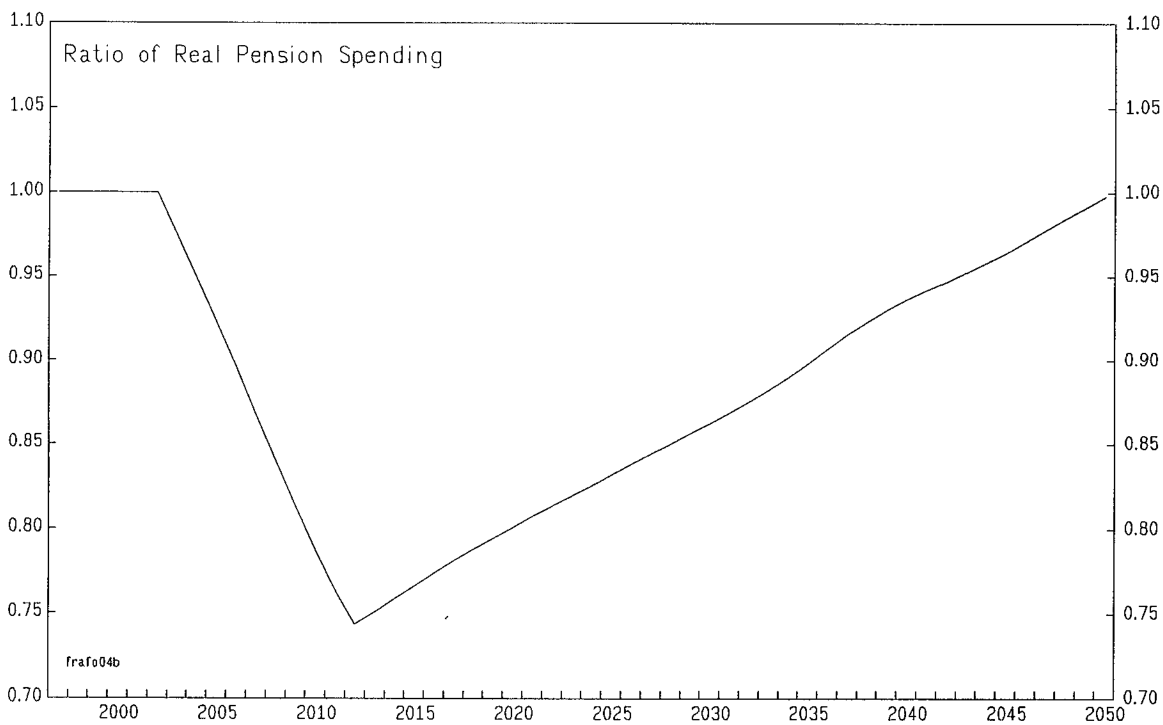
If the needed adjustment were to rely primarily on raising the ratio of revenue to GDP in order to match the increase in pension and health outlays, negative feedback from higher taxes to investment, labor market performance, and economic growth could well come into play. This feedback would worsen the overall outlook, not merely because public revenue and expenditure might rise to unsustainable levels, but because it would curtail long-run economic growth and reduce the prosperity that future generations are able to achieve.

Possible reforms would need to focus on restraining the growth of pension outlays, which account for the bulk of the likely increase in public expenditure. One way or another, it will be necessary to reduce the implicit rate of return that pension systems offer to their participants; this should probably be done in a way that takes account of intergenerational equity. Given the constant pressure that demographic developments will in the next few years begin to put on the public finances, another conclusion would be that a strategic plan to contain the growth of expenditure is needed to limit the risk of a damaging runup in public sector deficits, debt, and taxation.

CHART 4
FRANCE

Effects of Comprehensive Adjustment on Public Finance 1/

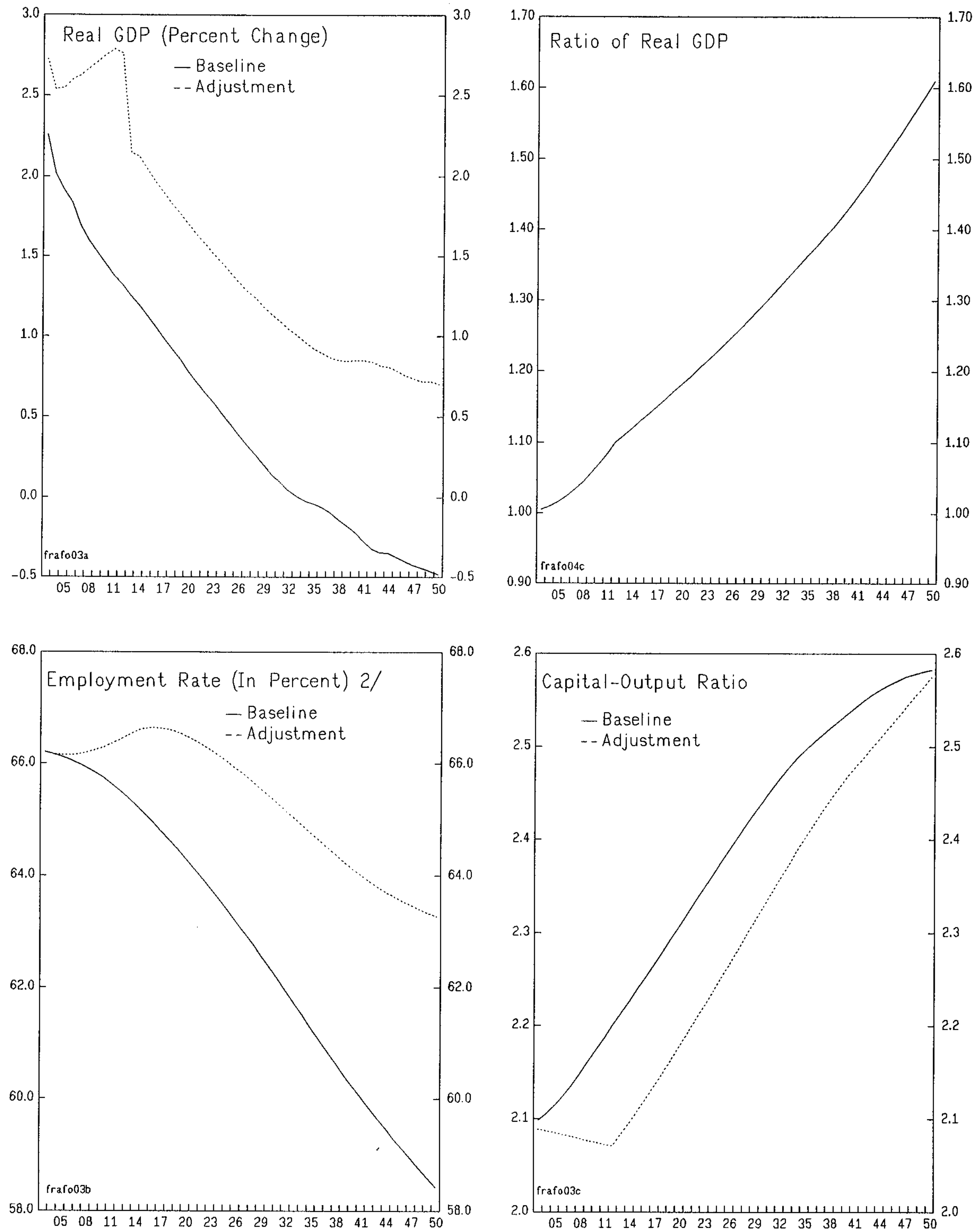




Source: Staff calculations.
1/ With feedback from fiscal to real variables.

CHART 5
FRANCE

Effects of Comprehensive Adjustment on Real Economy 1/



Source: Staff calculations.
1/ With feedback from fiscal to real variables.
2/ Employment as a percent of working-age population.

Table 3. France: Long-Run Effects of Pension and Health Care Reform - Stochastic Simulations 1/

	Minimum	Maximum	Mean	Standard Deviation	Lower quartile 2/	Upper quartile 2/
Comprehensive adjustment package 3/						
Real GDP						
Average growth rate						
1997-2050	1.2	2.3	1.7	0.2	1.6	1.8
2040-2050	0.0	1.8	0.8	0.3	0.6	1.0
Level in 2050 4/	7315	12834	9340	832	8759	9868
Present value 5/	137.1	167.7	151.1	5.1	147.5	154.3
Employment rate in 2050 6/	61.0	64.4	63.3	0.5	63.0	63.6
General government expenditure 7/	60.3	75.9	64.4	2.2	62.9	65.7
of which: Pensions 7/	20.2	25.0	22.5	0.7	22.0	23.0
Health 7/	6.0	16.5	9.0	1.4	8.0	9.8
Public debt 7/	55.8	125.3	78.3	8.7	72.3	83.2
Unfunded pension liability 8/	73.5	88.7	81.5	2.3	80.1	83.1
Differences from baseline						
Real GDP						
Average growth rate						
1997-2050 9/	0.9	1.1	0.9	0.1	0.9	0.9
2040-2050 9/	1.2	1.3	1.1	0.0	1.1	1.1
Level in 2050 4/	2765	5611	3527	383	3266	3756
Present value 5/	16.2	27.8	21.5	1.7	20.3	22.4
Employment rate in 2050 6/	6.3	4.1	4.9	-0.3	5.0	4.6
General government expenditure 7/	-16.1	-28.3	-21.9	-1.8	-20.6	-22.8
of which: Pensions 7/	-13.9	-18.5	-15.6	-0.8	-15.1	-16.1
Health 7/	-2.1	-7.0	-3.6	-0.7	-3.2	-4.0
Public debt 7/	-55.5	-115.4	-81.2	-10.2	-74.3	-87.7
Unfunded pension liability 8/	-181.9	-187.9	-184.0	-1.3	-182.9	-184.7

Source: Staff calculations. Sample size was 1000.

1/ Including feedbacks between fiscal and macroeconomic variables.
2/ 25 percent of the simulation results lie below (above) the lower (upper) quartile.
3/ Increase in the standard retirement age to 65 years, reduction in pension indexation by 1/2 percentage point annually, and health care reform.
4/ In billions of 1980 francs. For purposes of comparison, the 1997 figure is F 3800 billion.
5/ In trillions of 1980 francs. Discounted using a real rate of 3.5 percent per annum.
6/ In percent of working-age population.
7/ In 2050; percent of GDP. The ratios to GDP in 1996 are 54.5 percent for total expenditure, 12.5 percent for pensions, and 6.9 percent for health.
8/ In percent of 1996 GDP; discounted at a real rate of 3.5 percent per annum.

Stochastic Simulations of Long-Term Fiscal Outlook

This appendix first describes the structure of the model, then its calibration to the data, and finally the methods used to carry out the stochastic simulations. A key feature of the model is the interaction between developments in the public finances and the real economy.

I. Structure of the Model

The model has two interrelated blocks dealing with the real economy and the fiscal accounts. The key relationship on the ***real side*** is the production function

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

where A_t is total factor productivity, L_t is labor input, and K_t is the capital stock. Total factor productivity (TFP) grows at an exogenous rate γ in the version of the model without feedbacks from fiscal to real variables. When there are such feedbacks, it develops in accordance with

$$\Delta \ln A_t = \beta \, \Delta \ln K_t + \epsilon_t^A$$

Thus, TFP depends on the capital stock, an effect that is considered to be external to firms, as is standard in models of endogenous growth.[32] The stochastic shock is assumed to be i.i.d. with mean zero. As indicated above, the estimation of the parameters is discussed in the following section.

The capital stock, and by implication investment, is determined by

$$\Delta \ln K_t = \phi \, \alpha \, \frac{Y_t}{K_t} (\theta_0 - S_t^{rev}) + \epsilon_t^K$$

where S_t^{rev} is the share of general government revenue in GDP. The stochastic shock is assumed to be i.i.d. with mean zero. The equation says that the increase in the capital stock depends on the marginal product of capital, adjusted for the excess aggregate tax burden. The critical parameter is θ_0, which determines the threshold level of the tax burden beyond which the capital stock begins to decline. This functional form captures the behavior of the capital

---

[32]Growth models with endogenous productivity increase became widely accepted following the publication of Romer (1986). A detailed discussion may be found in Barro and Sala-i-Martin (1996).

stock quite well and is broadly consistent with the predictions of models of capital formation in which there is an adjustment cost to the capital stock.[33]

Labor input is by definition equal to $L_t = \lambda_t PNR_t$ where λ_t is the employment rate and PNR_t is the population that is not retired. When there are no feedbacks from fiscal to real variables, the employment rate is assumed to remain constant at its level in 2002 throughout the simulation period. When there is feedback, the employment rate would in principle depend on gross wages, the tax burden borne by non-retired persons, and the design and level of unemployment and other social benefits available to non-retired persons. As discussed below, empirical estimates reveal all of these factors besides the aggregate tax burden to be statistically insignificant, so the functional form used is the following:

$$\Delta\lambda_t = \eta \, \Delta S_{t-1}^{rev}$$

The production function and the equations for TFP, the capital stocks, and labor input constitute the real side of the model. Several additional indicators can be derived from the production function. First, the real gross wage is determined by marginal productivity conditions, i.e.,[34]

$$w_t = (1-\alpha) \frac{Y_t}{L_t}$$

and the real net wage as

$$w_t^{net} = (1 - S_t^{rev}) \, w_t$$

where S^{rev} is the share of general government revenue in GDP. This implictly assumes that the tax system is balanced between taxes on labor and capital income. The real interest rate may also be related to marginal productivity conditions

$$r_t = \mu \, \alpha \, \frac{Y_t}{K_t}$$

---

[33]The Annex provides some background on the microfoundations of this equation.

[34]In this model, unemployment is not modeled explicitly. However, the non-employment rate, which is a composite of labor force non-participation and unemployment, is.

where μ is a coefficient needed to calibrate the marginal productivity of capital to the observed real long-term rate of interest.[35] The nominal rate of interest can, of course, be calculated as $i_t=(1+r_t)(1+\pi_t)-1$, where π is the rate of inflation (assumed to be constant and exogenous to the model).

The ***fiscal side*** of the model disaggregates expenditure into four categories: interest, health, pensions, and other.[36] In order to capture the effect of population aging, health expenditure in turn is divided between young persons and old persons. Revenue is not disaggregated; this entails no loss of generality as the shares of capital and labor income in the economy are constant with a Cobb-Douglas production function. Thus, overall expenditure is given by

$$E_t = E_t^{interest} + E_t^{health} + E_t^{pension} + E_t^{other}$$

Interest payments are calculated on the average of beginning-of-year and end-of-year debt stocks

$$E_t^{interest} = i_t \frac{D_{t-1} + D_t}{2}$$

As indicated above, health spending is disaggregated by demographic group

$$E_t^{health} = E_t^{health,\ young} + E_t^{health,\ old}$$

In each group i, per capita spending grows in proportion to gross wages and an additional factor b_t which captures the historical excess in the growth of health care spending over what can be explained by growing income and by demographics:

$$E_t^{health,\ i} = E_{t-1}^{health,\ i}\ (1 + b_t)\ \frac{w_t^{nom}}{w_{t-1}^{nom}}\ \frac{Pop_t^i}{Pop_{t-1}^i}$$

For the purposes of the simulations, b_t is in general taken to be a random variable.

---

[35]The two may differ because of taxes and other elements of the cost of capital.

[36]All public finance variables are expressed in current price terms to facilitate inflation accounting and continuity with historical series.

The computation of pension spending is accomplished in several steps. First, the relevant demographic profiles are established. It is assumed that at any point in time *t*, a fraction of the population of a given age *a* is not retired. Thus, the non-retired population at *t* is given by

$$PNR_t = \sum_{a=0}^{100} w_{ta} P_{ta}$$

For example, for an unchanged standard retirement age of 60, the coefficients w_{ta} at each point in time are unity up to age 54, and zero for age 65 and above; and they assume the following values for ages 55 to 64:

Age	55	56	57	58	59	60	61	62	63	64
w_{ta}	0.90	0.80	0.70	0.60	0.50	0.20	0.10	0.07	0.04	0.02

Of course, when an increase in the retirement age is being modeled, this profile would shift over time.

Using the coefficients $r_{ta}=(1-w_{ta})$, it is also possible to calculate the gross flow of new retirees of each age in each period:

$$R_{ta}^{new} = (r_{ta}-r_{t-1,\ a-1})\ P_{ta}$$

Then, the total number of persons of all ages beginning to draw a pension in period t is

$$R_t^{new} = \sum_{a=0}^{100} R_{ta}^{new}$$

On the assumption that all persons entering retirement at a given time receive the same pension (this is approximately true now given the prevalence of early retirement schemes), the pensions paid to the cohort of persons retiring at time *c* are (for the case of pensions indexed on prices)

$$E_{tc}^{pension} = R_c^{new}\ s_{tc}\ \omega_c\ \rho_c\ w_c^{nom}\ \frac{p(t)}{p(c)}$$

where ρ_c is the effective replacement rate of pensions, ω_c is the ratio of wages at retirement age to average wages, and s_{tc} is the survival rate table for the (mixed-age) cohort c.[37] Total pension expenditure at time t is then given by:

$$E_t^{pension} = E_{0,init}^{pension} \frac{p(t)}{p(0)} s_{t,init} + \sum_{c=1}^{t} E_{tc}^{pension}$$

i.e., the sum of initial pensions (adjusted for indexation and the survival of recipients) and the sum of pensions paid to persons who have retired between periods 1 and t. Note that in modeling an increase in the retirement age, one is obliged to use the corresponding profiles of cohort survival and availability in the labor force.

The fiscal accounts are closed by defining the general government financial balance:

$$B_t = R_t - E_t$$

and the law of motion for the public debt

$$D_t = D_{t-1} + B_t$$

What remains to be determined are fiscal policy rules for adjusting revenue and other public expenditure. For the sake of simplicity, it is assumed that these variables are adjusted to approximate an exogenously given target for the fiscal balance, in percent of GDP. Thus, for public revenue, one has:

$$\frac{R_t}{Y_t^{nom}} = \frac{R_{t-1}}{Y_{t-1}^{nom}} - \theta_R \left(\frac{B_t}{Y_t^{nom}} - \kappa_t\right)$$

An analogous equation can be written for other government expenditure. The parameter θ_R measures the speed with which fiscal adjustment is undertaken—it can be interpreted as a measure of the "strength" of the adjustment effort, or of the "credibility" of the deficit target. Typically, this parameter will lie between 0 and 1.

II. Calibration of the Model

This section provides further information on the estimation of parameter values in the model. The baseline values are summarized in Table A1.

---

[37]The calculation of the mixed-age survival tables is technical and not described here in full detail.

In the *production function*, one sets α=0.4 in accordance with the approximate historical share of labor in GDP. As usual, total factor productivity is calculated as a residual.

Estimation of the equation for *total factor productivity* (TFP) began by rewriting it in distributed lag form:

$$\ln A_t = \sum_{k=1}^{n} a_k \ln A_{t-k} + \sum_{k=0}^{n} b_k K_{t-k} + \epsilon_t$$

Using the ADF test, unit roots could not be rejected for the levels of the capital stock and total factor productivity; however, unit roots were rejected for the first differences of both of the variables. The model was estimated with n=2 lags using annual data; the test statistics show that the second lag of total factor productivity is not significant. The estimation results are shown in Table A2; the model passes the other standard statistical tests (notably those for autoregressivity and normality of the residuals). The long-run elasticity of total factor productivity on the capital stock is about 0.4. Thus, the social production elasticity of capital is close to 0.8, almost double its private value.[38] A unit root was rejected for the error-correction term, showing that the variables are cointegrated. The model was re-estimated in error-correction form, which shows that the short-run elasticity of TFP on the capital stock is close to unity, as would be expected given that measured TFP responds strongly to fluctuations of investment over the business cycle.

The *capital stock* equation was estimated in two stages. First, a linear distributed lag model with θ_0=1 was estimated after confirming that a unit root is rejected for all of the variables:

$$\Delta\ln K_t = \sum_{k=1}^{n} a_k \Delta\ln K_{t-k} + \sum_{k=0}^{n} b_k MPK_{t-k}^{net} + \eta_t$$

[38]The social production elasticity in this model falls significantly short of unity, indicating that it would not generate permanent self-sustaining growth (though the transition to the steady state would take quite a long time). The model was re-estimated with a trend term to allow for the possibility that there might be an autonomous element to the growth of TFP; the trend term turned out to be insignificant (p=0.59), and the other parameters were virtually unchanged.

Table A1. France: Baseline Model Parameters

Name	Value	Description
α	0.4	Production elasticity of capital
β	0.39	Elasticity of TFP on capital stock
γ	.013	Growth rate of TFP in scenario without fiscal-macro feedback
γ_{min}	0.0	Floor for growth rate of TFP in scenarios with feedback
θ_0	0.8	Threshold level of taxation in investment equation
η	-0.25	Coefficient on taxation in employment equation
ρ	0.52	Effective replacement ratio of pensions
ω	1.25	Ratio of average wage at retirement age to economy-wide average wage
ζ	0.004	Non-demographic excess of health care growth over GDP growth
b_{targ}	-0.01	Target for general government balance/GDP
θ_R	0.2	Revenue partial adjustment coefficient
θ_E	0.02	Other expenditure partial adjustment coefficient
π	0.02	Rate of inflation in long term
υ	0.035	Real rate of time discount

Sources: Staff calculations; data provided by the authorities.

Table A2. France: Equation for Total Factor Productivity

(Sample: 1973 to 1996)

(1) Equation in levels

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
Constant	-0.35959	0.27682	-1.299	0.2103	0.0857
LTFP_1	0.45688	0.17244	2.650	0.0163	0.2806
LTFP_2	0.019480	0.15839	0.123	0.9035	0.0008
LKAP	3.2391	0.47779	6.779	0.0000	0.7186
LKAP_1	-5.2360	0.85978	-6.090	0.0000	0.6732
LKAP_2	2.1968	0.51326	4.280	0.0005	0.5044

R^2 = 0.994249   F(5, 18) = 622.4 [0.0000] σ = 0.00583529   DW = 2.67

(2) Solved static equation in levels

	LTFP =	-0.6867	+0.3817 LKAP
(SE)		(0.2893)	(0.03108)

(3) Other tests

AR 1- 2F(2, 16) =	3.5795	[0.0519]
ARCH 1 F(1, 16) =	0.50458	[0.4877]
Normality Chi²(2)=	1.5403	[0.4629]
Xi² F(10, 7) =	0.46441	[0.8689]
RESET F(1, 17) =	1.4723	[0.2416]

(4) Error-correction model

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
DLTFP_1	-0.019480	0.13735	-0.142	0.8886	0.0010
DLKAP	3.2391	0.40385	8.020	0.0000	0.7628
DLKAP_1	-2.1968	0.39793	-5.520	0.0000	0.6038
ecmkap_1	-0.52364	0.15030	-3.484	0.0023	0.3777

R^2 = 0.866224 σ = 0.00553584   DW = 2.67

(5) Solved static equation for error-correction model

	DLTFP =	+1.022 DLKAP	-0.5136 ecmkap
(SE)		(0.2393)	(0.1934)

(6) Unit root test on error-correction term

Critical values: 5%=-1.957 1%=-2.67

	t-adf	σ	lag	t-lag	t-prob
ecmkap	-2.0398*	0.010644	2	0.12569	0.9012
ecmkap	-2.1118*	0.010392	1	0.22186	0.8266
ecmkap	-2.2013*	0.010165	0		

Source: staff calculations. LTFP and LKAP are the natural logarithms of total factor productivity and the capital stock; the operator D denotes first differences.

The equation was initially estimated with n=2 lags, but reduced to the form reported in Table A3 after tests showed that neither the second lags, nor the constant term, were statistically significant.

In a second stage, non-linear least squares estimation was used to estimate the more general form actually used in the simulations (see above). When no lags of the dependent variable were included, this yielded θ_0=0.51, and 0.3 for the standard error. Taken at face value, this would imply, rather implausibly, that the capital stock in France should begin to decline once the general government revenue ratio reaches 51 percent of GDP. When one lag of the dependent variable was included, an estimate θ_0=1.0 was obtained, with a similar standard error. Based on this, a judgement was made to set θ_0=0.8, a level of taxation which has given rise to serious macroeconomic problems in several other countries.

The *employment rate* was modeled in a cross-sectional regression using 1994 data covering 18 industrial countries (Table A4). Explanatory variables included the ratio of general government revenue to GDP, the share of women in the labor force, the replacement ratio of social benefits for unemployed persons, and a measure of wage dispersion.[39] [40] The results show that the only statistically significant variables were the general government revenue ratio and the share of women (at the 5 percent and 1 percent levels if the insignificant variables are omitted). The parameters had the expected sign, with higher relative female labor market participation associated with a higher overall employment rate, and a higher tax burden associated with a lower employment rate.

These results were confirmed by estimating the regression with the 10-year changes in the employment rate, revenue ratio, and female labor force share. Over this period, the employment rate, the share of women in the labor force, and the tax burden have all increased (on average for the countries in the sample). The coefficients once again had the expected signs and were significant at the 10 percent level. The wage dispersion measure also had some explanatory power, with greater wage dispersion associated with a higher employment rate.

An equation for the employment rate was also estimated on the basis of time-series data for France. The equation was tested down from a general distributed lag model involving,

---

[39]Differences in the share of women in the overall labor force are seen as primarily reflecting exogenous differences across countries in social attitudes toward and legal institutions affecting female participation in the labor market. The share of women in the labor force is highest in the Nordic and Anglo-Saxon countries, and lowest in Southern Europe and Japan. Of course, differences in economic conditions (such as relation between the market wage available to women, and the shadow wage of household work) may also play a role in explaining differences in female labor force shares.

[40]The wage dispersion measure is intended to capture the effect of minimum wage laws and other policies (including toward competitive bargaining) that affect the wage structure.

Table A3. France: Equation for the Capital Stock

(Sample: 1972 to 1996)

(1) Equation in levels

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
DLKAP_1	0.90905	0.075655	12.016	0.0000	0.8730
MPKNET	0.28317	0.086149	3.287	0.0035	0.3397
MPKNET_1	-0.27325	0.088099	-3.102	0.0054	0.3142

R^2 = 0.994513 σ = 0.00248288 DW = 1.99

(2) Solved static long-run equation in levels

	DLKAP =	+0.1091 MPKNET
(SE)		(0.02599)

(3) Tests on the significance of each variable

variable	F(num,denom)	Value	Probability		Unit Root t-test
DLKAP	F(1, 21) =	144.38	[0.0000]	**	-1.2022
MPKNET	F(2, 21) =	6.8554	[0.0051]	**	1.1183

(4) Other tests

AR 1- 2	F(2, 19) =	0.57892	[0.5701]
ARCH 1	F(1, 19) =	0.048928	[0.8273]
Normality	Chi²(2)=	1.5809	[0.4536]
Xi²	F(6, 14) =	1.679	[0.1987]
Xi*Xj	F(9, 11) =	1.901	[0.1564]
RESET	F(1, 20) =	1.1495	[0.2964]

Source: staff calculations. DLKAP is the first difference of the natural logarithm of the capital stock; MPKNET is the output-capital ratio multiplied by one less the ratio of general government revenue to GDP.

Table A4. France: Cross-Section Regression for the Employment Rate

	ER94	ER94	DER	DER
Constant	0.385 (3.72)	0.384 (1.92)	-0.033 (-0.917)	-0.133 (-1.08)
GY94	-0.338 (-1.84)	-0.283 (-1.07)		
FEM94	0.559 (4.31)	0.572 (3.76)		
DGY			-0.555 (-1.65)	-0.549 (-1.72)
DFEM			0.491 (1.69)	0.397 (1.41)
RR94		-0.557E-03 (-0.326)		-0.207E-03 (-0.226)
D5D1		0.452E-02 (-0.059)		0.076 (1.606)
R^2	0.554	0.559	0.441	0.562
F	9.32	4.11	5.91	4.17
SSR	0.0538	0.0533	0.0316	0.0248

Source: Staff calculations. Values in parentheses are t-statistics. The regression included 18 industrialized countries (the G-7 plus Australia, Austria, Belgium, Denmark, Finland, Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland). ER94 is the employment rate (employment relative to population aged 15 to 64) in 1994; DER is its ten-year change. GY94 is the general government revenue ratio in 1994 and DGY is its 10-year change. FEM94 is the share of females in the labor force and DFEM is its 10-year change; YP is per capita GDP in 1985 (converted into dollar at purchasing-power exchange rates) drawn from Barro and Lee (1994). RR94 is the replacement ratio of social benefits for unemployed persons; and D5D1 is the ratio of wage earnings of persons in the fifth decile relative to persons in the first decile. The last two variables were drawn mainly from OECD (1996).

in a variety of combinations, benefit and tax ratios, the female labor force share, wage indicators, and so forth. It was found that most of the explanatory variables were highly collinear, and that only the net real wage and the general government revenue ratio had significant explanatory power, but only when one of these variables, not both, were included in the model. Given this choice, it was decided to use the general government revenue ratio (Table A5). A long-run coefficient of about -0.5 was found.

In both sets of cross-country regressions, and in the time series estimates, the parameter on the tax variable ranged from about -¼ to -½. In parametrizing the model, the lower value was chosen, both out of general caution but also to guard against possible omitted-variable bias. In particular, it is conceivable that the effective retirement age in various countries is related to both the measured employment rate and to the general government revenue ratio: earlier retirement would lower the employment rate while increasing pension expenditure and the taxes needed to finance it. Consistent data on the effective (as opposed to the legal) retirement age in various countries is not readily available.

The parameters for the *pension system* were based largely on information found in the official study *Perspectives à long terme des retraites* (see notably Table 41 in that publication for the replacement ratio). Data on health consumption by age were drawn from the *Enquête santé 1980* (summarized in Economie et Statistique), which suggest that older persons (60 years and above) consume about 1.6 times more health care services per capita than younger persons. This implies that in the second half of the 1990s, older persons account for about 30 percent of all health care spending, and younger persons for 70 percent.

The coefficient μ, which links the marginal productivity of capital with the *real interest rate*, was chosen to smoothly splice the two series in the year 2003, which is the first year of the model simulations.

III. Stochastic Simulations

To conduct the stochastic simulations, uncertainty was introduced by means of the shock terms in the total factor productivity and investment equations, and by allowing for parameter uncertainty in those equations. Uncertainty was also allowed for in the trend term in the health insurance equation; it will be recalled that this term captures that part of the longer-term increase in health care costs that cannot be attributed to demographics. All random variables were assumed to be normally distributed.

By and large, the estimates of the means and variances of the distributions used were derived from the regression estimates. The standard deviations used are summarized in Table A6. One methodological issue that arises is whether there is a non-zero covariance between any of the random variables being considered. For the sake of simplicity and tractability, it was assumed that the various sources of uncertainty are statistically independent of one another. However, this assumption also motivated the decision to limit, to just a few key variables and parameters, the sources of uncertainty in the model.

Table A5. France: Equation for the Employment Rate

Dependent variable: ER
(Sample: 1972 to 1996)

(1) Equation in levels

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
Constant	0.26025	0.059901	4.345	0.0003	0.4618
ER_1	0.73122	0.063189	11.572	0.0000	0.8589
GGRY	-0.21041	0.048984	-4.296	0.0003	0.4561

$R^2 = 0.980392$ F(2, 22) = 549.99 [0.0000] $\sigma = 0.00379638$ DW = 1.41

(2) Solved static long-run equation in levels

$$ER = \underset{(0.04049)}{+0.9683} \; \underset{(0.0882)}{-0.7829}\, GGRY$$

(3) Equation in first differences

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
DER_1	0.45687	0.15897	2.874	0.0086	0.2642
DGGRY	-0.24825	0.10087	-2.461	0.0218	0.2085

$R^2 = 0.487207$ $\sigma = 0.00414737$ DW = 2.11

(4) Tests of equation in first differences

AR 1- 2F(2, 21) =	1.5385	[0.2380]
ARCH 1 F(1, 21) =	0.034249	[0.8550]
Normality Chi²(2)=	2.0938	[0.3510]
Xi² F(4, 18) =	1.2811	[0.3141]
Xi*Xj F(5, 17) =	2.3761	[0.0828]
RESET F(1, 22) =	4.028	[0.0572]

Source: staff calculations. ER is the ratio of employment to working-age population (in percent); GGRY is the percentage share of general government expenditure in GDP; the operator D denotes first differences.

Table A6. France: Standard Deviations for Stochastic Simulations

Standard Deviation of	Value	Description
β	0.03	Elasticity of TFP on capital stock
θ_0	0.1	Threshold level of taxation in investment equation
η	0.2	Coefficient on taxation in employment equation
ϵ_t^A	0.006	Error term in TFP equation
ϵ_t^K	0.005	Error term in investment equation
b_t	0.022	Error term in health care equation

Source: Staff calculations.

The simulations take as their point of departure the macroeconomic and fiscal outlook as published in the May 1997 WEO. This scenario ends in 2002; the model is used to simulate developments for the period 2003–2050. A sample size of 1000 was chosen for the simulations to allow adequate convergence of the distributions. In essence, the procedure draws the random variables from a distribution with parameter means given in Table A1 and the standard deviations reported in Table A6.

A MODEL OF INVESTMENT

This annex explains why one might expect virtually all types of taxation to have a negative influence on investment. The point of departure is the standard profit-maximization problem of a representative competitive firm where there is a quadratic adjustment cost to changes in the capital stock

$$J = \max_{\langle K_t, L_t \rangle} \sum_{t=0}^{\infty} \beta_t \, [(1-\theta_t^P) \, F(K_t,L_t) - w_t(1+\theta_t^L)L_t - r_t(1+\theta_t^K)K_t - \delta K_t - \frac{\phi}{2}(K_{t+1}-K_t)^2]$$

and where β is the discount factor, K is the capital stock, L is labor, w is the wage, r is the real interest rate, δ is the rate of depreciation of capital, ϕ is an adjustment cost parameter, and the various θ's are tax rates on output, capital, and labor. One obtains the first-order conditions

$$\frac{\partial J}{\partial L_t} = \beta_t \, [(1-\theta_t^P) \, F_L(K_t,L_t) \; - \; w_t \, (1+\theta_t^L)] \; = \; 0$$

which implies that the marginal product of labor is equal to the wage adjusted for taxation, and

$$\frac{\partial J}{\partial K_t} = \beta_t \, [(1-\theta_t^P) \, F_K(K_t,L_t) \; - \; r_t \, (1+\theta_t^K) \; - \; \delta \; + \; \phi \, (K_{t+1}-K_t)] \; - \; \beta_{t-1} \, \phi \, (K_t - K_{t-1}) \; = \; 0$$

Noting that $\beta_t = \beta_{t-1} / (1+r_t)$, this first-order condition may be rewritten as

$$I_{t+1} = (1+r_t) \, I_t \; - \; \frac{1}{\phi} \, [(1-\theta_t^P) \, F_K(K_t,L_t) \; - \; (r_t \, (1+\theta_t^K) \; + \; \delta)]$$

which is simply the usual partial adjustment model: the change in the capital stock depends on (1) its lagged value and (2) the difference between the marginal product of capital net of product taxes (the first term inside the square bracket) and the interest and depreciation cost of capital including taxes (the second term inside the square bracket). The equation used in the paper attempts to capture key aspects of this equation in a much simpler and more stylized form.

REFERENCES

Barro, Robert J., "Government Spending in a Simple Model of Endogenous Growth," *Journal of Political Economy*, 98, 5, Part II, October 1990, pp. S103-S125.

Barro, Robert J. and Jong-Wha Lee, "Sources of Economic Growth," *Carnegie-Rochester Conference Series on Public Policy*, 1994.

Barro, Robert J. and Xavier Sala-i-Martín, *Economic Growth*, New York, McGraw-Hill, 1995.

Cashin, Paul, "Government Spending, Taxes, and Economic Growth," *IMF Staff Papers*, 42, 2 , June 1995, pp. 237–269.

Chand, Sheetal and Albert Jaeger, *Aging Populations and Public Pension Schemes*, Occasional Paper No. 147, Washington, International Monetary Fund, 1996.

Easterly, William and Sergio Rebelo, "Fiscal Policy and Economic Growth: An Empirical Investigation," Journal of Monetary Economics, 32, 1993, pp. 417–458.

Fischer, Stanley, "The Role of Macroeconomic Factors in Growth," Working Paper No. 4565, Cambridge, MA, National Bureau of Economic Research, 1993.

Henry, S.G.B. and Dennis Snower, *Economic Policies and Unemployment Dynamics in Europe*, Washington, International Monetary Fund, 1996.

Jones, Larry-E., Rodolfo E. Manuelli, and Peter E. Rossi, "On the Optimal Taxation of Capital Income," *Journal-of-Economic-Theory*, 73, 1, March 1997, pp. 93–117.

Jorgenson, Dale W., *Investment. Volume 1. Capital Theory and Investment Behavior*, Cambridge and London, MIT Press, 1996.

Layard, Richard, Nickell, Steven, and Richard Jackman, *The Unemployment Crisis*, Oxford and New York, Oxford University Press, 1994.

Levine, Ross and David Renelt, "A Sensitivity Analysis of Cross-Country Growth Regressions," *American Economic Review*, 82, 4, September 1992, pp. 942–963.

Livre blanc sur les retraites, Paris, La Documentation Française, 1991.

MaCurdy, Thomas, Work Disincentive Effects of Taxes: A Reexamination of Some Evidence, *American Economic Review*, 82, 2, May 1992, pp. 243–249.

Milesi-Ferretti, Gian Maria and Nouriel Roubini, "Growth Effects of Income and Consumption Taxes: Positive and Normative Analysis,' Working Paper WP/95/62, Washington, International Monetary Fund, June 1995.

Organisation for Economic Cooperation and Development, "The Macroeconomics of Ageing, Pensions, and Savings: A Survey," Working Party No. 1 on Macroeconomic and Structural Policy Analysis, ECO/CPE/WP1(97)10, Paris, September 1997.

_____, *Employment Outlook*, Paris, July 1996.

_____, *New Directions in Health Care Policy*, Health Policy Studies No. 7, Paris, 1995.

Perraudin, William and Turalay Kenc, "Pension Reform in Italy," unpublished paper, Birkbeck College, London, May 1997.

La Documentation Française, *Perspectives à long-term des retraites*, Paris, 1995.

Quang Chi Dinh, "La Population de la France à l'horizon 2050", *Economie et Statistique*, No. 274, 1994, pp. 7–32.

Rosen, Harvey S., "What is Labor Supply and Do Taxes Affect It?", *American Economic Review*, 70, 2, May 1980, pp. 171–76.

Romer, Paul M., "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, 94, 5, October 1986, pp. 1002–1037.

Sala-i-Martín, Xavier, "Transfers, Social Safety Nets, and Economic Growth," Working Paper WP/96/40, Washington, International Monetary Fund, April 1996.

Stokey, Nancy and Sergio Rebelo, "Growth Effects of Flat-Rate Taxes," *Journal of Political Economy*, 103, 3, June 1995, pp. 519–550.