WORKING PAPER SERIES

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Working Paper 1998-023B
http://research.stlouisfed.org/wp/1998/98-023.pdf

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November 1999

JEL Codes: D9, E6, H2, I2
Keywords: myopia, social security, endogenous growth

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ABSTRACT

The Social Security systems of the G7 countries were established in an era when populations were young and the number or contributors far outweighed the number of beneficiaries. Now, for each beneficiary there are fewer contributors, and this downward trend is projected to accelerate. To evaluate the prospects for these economies we develop an overlapping generations model in which growth is endogenously fueled by individuals' investments in physical and human capital and by the government's investment in human capital via public education expenditures. We analyze individuals' behavior when their expectations over their length of life are rational and adaptive (myopic). We examine for each of the economies and for each of the expectation assumptions whether policies exist that can offset the effects of aging, should they be adverse. Further, we examine how policies aimed at a specific target group affect the welfare of the economy as a whole.

"Population aging is the single most consistent pressure on federal income security spending, as public pension spending continues its relentless upward climb."

Douglas Young, former Canadian Minister of Human Resources Development

I. Introduction

The Social Security systems of the G7 countries were established in an era when populations were young and the number of contributors to the pay-as-you-go schemes far outweighed the number of beneficiaries. Over the post World War II period the systems have matured and the populations of the G7 countries have aged. Now, for each beneficiary there are fewer contributors, and this downward trend is projected to accelerate. To maintain benefit levels tax rates or productivity growth will have to rise. Evaluating the future of the systems, individual contributors express grave doubts that they will receive as they did give (Saito, 1998).

To evaluate the prospects for these economies we develop an overlapping generations model in which growth is endogenously fueled by individuals' investments in both physical capital, to fund their retirements, and human capital, to fund their children's education, and by the government's investment in human capital via public education expenditures. Individuals face uncertainty over their longevity. All old agents receive social security benefits, which are funded in a pay-as-you-go manner. We analyze individuals' behavior when their expectations over their length of life are rational or adaptive (myopic). Using simulations of our model in which parameter values are drawn from the individual economies of the G7, we examine for each of the economies and for each of the expectations assumptions whether policies exist that can offset the effects of aging, should they be adverse. Further, we examine how policies aimed at a specific target group, e.g. the elderly or the young, affect current and future welfare of the economy as a whole.

Our model is similar in construct to Kaganovich and Zilcha (1999), which also examines the effects of the public funding of social security and education on economic growth. We, however, take the constraints of the social security system (that benefits are determined as a replacement rate on wages, so benefits determine taxes) explicitly into account in our analysis. Thus we assume that the government, effectively, faces two budget constraints: a social security constraint and an education constraint, rather than the unified constraint with the explicit tradeoff assumed (more for social security implies less for education) by Kaganovich and Zilcha. Further, in their model, there is no uncertainty over length of life, a crucial component of our model.[1] Our model also differs from previous studies of myopia and public pensions in that we are not attempting to determine the optimal structure of the public pension system given myopia, as in Feldstein (1985) and Hu (1996). Rather our work takes the current systems in the G7 countries as given and examines the effects of myopia on economic growth and welfare, and looks for policies able to ameliorate those effects if adverse.

Our findings suggest that perfectly anticipated population aging, if slow enough, is beneficial to the economy as a whole and poses no threat to the solvency of the public pension system. This is because greater longevity induces higher rates of saving for retirement, even though taxes must be raised to maintain a given stream of benefits, and so increases the rate of economic growth and with it welfare. However, if population aging is perfectly anticipated but unduly rapid, economic welfare may fall and the social security system may become unsustainable. This is because to maintain benefits to the larger population of elderly the tax rate on the young must increase dramatically. Further, since their parents are living longer on average, the young receive a lower bequest on average. Both income effects reduce saving in terms of both human and physical capital by more than the age effect increases it. Growth

[1] For a nice review of the literature relating to social security, education, and their overlap, see Kaganovich and Zilcha (1999).

declines and with it social welfare. When agents are myopic both social welfare and growth are adversely affected since taxes rise but the positive age effect on saving is absent. Any policy targeted at the old, e.g. to maintain their standard of living over their individually unanticipated longer lives, will exacerbate the problem since taxes to fund such a program will reduce saving further. Policies directed at the very young, such as higher expenditures on public education, may generate some positive growth effects, but will not benefit the initial old, as the effects are felt only with a lag. Thus, for such policies to be able to offset the effects of both myopia and aging they must be put in place prior to the onset of aging.

II. The Model

Preliminaries

The model developed below is a variant of that developed in Pecchenino and Pollard (1998) and an extension of Pecchenino and Utendorf (1999),[2] and is similar to Kaganovich and Zilcha(1999). There is an infinitely-lived economy composed of finitely-lived individuals, firms, and a government. A new generation is born at the beginning of each period and lives for three periods divided into youth, middle age, and old age. Individual agents are identical and since there is no population growth, the size of each generation at birth can be normalized to unity. Let t index the period in which agents enter the workforce, and call these agents members of generation t.

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[2] Pecchenino and Utendorf solve a similar model under general functional form assumptions. As the results are not affected by the functional form assumptions we will assume specific functional forms throughout.

Consumers

At date t, agents in the first period of their lives, the young, do not consume, nor do they produce. They are, however, endowed with one unit of time that they combine inelastically with resources provided by their parents, $e(t)$, and the government, $e^g(t)$, to develop their human capital, $h_{t+1}(t+1)$. Agents in the second period of their lives, the middle-aged, supply their effective labor, the product of their one unit of time and their human capital developed in youth, inelastically to firms, for which they receive wage income, $w(t)h_t(t)$. They divide their after social security tax, $\tau(t)$, and school tax, $\omega(t)$, wage income plus any bequests, $B(t)$, they may receive, tax free, from their parents, between funding their children's human capital development, $e(t)$, their current consumption, $c_t(t)$, and saving, $s(t)$, for consumption when old, $c_t(t+1)$. Agents in the final period of their lives, the old, supply their savings, $s(t-1)$, inelastically to firms and consume their social security benefits, $T(t)$, and the return to their savings, $(1+\rho(t))s(t-1)$. With probability $p(t-1)$ an agent who worked during period $t-1$ will live throughout old age, and with probability $(1-p(t-1))$ the agent will die at the onset of old age. Agents may form expectations of living into old age rationally or adaptively (myopically). In the context of this model, rational expectations means that middle-aged agents know the probability of dying at the onset of old age, they have perfect foresight; adaptive expectations means that a middle-aged individual assumes that his life expectancy is a convex combination of the actuarial forecast, $p(t)$, the life expectancy of his parents' generation, $p(t-1)$, and, possibly of the life expectancy of his grandparent's generation, $p(t-2)$. If an agent dies at the onset of old age, his saving is bequeathed to the members of generation t, $B(t) = (1+\rho(t))s(t-1)$. Let $\hat{p}(t)$ be the member of generation t's assessment of life expectancy.

Let the preferences of a representative middle-aged worker at time t be represented by

$$U_t = \ln c_t(t) + \hat{p}(t)\ln c_t(t+1) + \delta \ln h_{t+1}(t+1) \tag{1}$$

Parents get utility from consumption and from educating their children, the value of this education is summarized by the child's human capital. This utility is derived from their "love of" or "duty to" their children rather than any personal return they may reap from their investment or any other strategic motive (see Cremer, et al., 1992). This *inter vivos* bequest motive encompasses the lifetime bequest motive.[3] Since agents do not know when they will die, additional unintentional bequests may be forthcoming.[4],[5]

Parental and government human capital investments are complements rather than substitutes, as both are essential for human capital formation. If a parent invests $e(t)$ in his child, and the government invests $e^g(t)$, then the child's human capital will be

(2) $$h_{t+1}(t+1) = e_t(t)^{\theta_1(t)}\, e^g(t)^{\theta_2(t)}\,.$$

The parameters $\theta_1(t)$ and $\theta_2(t)$ measure the elasticity of parental and government expenditures on human capital, respectively. This method of modeling educational attainment follows Hanushek's (1992) achievement function. Family and school expenditures, $e(t)$ and $e^g(t)$, respectively, as well as the

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[3] While other models endogenize both expenditures on children and bequests, e.g. Nishimura and Zhang (1992, 1995), they assume that income and interest rates are exogenous. In our model, where wages and interest rates are endogenous, introducing an end-of-life bequest motive makes the analysis intractable.

[4] The assumption of unintentional rather than altruistic bequests is consistent with empirical findings by numerous researchers as summarized by Hurd (1990). Laitner and Juster (1996) find support for intergenerational altruism but note that it is not the major explanation for saving.

[5] Assuming exogenous fertility and an altruistic bond between parents and their children runs counter to the empirical findings of Cigno and Rosati (1996). They find that parents are self-interested and choose their saving and fertility decisions without regard to their offspring. Given the similarities between our model and Pecchenino and Utendorf (1999), we believe that if we removed the altruistic bond between parents and children and funded education via intergenerational education loans, our results would continue to hold. Our model further differs from Barro (1974) and other dynastic models, such as Ehrlich and Lui (1991), in which parents internalize the lifetime utility of their children. In these models the effects of changes in taxes are negated via changes in bequests, and so are ill-suited to analyzing social security or publicly funded education. Our formulation is similar to the parent child utility linkage assumed in Boldrin (1993). We adopt it so that we can study the effects of changes in expected longevity on social security and education taxes in response to demographic changes.

efficiency of those expenditures, $\theta_1(t)$ and $\theta_2(t)$, which determine the quality of the component of education received from one's parent and the government, respectively, matter for human capital development. The utility a parent receives from the dependent child's human capital is $\delta \ln h_{t+1}(t+1)$, where δ is the discount placed on the child's human capital.

Firms

The firms are perfectly competitive profit maximizers that produce output using the production function $Y(t) = A(t)K(t)^{\alpha}H(t)^{1-\alpha}$, $\alpha \in (0, 1)$. $K(t)$ is the capital stock at t, which depreciates fully in the production process. $H(t)$ is the effective labor input at t, $H(t) = N(t)h_t(t)$, where $N(t)$ is labor hours. $A(t) > 0$ is a productivity scalar. The production function can be written in intensive form $y(t) = A(t)h_t(t)^{1-\alpha}k(t)^{\alpha}$ where $y(t)$ is per capita output and $k(t)$ is the capital labor ratio.

Since firms are competitive they take the wage, $w(t)$, and rental rate, $R(t)$, as given. The firms then hire labor and capital up to the point where their marginal products equal their factor prices.

(3) $$(1-\alpha)A(t)h_t(t)^{-\alpha}k(t)^{\alpha} = w(t)$$

(4) $$\alpha A(t)h_t(t)^{1-\alpha}k(t)^{\alpha-1} = R(t)$$

The Government

The government administers the social security program and funds education. It levies proportional income taxes, $\tau(t)$, on the middle-aged to finance social security expenditures and levies proportional income taxes, $\omega(t)$, on the middle-aged to fund education expenditures. Social security benefits are specified as a replacement rate on current workers wages. So,

$$T(t+1) = \xi(t)w(t+1)h_{t+1}(t+1)$$

where $T(t+1)$ are the transfers to the old at date $t+1$ and $\xi(t)$ is the replacement rate on wages for agents in middle age at t. There is no debt in the model so expenditures on social security and education must be fully funded through tax receipts at each period *t*. Since total social security benefits to the old must be balanced by social security tax revenues

(5) $$p(t)T(t+1) = p(t)\xi(t)w(t+1)h_{t+1}(t+1) = \tau(t+1)w(t+1)h_{t+1}(t+1) .$$

Solving equation (5) for $\tau(t+1)$ yields

(6) $$\tau(t+1) = p(t)\xi(t)$$

Total spending on education must equal total education tax revenues

(7) $$e^g(t) = w(t)h_t(t)\omega(t) .$$

III. Equilibrium

The representative agent takes as given his human capital, wages, return on saving, the social security and education tax rates, social security benefits, bequests, and government expenditures on education. The agent then chooses saving and education expenditures to maximize lifetime utility as given by equation (1) subject to (2) and the following budget constraints

(8) $$c_t(t) = w(t)h_t(t)(1-\tau(t)-\omega(t)) - s(t) - e(t) + (1-p(t-1))B(t)$$

(9) $$c_t(t+1) = (1+\rho(t+1))s(t) + T(t+1)$$

where constraint (8) encompasses the assumption that bequests are allocated equally across all members of a generation so that the bequest dependent wealth distribution is uniform, as in Hubbard and Judd (1987). This assumption allows us to conduct a representative agent analysis, and restricts uncertainty to the timing of death alone.

The first-order conditions for this maximization problem are

(10) $$s(t): -\frac{1}{c_t(t)} + \frac{\hat{p}(t)(1+\rho(t+1))}{c_t(t+1)} = 0$$

(11) $e(t): -\frac{1}{c_t(t)} + \frac{\delta\theta_1}{e(t)} = 0$.

Utility is maximized by equating the marginal rate of substitution between consumption and saving with the marginal rate of substitution between consumption and parental expenditures on their child's human capital development.

The goods market clears when the demand for goods for either consumption or savings equals the supply of goods.

(12) $c_t(t) + p(t-1)c_{t-1}(t) + s(t) + e(t) + e^g(t) = w(t)h_t(t) + R(t)k(t)$

Substituting equations (3), (4) and (6), (7), (8) and (9) into (12), and making use of the fact that by arbitrage the return on capital must equal the return on saving

(13) $R(t) = 1 + \rho(t)$

yields

(14) $s(t-1)=k(t)$.

Savings at time *t-1* totally determines the capital stock at time *t*.

Definition: A competitive equilibrium for this economy is a sequence of prices and taxes $\{\mathrm{w(t)}, \rho\mathrm{(t)}, \mathrm{R(t)}, \tau\mathrm{(t)}, \omega\mathrm{(t)}\}_{\mathrm{t=0}}^{\infty}$, a sequence of allocations $\{c_t(t), c_t(t+1)\}_{t=0}^{\infty}$ and a sequence of human and physical capital stocks, $\{h_t(t), k(t)\}_{t=0}^{\infty}$, $k(0)$, $h_0(0)>0$ given, such that given agents and the government's expectations over longevity, and given these prices, allocations, and capital stocks, agents' utility is maximized, firms' profits are maximized, the government budget constraints are satisfied, and markets clear.

The equilibrium is fully characterized by the following set of difference equations in *k(t+1), e(t)* and predetermined variables.

(15) $$\frac{\hat{p}(t)}{\left[1+\frac{(1-\alpha)\xi(t)}{\alpha}\right]k(t+1)} -$$

$$\frac{1}{A(t)[(1-p(t-1)\xi(t-1)-\omega(t))(1-\alpha)+(1-p(t-1))\alpha]e(t-1)^{\theta_1(t)(1-\alpha)}e^g(t-1)^{\theta_2(t)(1-\alpha)}k(t)^{\alpha}-e(t)-k(t+1)}=0$$

and

(16) $$\frac{\delta\theta_1}{e(t)} -$$

$$\frac{1}{A(t)[(1-p(t-1)\xi(t-1)-\omega(t))(1-\alpha)+(1-p(t-1))\alpha]e(t-1)^{\theta_1(t)(1-\alpha)}e^g(t-1)^{\theta_2(t)(1-\alpha)}k(t)^{\alpha}-e(t)-k(t+1)}=0$$

IV. The Analytics of Growth

As is shown in the Appendix, the equilibrium behavior of the economy can be characterized by a single equation

(17) $$k(t+1) = Z(t)k(t)^{\alpha+(\theta_1(t)+\theta_2(t))(1-\alpha)}$$

where

$$Z(t) = \left(\frac{\delta\theta_1(t)}{\varphi(t)+\delta\theta_1(t)(1+\varphi(t))}\right)\left[(1-p(t-1)\xi(t-1)-\omega(t))(1-\alpha)+(1-p(t-1))\alpha\right]A(t)\varphi(t-1)^{\theta_1(t-1)(1-\alpha)} \cdot$$
$$\left(\frac{(1-\alpha)\omega(t-1)}{\frac{\delta\theta_1(t-1)}{\varphi(t-1)+\delta\theta_1(t-1)(1+\varphi(t-1))}[(1-p(t-2)\xi(t-2)-\omega(t-1))(1-\alpha)+(1-p(t-2))\alpha]}\right)^{\theta_2(t-1)(1-\alpha)}$$

and

$$\varphi(t) = \frac{\delta\theta_1(t)}{\hat{p}(t)}\left[1+\frac{(1-\alpha)\xi(t)}{\alpha}\right].$$

The economy exhibits balanced growth if $\theta_1(t) + \theta_2(t) = 1$ and $Z(t) > 1$ for all t.

Proposition 1: Along a balanced growth path (where all parameter values are time independent), economies with higher education taxes, ω, will have higher growth rates if $\theta_2[(1-p\xi)(1-\alpha)+(1-p)\alpha] > \omega$.

Proof: See Appendix.

The education tax, ω, represents the marginal cost of public education while the marginal benefit to the taxpayer is the marginal increase in income in middle-age, $[(1-p\xi)(1-\alpha)+(1-p)\alpha]$ discounted by the marginal efficiency of the government's educational input, θ_2. So long as the discounted marginal benefit exceeds the marginal cost, agents receive a positive steady-state income effect from an increase in the education tax rate, leading to increases in saving and investment in one’s children’s human capital. However, if the marginal cost exceeds the discounted marginal benefit, both saving and human capital investment fall. Thus, as Hanushek (1986) suggests, the value of education is higher the better are the teachers, here measured by θ_2, the quality of government funded education. Clearly, if the economy is not on a balanced growth path , because of, for example, increases in longevity, increases in the education tax from a suboptimal towards a growth maximizing level can have growth increasing effects so long as the positive human capital effect tomorrow exceeds the negative physical capital effect today.

Proposition 2: Along balanced growth paths, economies with higher aged-dependency ratios, higher p, have either higher or lower equilibrium growth rates.

Proof: See Appendix.

Increasing the expected lifespan has both negative and positive effects on equilibrium capital accumulation. If agents live longer, then, all else equal (including the age of retirement), they consume a higher proportion of their saving and leave less to their children. This reduces expected income for middle aged agents, leading to reductions in saving. While this bequest effect reduces saving, an age effect does the opposite, leading to increased saving to fund a longer retirement. Since social security taxes increase as the population ages, the middle aged's income falls compounding the negative bequest effect. This effect would be compounded if labor supply were elastic, as some agents would choose to work less in response to the higher taxes.[6] Thus, the effect on physical capital accumulation is ambiguous. Thus, suppose at date *t* agents plan for the future expecting their parents to live as long as their grandparents did, and they to live as long as their parents: an unchanged demographic structure. If they live longer than they expect, their saving will be inadequate to fund their longer life at the anticipated level of consumption. Further, the bequests they leave to their children will be smaller, leaving them with less income out of which to save, still less once social security taxes have adjusted to the increased longevity, if anticipated by the government. Even one generation of unexpectedly long-lived agents can have permanent effects on the height of the growth path, if not on the long-run equilibrium level of growth. In the next section we examine the effects of population aging, and the expectations thereof, on growth and economic welfare.

V. Simulations: System Sustainability and Social Welfare

We begin by calibrating the model to match the growth experiences of each of the G7 economies. The initial values for the parameters in the model are given in Table 1 and the equations for growth are set out in the Appendix. Each period is a generation, which we set equal to 25 years. The share of physical capital, α, is 0.30 for all countries. The weight given by parents in their utility functions to the

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[6] All our results concerning the growth and welfare effects of tax changes give lower bounds on the tax effects under our assumption of inelastic supply of labor. Clearly, for small changes in taxes this assumption may be reasonable, but this is not the case for the large changes in taxes forecast for many countries as they try to maintain their Social Security systems in the face of population aging.

human capital development of their children, δ, is 0.98, again for all countries. The education tax rate, ω, is the 1990 ratio of public expenditures on all levels of education to GDP adjusted for labor's share in output (OECD, 1996). The replacement rate, ξ, is the average public pension benefit as a percent of average gross wage in 1995 (Chand and Jaeger, 1996). France, Germany and Italy have the most generous public pension systems with replacement rates greater than 50 percent. Japan and the United Kingdom have the least generous system with replacement rates below 20 percent.

The aged-dependency ratio, *p*, is the 1995 ratio of public pension system beneficiaries to contributors (Chand and Jaeger, 1996). Italy has the most beneficiaries relative to contributors (0.77); for all other countries $p<0.5$. The United States has the fewest beneficiaries relative to contributors (0.24).

Table 1
Baseline Parameter Values

Parameter	*Canada*	*France*	*Germany*	*Italy*	*Japan*	*U.K.*	*U.S.*
α	0.30	0.30	0.30	0.30	0.30	0.30	0.30
δ	0.98	0.98	0.98	0.98	0.98	0.98	0.98
ξ	0.292	0.601	0.520	0.539	0.196	0.175	0.375
ω	0.089	0.073	0.059	0.074	0.051	0.070	0.074
p	0.28	0.40	0.43	0.77	0.38	0.37	0.24
θ_2	0.708	0.808	0.885	0.762	0.921	0.651	0.736
Growth of output	0.027	0.021	0.021	0.026	0.034	0.020	0.017

The parameter θ_2 measures the elasticity of governmental expenditures on education. We use the secondary school graduation rate to measure this (OECD, 1996). For balanced growth $\theta_1+\theta_2=1$. Thus, our choice of θ_2 ties down the value of θ_1.

Using these parameter values and setting the growth rate of the economy at its long run average rate allows us to determine the value of the constant, *A*, in the production function.[7] We then introduce population aging and re-simulate the model, keeping all other variables, including *A*, at their initial values. Specifically, we assumed that each generation through those entering the workforce at $t=j-1$ had $p(t)=p$ probability of living through old age. For the generations j, $j+1$ and $j+2$, the probability of living through old-age increases to the values found in Table 2 (Chand and Jaeger, 1996).[8] For all future generations $p(t) = p(j+2)$. The parameter $p(t)$ captures both the projected increases in longevity and the declines in birth rates. In all countries, as the population ages social security taxes rise to maintain the replacement rate as shown in equation (6).

Table 2
Aged-Dependency Ratios: Perfect Foresight

Parameter	*Canada*	*France*	*Germany*	*Italy*	*Japan*	*U.K.*	*U.S.*
$p(j-1)$	0.28	0.40	0.43	0.77	0.38	0.37	0.24
$p(j)$	0.34	0.42	0.50	0.71	0.48	0.40	0.24
$p(j+1)$	0.59	0.63	0.83	1.11	0.56	0.48	0.40
$p(j+2)$	0.63	0.71	0.83	1.42	0.67	0.48	0.43

Perfect Foresight

As the population ages, we assume first that agents have perfect foresight: they know the relevant value of *p* for their generation, that is, $\hat{p}(t) = \mathrm{p}(t)$. When individuals perfectly foresee a longer life, they have the incentive to save more to prepare for it; however, because their taxes to pay for higher social security benefits rise, and their bequests from their longer lived parents fall, they have less income from

[7] The growth rate is based on the growth of real per capita GDP over the period 1970-90 (Summers and Heston, 1991).

[8] The projected aged-dependency ratios for Italy given in Chand and Jaeger rise above 1.0 in periods $j+1$ and $j+2$. We suspect that Chand and Jaeger's values reflect the adverse formal sector labor supply effects of higher social security taxes, which we abstract from in our model. However, we find that for $p(j+i)<1$, Italy's system is unsustainable.

which to save. In all of the G7 countries when aging occurs the former effect initially dominates and growth rises relative to the baseline.[9] In the long run the net effect on saving and growth for Canada, Japan, the UK and the US is positive, Figure 1. For France, Germany and Italy, high aged-dependency ratios, *p*, in conjunction with generous replacement rates, ξ, result in a negative effect on long-run growth.

Individuals prefer a longer life relative to a shorter life and so, ceteris paribus, a perfectly anticipated increase in *p* has a positive effect on lifetime utility, as evident from equation (1). If aging increases growth relative to the baseline (Canada, Japan, United Kingdom and United States) then lifetime consumption rises. In these countries both the direct and indirect effects of an increase in *p* on lifetime utility are positive and so utility rises, Figure 2. If, however, aging reduces growth relative to the baseline (France, Germany and Italy) then consumption falls. In these countries, the net effect on utility depends on the relative strength of the two effects. In France and Germany, the benefits of a longer life outweigh any reductions in growth so social welfare rises, Figure 2. In Italy the burden of an aging population in combination with a generous public pension system results in a decline in lifetime utility. The decline in the growth rate and in lifetime utility in Italy indicates that the public pension system is unsustainable in the long run.[10]

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[9] In the United States $p(j-1) = p(j)$ resulting in no initial change in the growth rate. In Italy $p(j-1)>p(j)$ resulting in an initial decline in the growth rate.

[10] The long-run infeasibility of the Italian pension system occurs whenever $p(j+1)$ and $p(j+2)$ are 0.8 or higher. At these values maintaining pension levels reduces saving dramatically so that growth rates become negative and economy collapses. Raising these p values above .8 reduces the time before the infeasibility becomes apparent.

Adaptive (Myopic) Expectations

We next conduct a number of simulations under alternative assumptions on individuals' expectations of their longevity and compare these to the perfect foresight results. To do so we assume that a middle-aged agent assumes that his life expectancy is a convex combination of the actuarial forecast, *p(t)*, the life expectancy of his parents' generation, *p(t-1)*, and, possibly the life expectancy of his grandparent's generation, *p(t-2)*. Thus, define

(18) $\hat{p}(t) = \lambda_1 p(t) + \lambda_2 p(t-1) + \lambda_3 p(t-3)$

where $\lambda_1, \lambda_2, \lambda_3 \leq 1$ and $\lambda_3 = 1 - \lambda_1 - \lambda_2$.

We present results for three possible combinations of the λs. The first specification is $\lambda_3 = 1$. Individuals assess their probability of living into old age as equivalent to that of their grandparent's generation. The second specification is $\lambda_2 = 1$. Individuals assess their probability of living into old age as equivalent to that of their parent's generation. The third specification is $\lambda_1 = \lambda_2 = 0.5$. In this case individuals place equal weight on the actuarial forecast and the experience of their parent's generation in assessing their own life expectancy. In all three specifications, upon reaching old age, the true *p* is revealed. If agents are myopic, p(t)> $\hat{p}(t)$, in order to maintain balance in the social security system (holding ξ fixed) the government raises the tax rate, τ.

Myopia is harmful both to an economy's growth rate and social welfare. This is because when an economy ages, and this aging is not taken into account, agents do not save adequately for their, unanticipated, longer lives, and they receive smaller bequests from their longer-lived parents which further reduces their saving.[11] Increasing social security taxes to maintain the benefits of the elderly reduces the take home wages of the workers, which reduces their saving even further.

Because, in our model, no further aging occurs after period $t=j+2$, the growth rate of a myopic economy will converge to the perfect foresight long run equilibrium value. The capital stock, however, remains below the perfect foresight level as a result of the inadequate savings of the initial generations. Consequently, lifetime utility never attains the perfect foresight levels, as shown in Figures 3a-g. The worst long-run deviation is that for Germany. When $\lambda_2=1$ the lifetime utility for generation $j+8$ is 3.8 percent below perfect foresight utility.

The greater the degree of myopia, which we define as the greater the weight on λ_3, the greater the loss in welfare. When $\lambda_3=1$ the effects of myopia on welfare are so severe initially that generation $j+1$ and possibly $j+2$ would prefer that p had not increased. That is, lifetime utility for these myopic generations is below the baseline utility.

Education Taxes

Faced with a myopic population, is there any means available to a government to effect higher rates of saving? In our model, any forced saving plan, such as government imposed mandatory pensions, would have the effect of reducing individuals own saving one-to-one (or more than one-to-one if the return on government pensions exceeds the return on own saving). Thus, to achieve an increase in saving, government mandates would have to cause individuals to save in excess of their desired amount. While this may make them better off in an ex post sense, it will not make them better off ex ante.

Evidence from the Australian superannuation funds (the privatized portion of its pension system) provides support for the inability of governments to force an increase in saving. In the first five years

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[11] In our model myopic individuals do save for retirement, but their savings are inadequate given the increase in *p*. This is different from the general assumption in public pension models that myopic agents save nothing for retirement. See for example, Feldstein (1985) and Hu (1996).

since contributions to the system became mandatory the $110 billion in accumulated assets were mostly offset by borrowings (*The Economist*, 1998).

If, however, the government increases the education tax prior to the onset of aging, individuals are forced to save, in terms of their children's human capital accumulation, but do not view paying the tax as forced saving. This generates improvements in growth and social welfare. Figure 4 shows the effects of a 10 percent increase in the education tax rate in each of the G-7 countries on lifetime utility when myopia is most severe ($\lambda_3=1$). This policy works precisely because the actual education taxes, those in the baseline analyses, are below their optimal levels. If the tax rates were above their optimal levels, a reduction of these taxes would have a similar beneficial effect.

The 10 percent increase in the education tax not only increases lifetime utility relative to the unchanged tax scenario, but relative to the baseline, for all countries except Italy. This result holds for all variations of the λs. For Italy, the increase in the education tax delays but does not eliminate the unsustainability of the pension system.

Trust Fund

Another way to handle myopia is through the use of a trust fund. The value of a trust fund in any period t, is the difference between revenues and expenditures of the public pension system and the gross return on any accumulated balances. The trust fund is equivalent to government savings.

$$s^g(t) = \tau(t)w(t)h_t(t) - p(t-1)\xi(t-1)w(t)h_t(t) + (1+\rho(t))s^g(t-1)$$

Since $\tau(t) = p(t-1)\xi(t-1) + \gamma(t)$, where $\gamma(t)$ is the increase in the social security tax rate to support pre-funding of benefits, the above equation can be rewritten as

(17) $$s^g(t) = \gamma(t)w(t)h_t(t) + (1+\rho(t))s^g(t-1)\,.$$

The capital stock at time *t* is now a combination of private saving *s(t-1)* and public saving $s^g(t-1)$. So the goods market clearing equation (14) is now $s(t-1) = k(t) - s^g(t-1)$.

The trust fund system can be set up in two ways. The first is to raise $\tau(t)$ by setting $\gamma(t)>0$ and lower τ in period $t+1$ and possible $t+2$ and on without changing ξ. This always lowers lifetime utility for generation t relative to the non-trust fund myopia case since this generation sees its taxes rise without any offsetting increase in the replacement rate and thus is not Pareto improving.

The second method is to raise $\tau(t)$ by setting $\gamma(t)>0$ and increase $\xi(t)$. Under a one-generation trust fund, the replacement rate, $\xi(t)$, is chosen so that the trust fund is exhausted in period $t+1$. Using this scheme it is possible to find a $\gamma(t)$ and $\xi(t)$ combination such that the lifetime utility of generation t improves relative to the myopic no trust fund case. However, the increase in the tax rate and the rise in the replacement rate lower private savings by more than the increase in government saving. As a result total savings declines and future generations are made worse off. Because of this negative effect on private saving, it is not possible to continuously pre-fund the system through higher taxes and replacement rates in a Pareto optimal fashion.

Sensitivity Tests

We tested the sensitivity of these results to the values chosen for several of the parameters in the model. First, we increased the value of α in the model from 0.3 to 0.4. This change had no effect on the nature of the results. Next we changed the value of δ in the model, lowering it from 0.98 to 0.75 and then to 0.50. Lowering the value of δ in the model produced the same general results as when δ=0.98. Given the uncertainty regarding the true value of θ_2, the elasticity of governmental expenditures on education, we reran the simulations using two alternative measures. We used θ_2=0.75 and θ_2=0.50 for each of the countries. Reducing the effectiveness of governmental expenditures on education did not affect the results in a qualitative manner. However, combining a low θ_2 (0.5) with a low weight on one's children's human capital, δ=0.75, for example, increases the likelihood that aging will have a negative effect on the growth rate even when perfectly anticipated. In France and Germany this combination eventually lowers lifetime utility, even under perfect foresight, thus rendering the pension system unsustainable. These two countries, like Italy, have generous pension systems in conjunction with rapidly aging populations. These two factors increase the vulnerability of the pension systems.

VI. Conclusion

This paper examines the role of aging and expectations in determining the viability of public pension systems in the G7 countries. Over a period of three generations the proportion of retirees relative to workers rises and then remains constant. The government attempts to maintain the generosity of the public pension system by fixing the replacement rate at its pre-aging rate. We examine the effects of this policy in aging economy on growth and welfare under alternative assumptions on individuals' expectations of longevity.

If individuals fully anticipate population aging and hence increase saving for retirement then aging need not reduce the growth rate of the economy. Given perfect foresight growth declines only if there is a rapidly aging economy in conjunction with a generous public pension system. If individuals have perfect foresight and prefer a longer life to a shorter life, aging does not reduce welfare, even if the growth rate falls. However, if a country's public pension system is very generous and aging is rapid, the system will become unsustainable even if labor supply decisions are unaffected by the increase in taxes.

If individuals are myopic then growth and welfare falls relative to the perfect foresight economy and the non-aging economy. With adaptive (myopic) expectations the growth rate of the economy will, in the long run, match the perfect foresight growth rate. Welfare, however, will remain below that of perfect foresight. Given a myopic population, few policies are available to the government to offset the adverse growth and welfare effects. However, the government can raise the growth rate and welfare by inducing saving through human capital development, i.e. raising the education tax rate. Such a policy, however, must be in place prior to the onset of aging.

While myopia in our model results from agents' failure to fully account for changing demographics, the effects on saving are similar to models in which consumers fail to adjust to changes in fiscal policies. Poterba (1988) for example, notes that while the U.S. Social Security reforms enacted in 1983 reduced the present value of benefits for young workers there is little evidence that these changes have had any effect on saving behavior. These results indicate that myopia rather than aging is primarily responsible for reducing growth and welfare when countries maintain their pay-as-you-go social security systems as the population ages.

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Appendix - Growth

From (15) and (16)

(A1) $e(t) = \varphi(t)k(t+1)$

where $\varphi(t) = \frac{\delta\theta_1(t)}{\hat{p}(t)}\left[1 + \frac{(1-\alpha)\xi(t)}{\alpha}\right]$.

Combining (A1) and (16) yields

(A2)

$$k(t+1) = \frac{\delta\theta_1(t)}{\varphi(t) + \delta\theta_1(t)(1+\varphi(t))} *$$
$$\left[(1 - p(t-1)\xi(t-1) - \omega(t))(1-\alpha) + (1 - p(t-1))\alpha\right]A(t)\varphi(t-1)^{\theta_1(t-1)(1-\alpha)} e^g\,(t-1)^{\theta_2(t-1)(1-\alpha)}\,k(t)^{\alpha+\theta_1(t-1)(1-\alpha)}$$

From (7), (3), and (A2)

(A3) $$e^g(t) = \frac{(1-\alpha)\omega(t)k(t+1)}{\frac{\delta\theta_1(t)}{\varphi(t) + \delta\theta_1(t)(1+\varphi(t))}\left[(1 - p(t-1)\xi(t-1) - \omega(t))(1-\alpha) + (1 - p(t-1))\alpha\right]}$$

Lag (A3) and substitute it into (A2) to yield

(A4) $k(t+1) = Z(t)k(t)^{\alpha+(\theta_1(t)+\theta_2(t))(1-\alpha)}$

where

$$Z(t) = \left(\frac{\delta\theta_1(t)}{\varphi(t) + \delta\theta_1(t)(1+\varphi(t))}\right)\left[(1 - p(t-1)\xi(t-1) - \omega(t))(1-\alpha) + (1 - p(t-1))\alpha\right]A(t)\varphi(t-1)^{\theta_1(t-1)(1-\alpha)} \cdot$$
$$\left(\frac{(1-\alpha)\omega(t-1)}{\frac{\delta\theta_1(t-1)}{\varphi(t-1) + \delta\theta_1(t-1)(1+\varphi(t-1))}[(1 - p(t-2)\xi(t-2) - \omega(t-1))(1-\alpha) + (1 - p(t-2))\alpha]}\right)^{\theta_2(t-1)(1-\alpha)} .$$

So, when $Z > 1$ and $\theta_1 + \theta_2 = 1$, then $k(t+1) > k(t)\ \forall t$.

Along a balanced growth path

$$Z = \left(\frac{\delta\theta_1}{\varphi + \delta\theta_1(1+\varphi)}\right)^{1-\theta_2(1-\alpha)} \left[(1-p\xi-\omega)(1-\alpha)+(1-p)\alpha\right]^{1-\theta_2(1-\alpha)} [(1-\alpha)\omega]^{\theta_2(1-\alpha)} A\varphi^{\theta_1(1-\alpha)} .$$

Proof of Proposition 1: Differentiating Z with respect to ω yields

$$Z(1-\alpha)\left\{\frac{\theta_2}{\omega} - \frac{[1-\theta_2(1-\alpha)]}{(1-p\xi-\omega)(1-\alpha)+(1-p)\alpha}\right\} > 0$$

if

$$\theta_2[(1-p\xi)(1-\alpha)+(1-p)\alpha] > \omega .$$

Proof of Proposition 2: Differentiating Z with respect to p (where $\hat{p} = p$) yields

$$[(1-\alpha)\omega]^{\theta_2(1-\alpha)} A \left\{ \begin{array}{l} \left(\frac{\delta\theta_1}{\varphi+\delta\theta_1(1+\varphi)}\right)^{1-\theta_2(1-\alpha)} \left[(1-p\xi-\omega)(1-\alpha)+(1-p)\alpha\right]^{1-\theta_2(1-\alpha)} \theta_1(1-\alpha) * \\ \qquad \varphi^{\theta_1(1-\alpha)-1}\left(\frac{\partial\varphi}{\partial p}\right) - \\ \left(\frac{\delta\theta_1}{\varphi+\delta\theta_1(1+\varphi)}\right)^{1-\theta_2(1-\alpha)} \varphi^{\theta_1(1-\alpha)}(1-\theta_2(1-\alpha))\left[(1-p\xi-\omega)(1-\alpha)+(1-p)\alpha\right]^{-\theta_2(1-\alpha)} * \\ \qquad (\xi(1-\alpha)+\alpha) - \\ \left[(1-p\xi-\omega)(1-\alpha)+(1-p)\alpha\right]^{1-\theta_2(1-\alpha)} \varphi^{\theta_1(1-\alpha)}[1-\theta_2(1-\alpha)]\left(\frac{\delta\theta_1}{\varphi+\delta\theta_1(1+\varphi)}\right)^{-\theta_2(1-\alpha)} * \\ \qquad \left(\frac{\delta\theta_1(1+\delta\theta_1)\frac{\partial\varphi}{\partial p}}{[\varphi+\delta\theta_1(1+\varphi)]^2}\right)^{1-\theta_2(1-\alpha)} \end{array} \right\}$$

The first bracketed term is negative, since $\partial p/\partial\varphi<0$, the second term is also negative, while the third term is positive. The overall sign is ambiguous.

Figure 1

Growth Rate under Perfect Foresight

Percentage Point Deviation from baseline

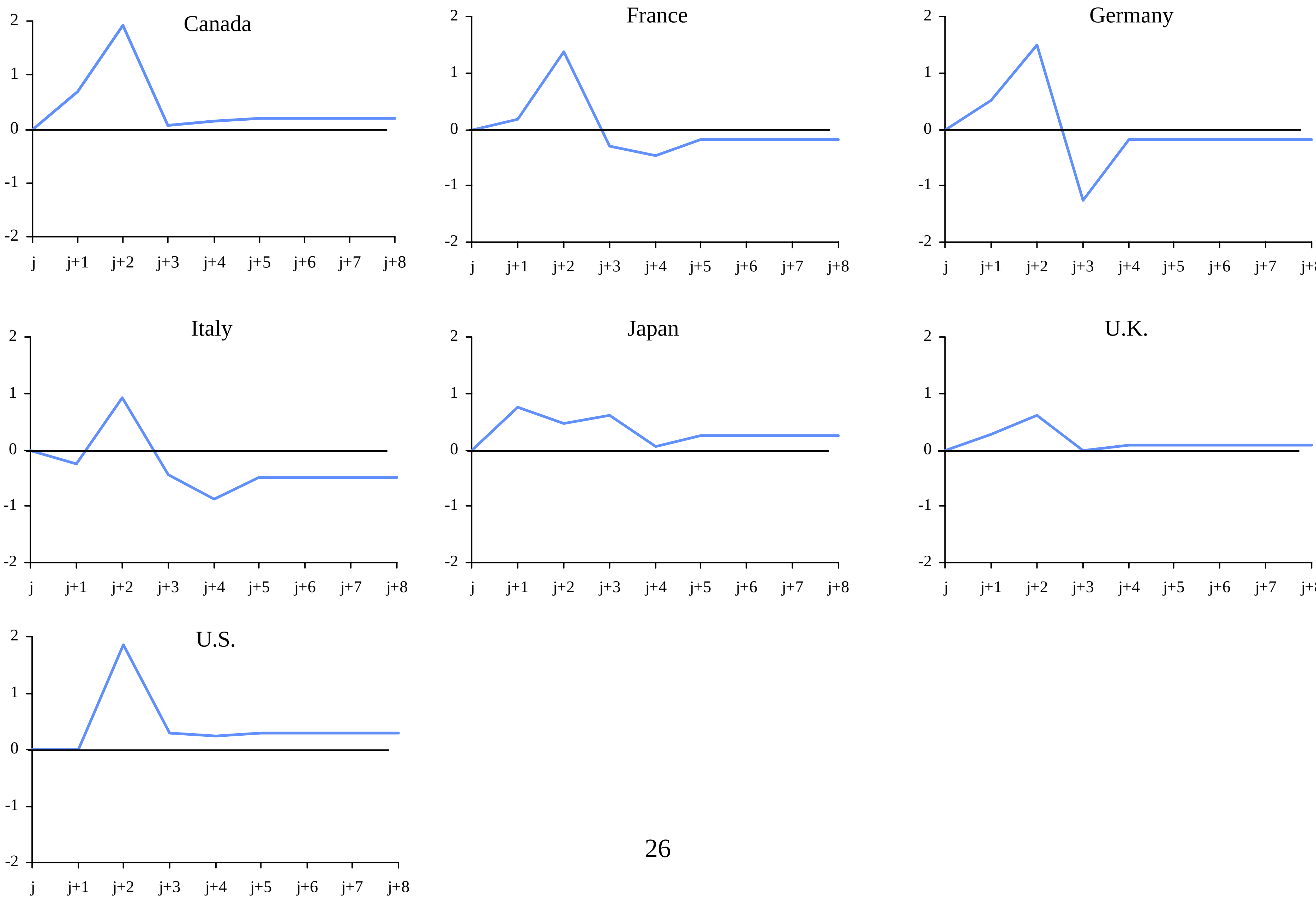

Figure 2

Lifetime Utility under Perfect Foresight

Deviation from baseline

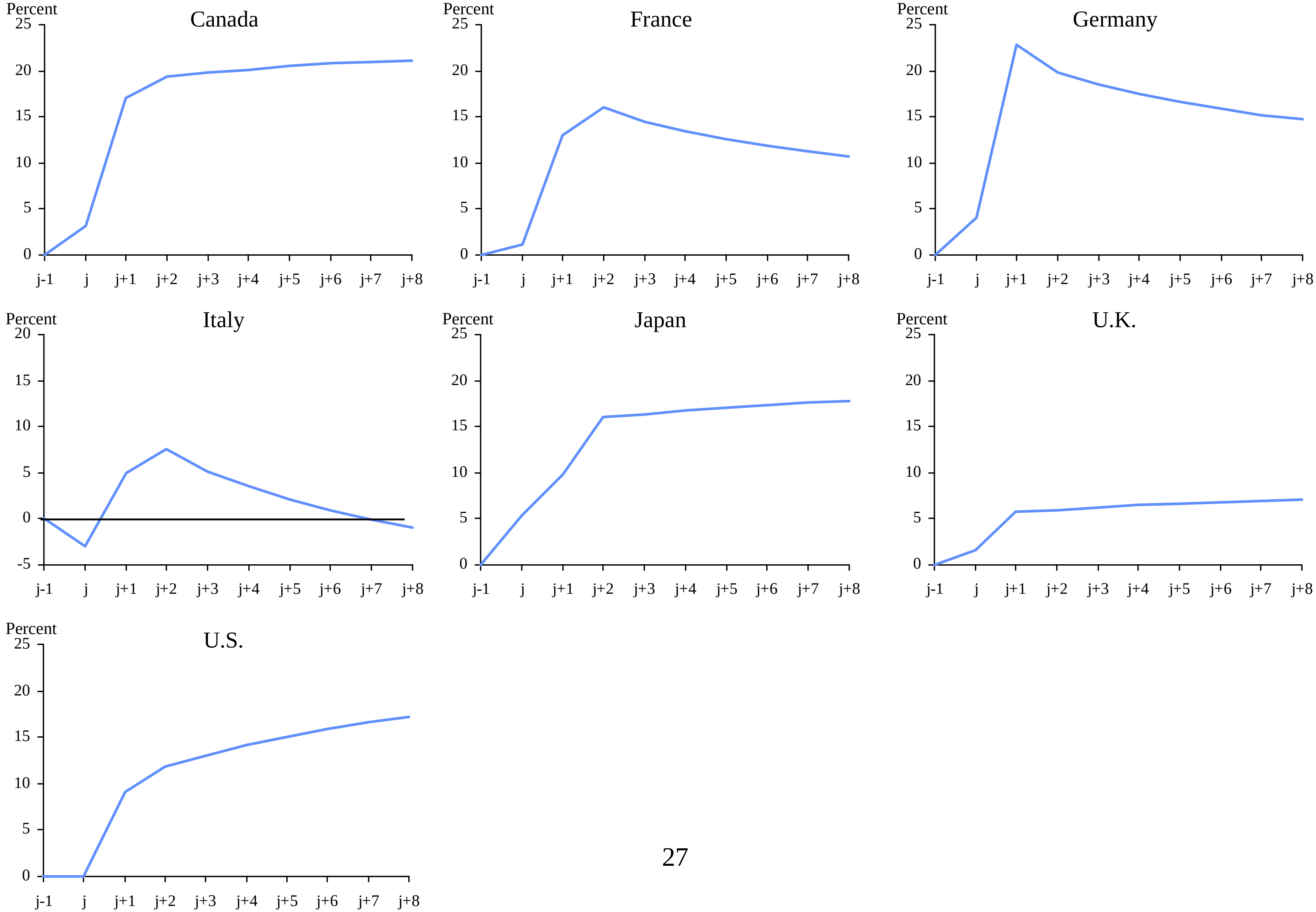

Figure 3a

Lifetime Utility - Canada

Deviation from perfect foresight

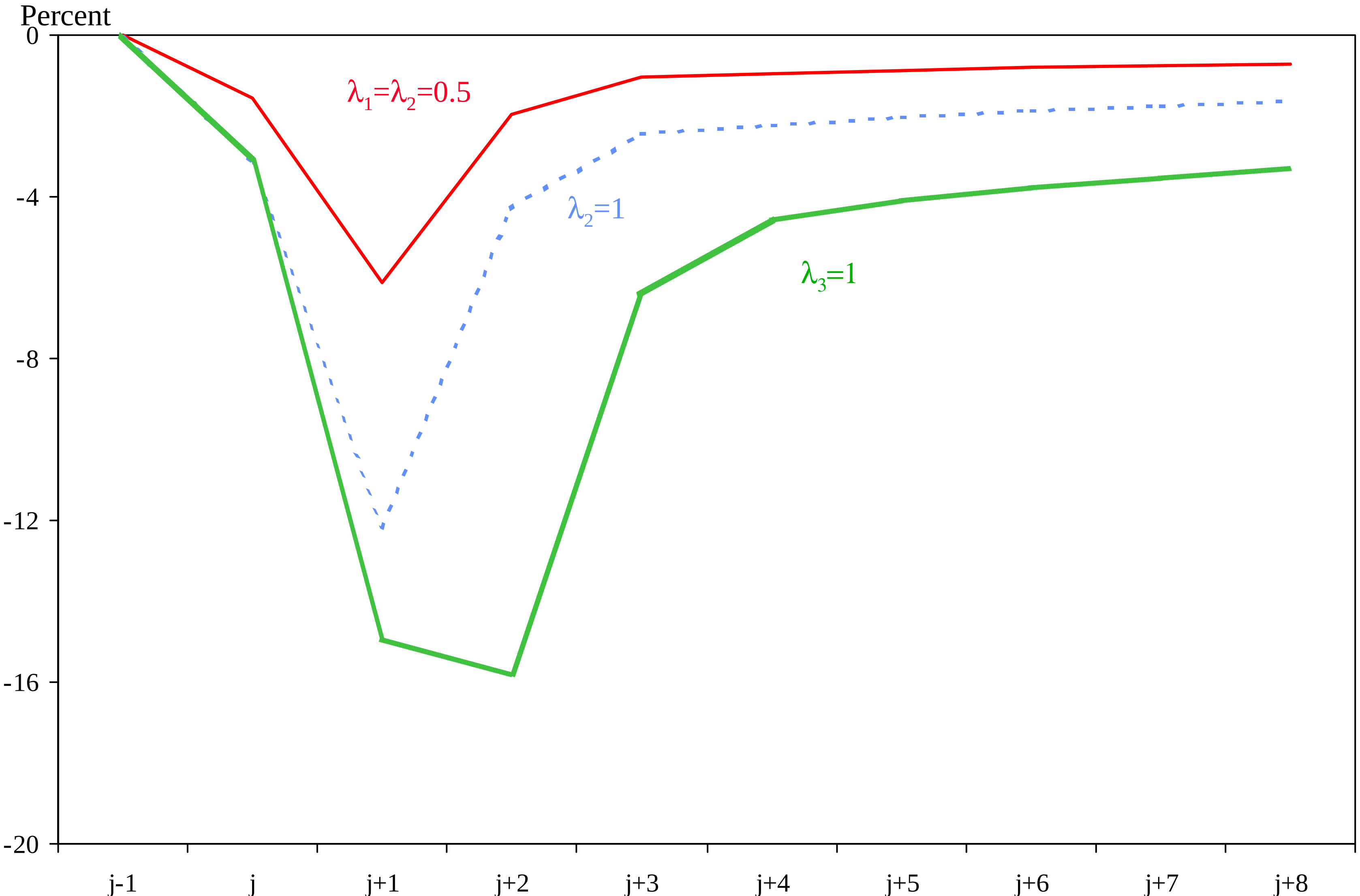

Figure 3b

Lifetime Utility - France

Deviation from perfect foresight

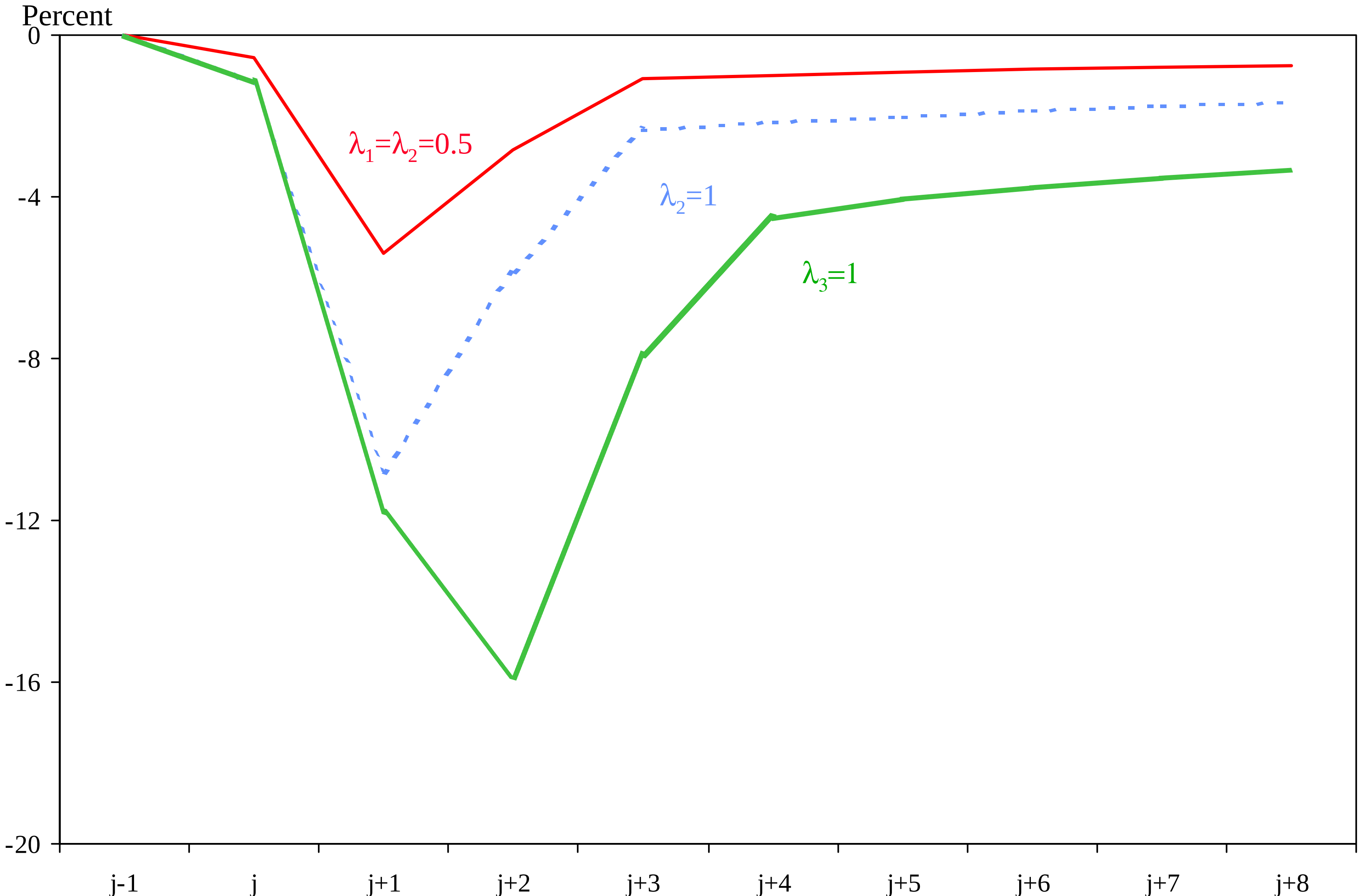

Figure 3c

Lifetime Utility - Germany

Deviation from perfect foresight

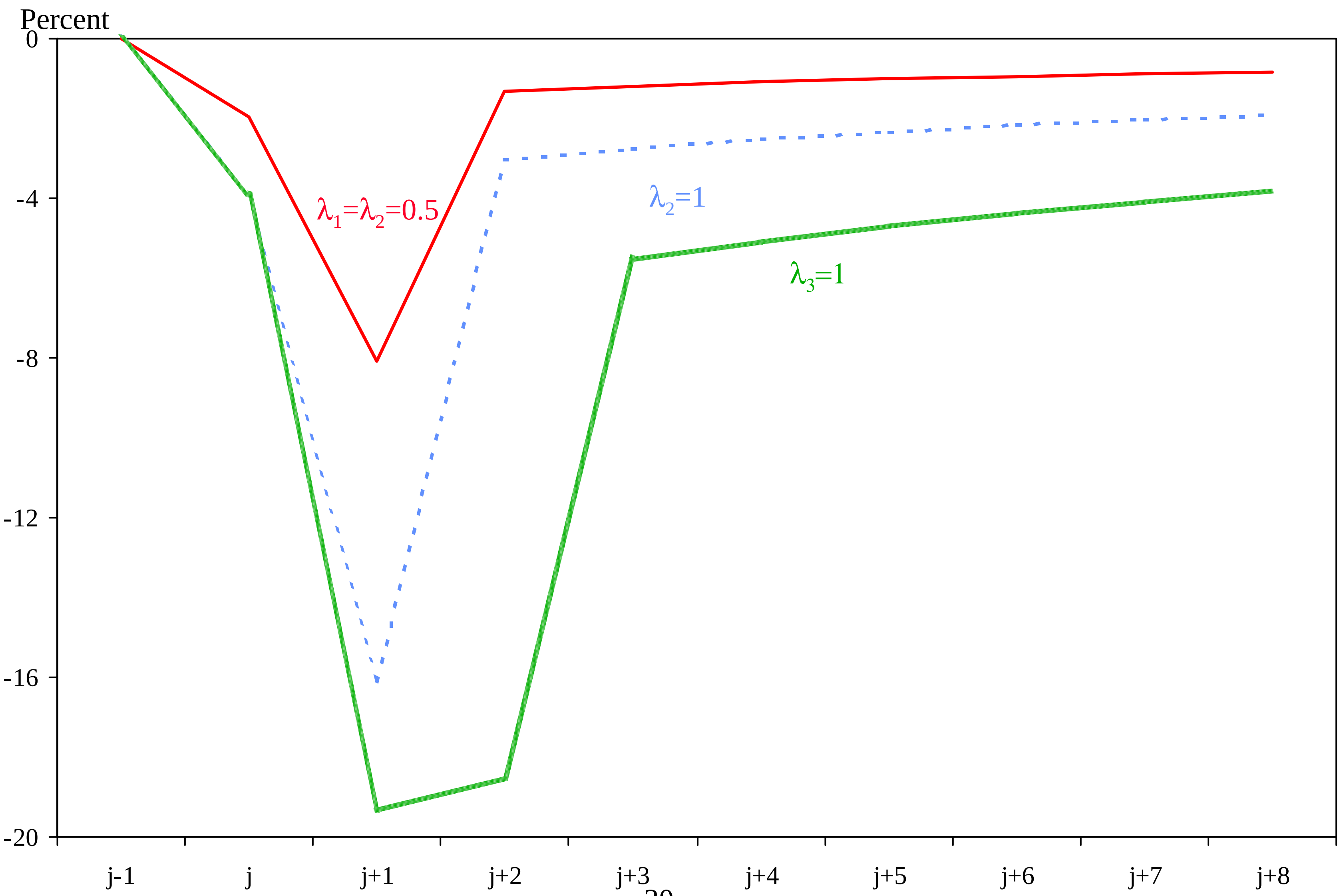

Figure 3d

Lifetime Utility - Italy

Deviation from perfect foresight

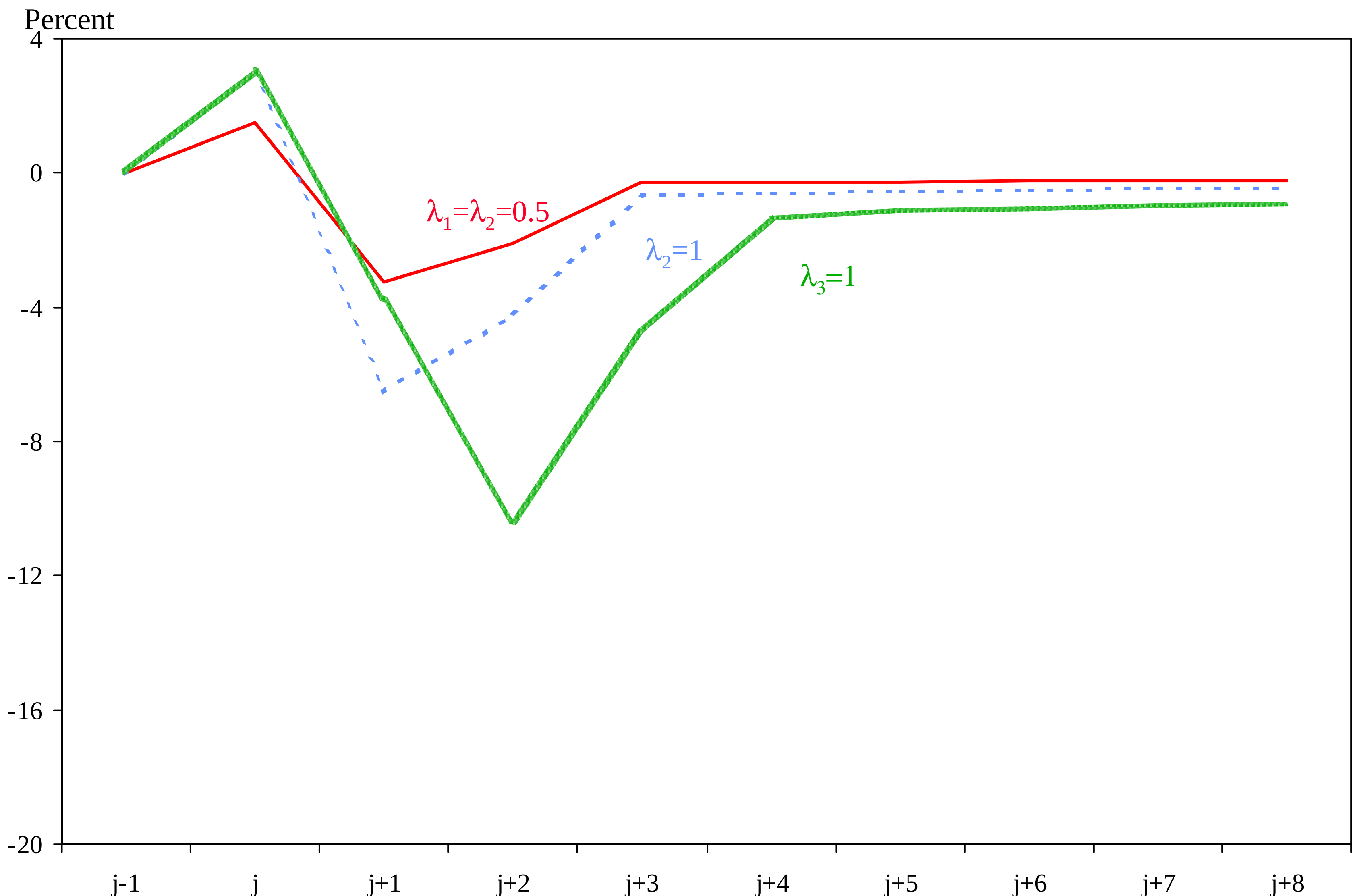

Figure 3e

Lifetime Utility - Japan

Deviation from perfect foresight

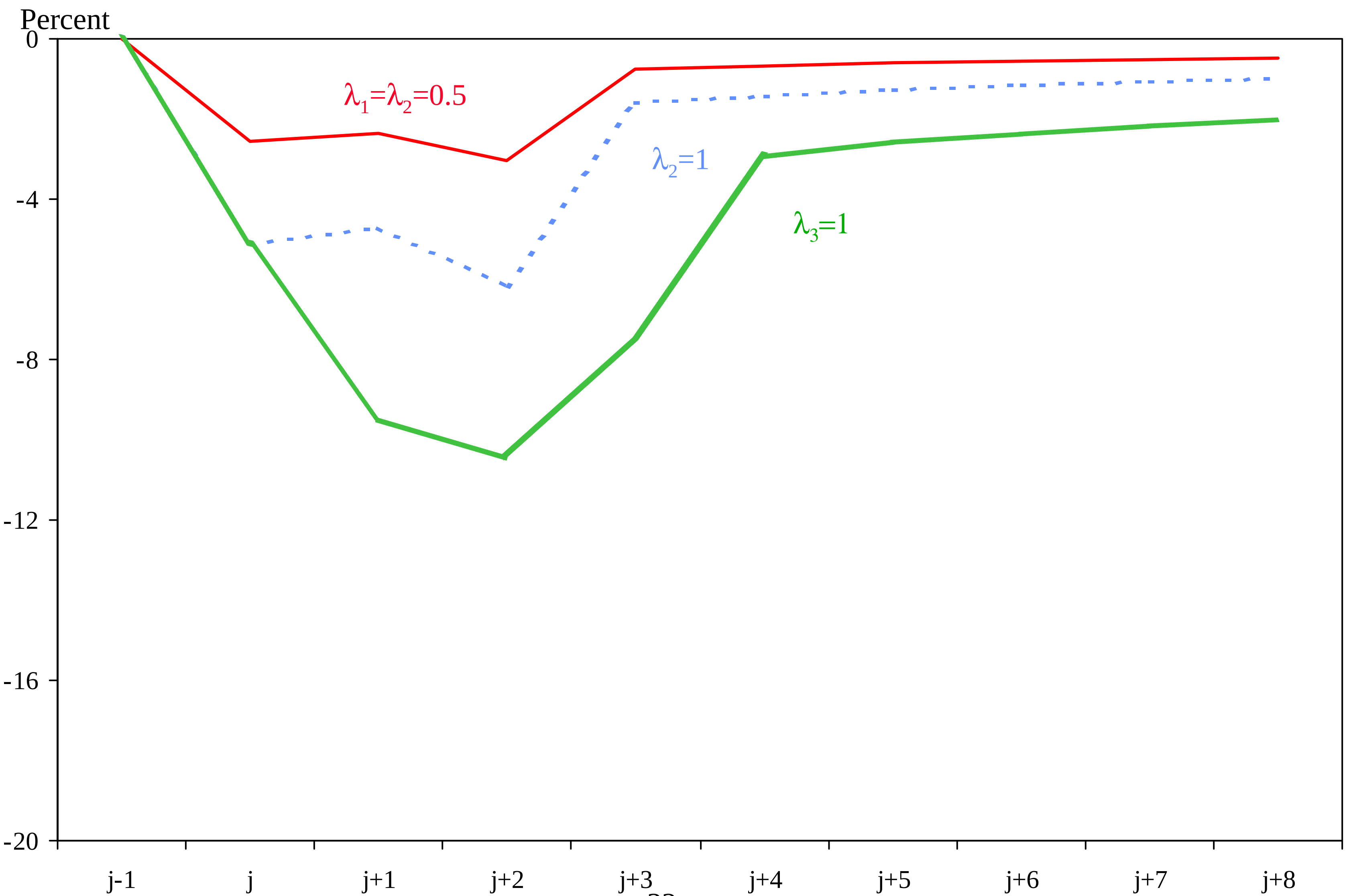

Figure 3f

Lifetime Utility - U.K.

Deviation from perfect foresight

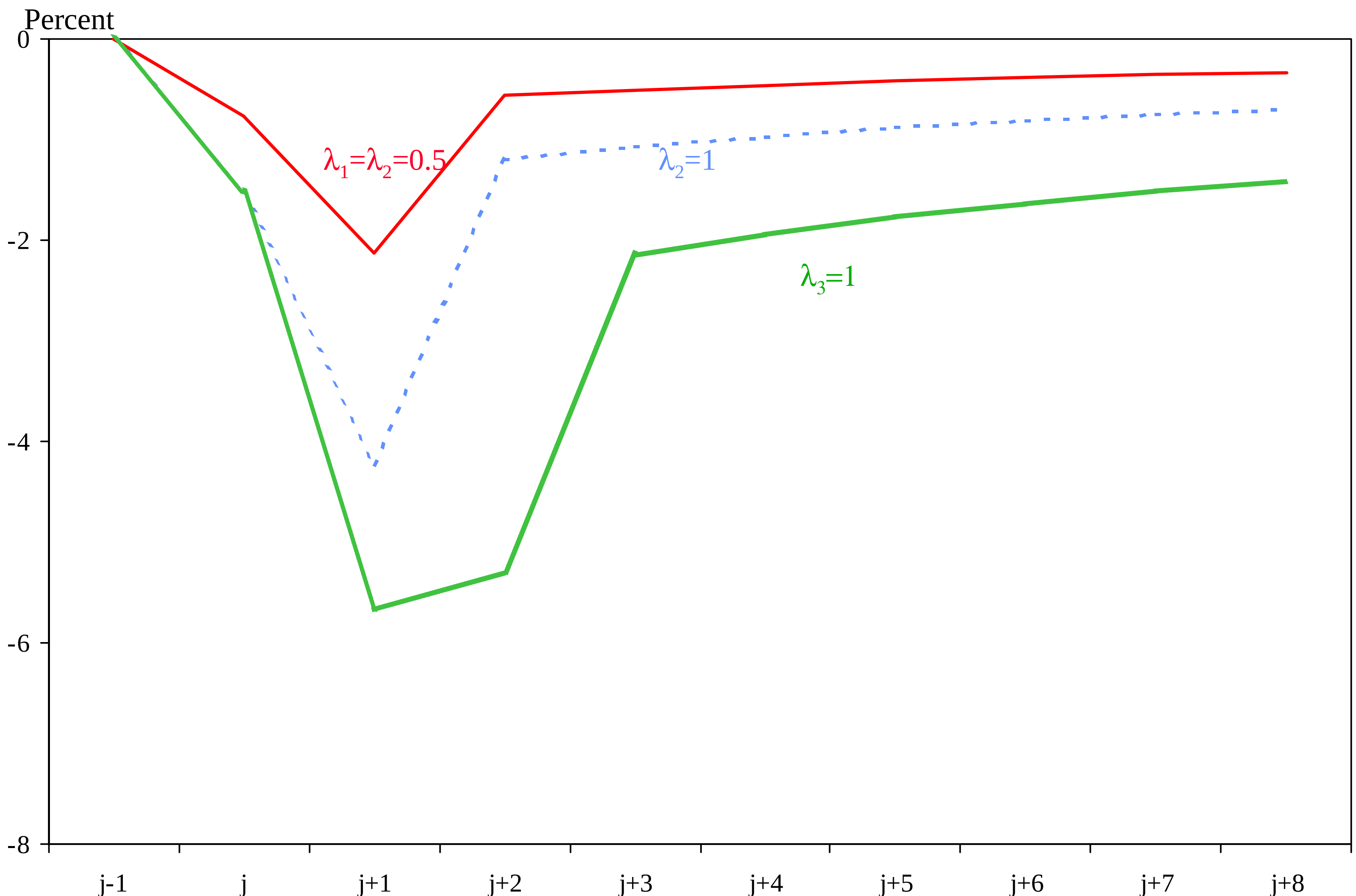

Figure 3g

Lifetime Utility - U.S.

Deviation from perfect foresight

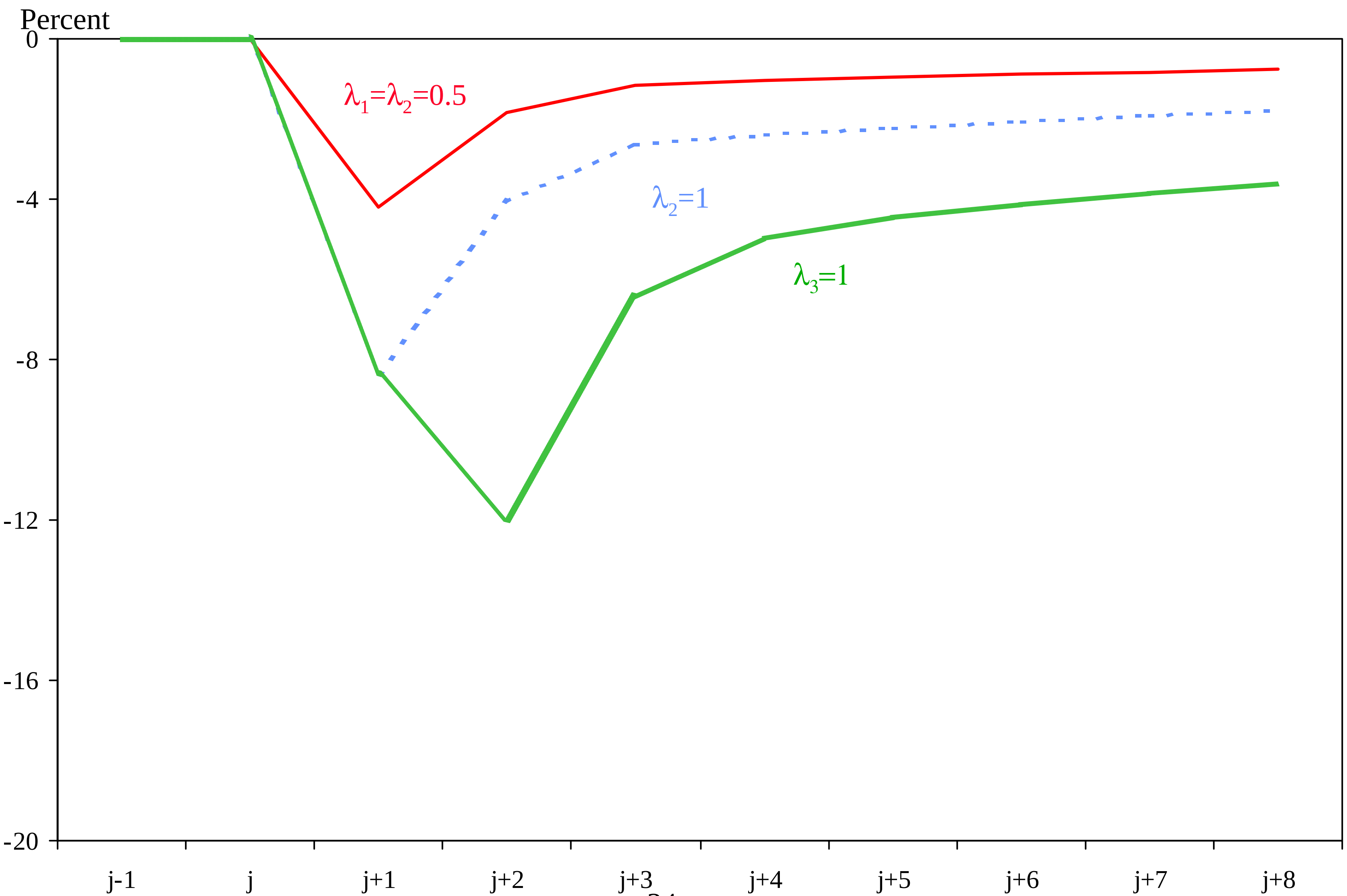

Figure 4

Lifetime Utility With a10% Increase in ω

Deviation from original tax, $\lambda_3=1$