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A Framework for the Analysis of Pension and Unemployment Benefit Reform in Poland

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Abstract

This paper examines the impacts on welfare, savings, labor supply, and the government budget of several possible reforms of the Polish pension and unemployment benefit systems. The framework of analysis is a life cycle simulation model of household consumption, labor supply and retirement decisions. The paper builds on past work by Perraudin and Pujol (1992). The present study focusses on the length of averaging periods in pension benefit calculations, measures to offset incentives to early retirement, and interactions between pension and unemployment benefit systems.

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Summary

Budgetary stringency and growing populations are obliging governments in a number of countries to contemplate cutbacks in retirement and unemployment benefit systems. In designing such reforms it is important to minimize the impact on household welfare and to avoid undesirable incentive effects. Precisely where such cuts should be made within a given benefit system is a difficult question, however.

This paper attempts to provide a framework within which such questions may be addressed. In particular, it examines the implications for household welfare, incentives, and net tax payments of a series of specific possible rule changes in the Polish pension and unemployment benefit system. The framework used is a dynamic programming model of a household facing a detailed set of tax rates, benefit entitlements, and retirement possibilities. The household's optimal labor supply, savings decisions, and choice of retirement date are obtained by numerical solution. This model builds very directly on earlier work by Perraudin and Pujol (1993).

The kind of reforms that are analyzed include reductions in retirement benefit payments to penalize early retirement, income tapers on post-retirement income, and changes in the way in which labor income is averaged over the life-cycle in order to calculate pension benefits. The impact of such reforms on savings, welfare, labor supply, and taxes is examined. A sensitivity analysis is performed to establish the degree to which changes in the assumed parameters of the model affect the simulations.

I. Introduction

Pension and unemployment benefit reform in Poland is an urgent priority. Growth in social insurance expenditures has weakened control of the deficit and hence hampered stabilization efforts. The government's budgetary balance has suffered a series of major shocks in the past three years. On the plus side, expenditures have been reduced by a cutback in household sector subsidies. A major decline in profit tax receipts, however, and a large increase in social expenditures have pushed the budget seriously into deficit. The 1992 deficit amounted to 7 percent of GDP and, while the authorities plan to limit the deficit to 5 percent of GDP in 1993, revenue uncertainties make the target look vulnerable. These developments necessitate cutbacks in the benefit system. Much of the rapid growth in benefit expenditures has come from old-age and disability pensions. From 1987 to 1991, the total number of pensioners grew by 16 percent while the ratio of the average pension to the average wage rose by 14 percent. The total cost of pensions rose from 6.6 percent to 9.2 percent of GDP over the same period. 1/

Before discussing specific measures that might be taken, two general points should be made. First, it is important to realize that different elements of benefit expenditure are closely interlinked. A large part of the increase in pension benefit expenditures is due to a surge in early retirements. While some of this may be due to workers' anticipations of a tightening of retirement rules and reduction in benefit levels, a good deal must also be the consequence of actual or feared unemployment. Unemployment benefits have been significantly pared back in the last few years, and the length of time for which earnings-related benefits are available has been reduced. The chance to switch to state benefits, such as retirement or disability pensions, for which there is no fixed term and whose levels are relatively generous has, therefore, become increasingly attractive. Hence,benefit reforms should be designed within an integrated framework that allows for potential spill-overs between different parts of the system.

Second, benefit cutbacks should, as far as possible, be implemented so as to avoid creating poverty amongst the old. The average retired household in Poland enjoys a relatively high standard of living. Chart 1 shows that in the last three years average monthly per capita expenditure by pensioner households has grown from 95 percent to 105 percent of similar spending by average Polish households. Nevertheless, concerns remain that part of the pensioner population is below the poverty line and that reform of the pension system will exacerbate this problem. Several factors make old households in Poland vulnerable. First, the very generosity of the Polish benefit system with much higher replacement ratios than those observed in the average western industrial economy, has discouraged the accumulation of personal savings. Hence, pensioners are now not in a position to supplement government pensions with their own savings, as is common in other countries. Second, what personal savings the old had accumulated in the past were further eroded (if not indeed eliminated) by the hyperinflation of the late 1980s which was accompanied by large negative real interest rates. In the absence of a stock market or of significant owner-occupied housing, most

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1/ For comparison, the cost of unemployment benefits has risen steeply but from a low base and represented just 1.2 percent of GDP in 1991.

savings in Poland was held in nominal assets such as bank accounts and hence was affected by the jump in prices. Third, real wage declines and growing unemployment mean that extended families will not be in a position to assist aged relatives sufficiently to make up for the withdrawal of support by the state.

Given the above general considerations, this paper employs a simulation model of a dynamically optimizing household to examine a number of possible reforms of the current Polish pension and unemployment benefit systems. The study builds on a previous paper by Perraudin and Pujol (1992) which applied similar methods to analyze Australian retirement incomes policy. Comparable models have been developed by Seidman (1983,1986), Auerbach and Kotlikoff (1984,1985) and Craig and Batina (1991). The model employed here possesses a wide range of features and contingencies and may plausibly be described as a realistic model of households facing either the current Polish retirement and unemployment benefit systems or various alternative systems that have been proposed. Factors explicitly modelled include: (i) consumption-leisure choices, (ii) endogenous retirement decisions, (iii) uncertain date of death, (iv) a bequest motive and inheritances, (v) liquidity constraints, (vi) unemployment, (vii) a lump-sum pension element, (viii) a labor-income-based pension element, (ix) private pension schemes with potentially different tax treatment from non-pension private savings, (x) income testing of pension benefits, (xi) the reduction of pension entitlements upon early retirement, (xii) dependence of pension benefit on the number of contributing years.

To analyze benefit reform in Poland systematically, I begin, in Section 2, by giving a concise description of current regulations. Section 3 sets out the simulation model of a single household that will subsequently be used to assess different possible rule changes. Section 4 discusses a number of possible reforms in the system, focussing on their welfare implications and the effects they might have on the government budget, labor supply and savings. Section 5 concludes the paper by summarizing recommendations based on the simulations reported before. The parametrization of the model is detailed in an appendix.

II. The Benefit System in Poland

This section draws upon the descriptions of the Polish cash benefit system to be found in *Williams et al. (1991)*, *Barr (1992)* and *Diamond (1992)*.

Pension System Provisions

There follows a short description of the basic provisions of the Polish pension benefit system. 1/ Three conditions must be met before a worker is eligible to receive a retirement pension. First, one must have

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1/ The main state pension scheme is administered by the Social Insurance Institution or ZUS. Two other state pension schemes exist for priests and private sector farmers.

contributed for 25 (20) 1/ qualifying years. Reduced benefits are available under certain circumstances to those who have worked only 20 (15) qualifying years. Second, recipients must cease full-time working. Note that this constraint hardly binds since it is possible to work almost a full working week while still drawing a pension. Third, recipients must be older than 65 (60).

For large sections of the workforce the third, age requirement does not apply. Groups deemed to be in hazardous or otherwise demanding occupations may retire at 60 (55). Such groups include miners, firemen, teachers, journalists, academics, customs officers and artists. In addition, women with 30 qualifying years may retire at 50, while men in disability groups 1 or 2 (see below) with 25 qualifying years may retire at 60. Some professions, including teachers and miners, have the right to retire if they have accumulated enough qualifying years (30 for teachers, 25 for underground miners) whatever their age. The exceptions to the age requirement apply to such a substantial fraction of the population that the average age for new retirees in 1990 was 58 for men and 57 for women. 2/

Once eligible for a pension, a worker's benefit level depends on earnings and the number of qualifying years he has accumulated. Under the Social Insurance Act of October 1991, the pension entitlement equals 24 percent of the national average wage plus, for each qualifying year during which contributions were made, 1.3 percent of the worker's pension base. 3/ The pension base is the average of labor earnings in the best three of the last 12 years of work. 4/ The authorities intend to increase the averaging period each year by one year until the pension base for a new retiree equals the average of the best 10 years out of the last 20. 5/

1/ Figures for women are given in parentheses after the corresponding figure for men.

2/ See Tymowska and Wisniewski (1991).

3/ Parliament initially approved more generous percentages but backed away from these given the budgetary implications.

4/ Prior to the October 1991 law reforming the pension system, the final wage applicable to benefit calculations was just a workers' earnings in the last twelve months of his working life.

5/ Note that, for a given worker, the averaging rules depend upon the year of retirement, not age. This complicates optimal retirement decisions somewhat.

Table 1: Polish Pension Recipients by Sex and Age in 1990

	Pensioners (thousands)					
	Old Age			Disability		
Age	Men	Women	Total	Men	Women	Total
0-19	-	-	-	0.0	0.0	0.0
20-24	-	-	-	6.9	1.9	8.8
25-29	-	-	-	19.1	5.0	24.1
30-34	-	-	-	34.2	22.7	56.9
35-39	-	-	-	68.4	38.9	107.3
40-44	-	-	-	89.9	65.6	155.5
45-49	19.0	15.9	34.9	107.8	67.4	175.2
50-54	44.5	57.9	102.4	159.7	153.5	313.2
55-59	129.7	184.5	314.2	207.3	200.2	407.4
60-64	264.8	286.9	551.7	201.1	162.5	363.6
65-69	280.5	287.5	568.0	108.8	134.3	243.1
70-74	145.4	150.2	295.6	53.1	73.9	127.0
75-79	120.3	128.8	249.1	39.3	70.2	109.5
80+	101.5	110.3	211.8	31.5	67.1	98.6
Total	1105.7	1222.0	2327.7	1127.1	1063.2	2190.3
Source: Social Insurance Office (ZUS) and Barr (1992).						

Workers are given partial credit for periods during which no contributions were made (for example, periods spent in higher education, military service or childcare), receiving 0.7 percent of their pension base for each non-contributory year.

Under the new income tax law of July 1991, 1/, pension benefits are fully taxable. There is a minimum pension equal to 35 percent of the average wage, and a maximum implied by the fact that the pension base applicable for benefit calculations has an upper limit of 2.5 times the average wage. Pensions are subject to a simple earnings test in that those earning more than 120 percent of the average wage receive no benefits, while pensioners earning 60-120 percent lose the flat-rate part of the pension, i.e., 24 percent of the average wage.

The indexing provisions in the pension system have changed substantially over the last few years. Rapid inflation in the 1980s seriously eroded pensioners' purchasing power. In 1988 and 1989, benefit levels were adjusted on an ad hoc basis to ameliorate this problem. In 1990, pension payments were indexed by average wages. Entitlements continued to depend on the nominal wage received in the last year before retirement, however, leading to wide disparities between the benefits received by those who had retired before and after the hyperinflation. The law of October 1991 remedied the situation by implementing the benefit formula described above according to which both the pension base and flat-rate components of the pension are indexed by average wages.

Disability Pensions

In Poland, the disability pension system is relatively generous. Eligibility requires little more than a doctor's certificate. Three levels of disability are recognized. Group 1 are severely disabled persons, unable to look after themselves, Group 2 consists of those unable to work, while Group 3 is individuals with long-term medical problems who, due to disability, can only work part-time. As with old age pensions, disability pension recipients are not permitted to work full-time but working for a substantial fraction of the full working week is allowed. Group 3 benefit levels equal 75 percent of the old age pension. Group 2 receives an amount calculated just like the old-age pension (i.e., taking account of previous earnings and qualifying contributory years), while Group 1 receive the old age pension plus a supplement equal to 30 percent of the minimum pension.

The Unemployment Benefit System

Unemployment has increased extremely rapidly since Poland's reform process began, rising from negligible levels at the start of 1990 to 2.2

1/ The new law came into force on 1st January, 1992, replacing four payroll and income taxes with a single personal income tax. For a detailed description, see Gorecki and Wisniewski (1992).

million or 12.2 percent of the workforce by March 1992. 1/ The latest information suggests that this increase has leveled off. Table 1 gives a breakdown of unemployment by sex, age and level of education. Clearly, a substantial youth unemployment problem has developed, while the unemployment rate among 25 to 54 year old is also relatively high. The proportion of the female unemployed is much higher than one would find in a Western European country. 2/ From the educational breakdown, it appears that, while there is very little white-collar unemployment, unemployment is not so concentrated among the unskilled as in other countries.

Under the Polish unemployment benefit system, instituted in December 1989, unemployed workers received 70 percent of their previous wage for 3 months, followed by 60 percent for the subsequent 6 months, and 40 percent thereafter. 3/ The benefit entitlement was in nominal terms and hence decreased more rapidly than the above percentages suggest when inflation accelerated. The minimum and maximum benefit levels were the minimum and average wages. Since these were indexed, this introduced some safety net in the face of large price movements.

Unemployment benefit eligibility initially did not depend upon past labor market participation and a large proportion of applicants in the first year of the scheme were not unemployed in an economic sense. In July 1990, eligibility was tightened by requiring that unemployed had worked for 180 days in the past year. The minimum benefit was also slightly reduced and some special extra payments to unemployed graduates were reduced. Despite these measures, the high unemployment totals undoubtedly still contain many people who are not genuinely members of the workforce. The high proportion of women among the unemployed, commented on above, may well reflect unemployment claims by housewives not really in search of work.

The October 1991 Employment Law introduced an indexed, flat-rate unemployment benefit of 36 percent of the average wage in the previous quarter (with a supplement of 15 percent of the average wage for those in training programs). An important feature of the new benefit was that it was only payable for 12 months except to workers approaching retirement. Claimants ceased to receive benefits if they turned down two job offers and tighter rules were adopted to discourage work in the private sector particularly in agriculture at the same time as claiming benefits.

1/ The deterioration has exceeded that in other Central or Eastern European countries (see Boeri and Keese (1992), page 150). Unemployment rates in Czechoslovakia and Hungary, for example, were 7.75 percent and 8 percent at the end of 1991.

2/ For example, in the UK women represent 23 percent of total unemployment.

3/ The December 1989 law allowed anyone out of work to claim unemployment benefit. In July 1990, eligibility was tightened so that benefit can only be obtained if no job or training program is available and if the claimant has worked for 180 days in the past year.

Table 2: Polish Unemployment by Sex, Age and Education

Shares in Total Unemployment									
	Sex		Age			Education			
	Women	Men	≤ 24	25 to 54	≥ 55	Primary	Vocational	Secondary	Higher
Shares in Total Unemployment	52.8	47.2	36.3	53.6	10.1	29.7	37.0	30.3	3.0
Unemployment Rates	12.8	10.6	26.4	10.7	3.7	9.8	13.3	11.7	4.2

Source: Boeri and Keese (1992).
Note: sex and education breakdowns refer to November 1991. Age breakdowns refer to October 1991. 1988 employment data is used in the calculation of unemployment rates.

Demographic Pressures

Barr (1992) argues 1/ that, extrapolating past trends, the current population age structure implies that the number of pensioners should be constant over the next few years. Hambor (1992) analyzes population trends for several Central and Eastern European countries. Under a number of strong simplifying assumptions, he derives potential worker/retiree ratios. Of the countries he examines, Poland shows the worst proportional deterioration, with the relevant ratio falling from 2.9 in 1990 to 2.0 in 2020, although the ratio in Hungary falls to an even lower level of 1.6 by 2020 from the 1990 level of 2.1. 2/ Hambor's simulations, however, suggest that demographic pressures on pension expenditure will not become serious until well into the first decade of the next century. Given reasonable assumptions about real wage growth, Hambor suggests that indexing on prices rather than wages would largely eliminate future demographic pressure on pension expenditures.

III. A Simulation Model

This section describes the simulation model that will be used below to analyze various policy options. The model represents an intertemporally optimizing household, choosing leisure, consumption, bequests and retirement date subject to various constraints. The constraints include a lifetime wealth constraint, liquidity constraints that prevent borrowing in anticipation of future income, and unemployment constraints which limit total household labor supply. The basic programming problem for the household is:

$$\max_{(C_s, L_s)_{s=1}^{T}} \sum_{t=1}^{T} \pi_t \frac{(1+\delta)^{1-t}}{1-\frac{1}{\alpha}} U_t^{1-\frac{1}{\alpha}} + \sum_{t=1}^{T} (\pi_t - \pi_{t+1}) \frac{\alpha_1 (1+\delta)^{1-t}}{1-\mu} B_t^{1-\mu} \quad (1)$$

$$\text{where} \quad U_t \equiv \left(C_t^{1-\frac{1}{\rho}} + \alpha_0 L_t^{1-\frac{1}{\rho}}\right)^{\frac{1}{1-\frac{1}{\rho}}} \quad (2)$$

where C_t and L_t are respectively consumption and leisure in period t, T is the maximum possible life-span, B_t is the agent's bequest if he dies in period t, equal to his savings accumulated up to that date, deflated by a price index Q_t where:

Q_t may be thought of as a price index for 'full consumption' comprising consumption goods and leisure. δ, α, ρ, α_0, α_1 , and μ are fixed parameters

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1/ See Barr (1992), chapter 5.

2/ In contrast, Hambor suggests that the same ratio in the United States will decline from 4.7 in 1990 to 3.3 in 2020.

$$Q_t \equiv \left(\left((1+\tau_c)\, P_t\right)^{1-\rho} + \alpha_0^{\rho} \left((1+\tau_{wt})\, w_t\right)^{1-\rho} \right)^{\frac{1}{1-\rho}} \tag{3}$$

of which δ, α, ρ, represent respectively the rate of time preference, the coefficient of intertemporal substitution, and the leisure-consumption substitution elasticity. π_t represents the probability that the agent remains alive at date t and we suppose that the maximum life-span is T so $\pi_{T+1} = 0$. The maximization is carried out subject to the following constraints.

1. Lifetime Wealth Constraint

$$\sum_{t=1}^{T} \frac{w_t(1-\tau_{wt})\ (1-L_t)}{\Pi_{i=0}^{t-1}\ (1+r_i(1-\tau_{si})\ )} + \sum_{t=1}^{T} \frac{Z_t - W_t}{\Pi_{i=0}^{t-1}\ (1+r_i\ (1-\tau_{si})\ )} -$$

$$\sum_{t=1}^{T} \frac{(1+\tau_c)\ P_t C_t}{\Pi_{i=0}^{t-1}\ (1+r_i(1-\tau_{si})\ )} - \sum_{t=1}^{T} \frac{w_t(1-\tau_{wt})\, L_t}{\Pi_{i=0}^{t-1}\ (1+r_i(1-\tau_{si})\ )} - \frac{(1+\tau_h)\, Q_T B_T}{\Pi_{i=0}^{T}\ (1+r_i(1-\tau_{si})\ )} = 0 \tag{4}$$

where P_t is the price of the consumption good, W_t is bequests received in period t, w_t is the wage rate, Z_t is lump sum transfers, r_t is the gross interest rate, τ_{wt}, τ_{st}, τ_c and τ_h are tax rates on labor and savings income, consumption goods and inheritances respectively, all at time t. Here, total labor endowment in each period is normalized to unity. Q_t is a composite price index based on the value of full consumption and involving the parameters of the agents utility function.

2. Liquidity Constraints

$$S_t \geq 0 \quad t=1,2,\ldots,T \tag{5}$$

where S_t is liquid private sector savings at period t and equals the partial sum of the budget constraint.

3. Employment Constraints

$$L_t \geq L_t^* \quad t=1,2,\ldots,T \tag{6}$$

where $L_t^* = 1,2,\ldots T$ are fixed constants that represent the minimum leisure that the household can consume in given periods.

The solution of this program is considerably complicated by the presence of all the various constraints. Let us start by considering the simple case in which $\pi_t = 1$ for $t = 1,2,\ldots T$ and there are no liquidity or labor supply

constraints and no bequest motive. One may then obtain the optimal paths for the decision variables by solving the following system of equations.

$$(1+\delta)^{1-t} u_t^{\frac{1}{\rho}-\frac{1}{\alpha}} C_t^{-\frac{1}{\rho}} = \lambda_t (1+\tau_c) P_t \tag{7}$$

$$(1+\delta)^{1-t} u_t^{\frac{1}{\rho}-\frac{1}{\alpha}} \alpha_0 L_t^{-\frac{1}{\rho}} = \lambda_t w_t (1-\tau_{wt}) \quad \text{for } t < t_r \tag{8}$$

where t_r is the date of retirement from the workforce, and where $\{\lambda_t\}_{t=1}^{T}$ is a vector of marginal utilities of wealth in each period. In each pair of adjacent periods, t, and $t+1$, the marginal utilities of wealth satisfy the relation: $\lambda_t=\lambda_{t+1}/(1+r_t(1+\tau_{st})$. In other words, there is effectively just a single discounted Lagrange multiplier for the agent's program, associated with the single life-time wealth constraint. The last degree of freedom in the problem is then resolved by choosing λ_1 such that savings at the end of life are zero.

Introducing the possibility of early death and a bequest motive implies two changes to the approach one must take to solving the problem. First, the formula for updating λ_t takes the more complicated form:

$$\lambda_{t+1} = \frac{(\lambda_t - \alpha_1(\pi_t - \pi_{t+1})\ (1+\delta)^{1-t} Q_t^{-1} B_t^{-\mu})}{(1+r_t\ (1-\tau_{st}))} \tag{9}$$

and second the terminal condition required to pin down the single degree of freedom in the λ_t's is:

$$(1+\delta)^{1-T} \alpha_1 B_T^{-\mu} = \lambda_T Q_T \tag{10}$$

i.e., that the marginal utility of an extra unit of bequests in the final period of life divided by the price of bequests is equal to the terminal utility of wealth.

The inclusion of labor supply and liquidity constraints substantially complicates matters. For each period, two additional complementary slackness conditions must be added to the basic maximization problem. As far as the above equations are concerned, these imply, first, that we must replace λ_t by $\lambda_{t+\gamma t}$ where γ_t is a Lagrange multiplier that is strictly positive in periods in which the liquidity constraints bind and otherwise zero. Second, $w_t(1-\tau_{wt})$ must be replaced by $w_t(1-\tau_{wt})+\eta_t$ where η_t is a Lagrange multiplier which is strictly positive in periods in which the employment constraints bind and otherwise zero. Suppose one knows in advance in which periods the constraints

bind. One may then compute the optimal path by substituting out consumption and leisure in the periods in which the constraints bind using respectively the liquidity and labor supply constraints. The additional equations that one then has can be used to find the values of the additional Lagrange multipliers.

In the case of the labor supply constraints, it does not matter that one does not know in advance in which periods the constraints bind since one can write a solution algorithm in which the algorithm checks as it runs through the household's optimal program to see if the constraint is contravened and then changes the calculation accordingly. However, the fact that one does not know in advance in which periods the liquidity constraints bind leads to major computational complications. In principle, one may employ brute force methods, solving the problem for different combinations of binding Lagrange multipliers and then taking the solution to be the one that yields the maximum utility without contravening the constraints. But, such methods are not feasible using conventional computers. The approach taken in the algorithms employed in this paper is to assume that the constraints bind at the start of the household's 'life' and then hold continuously until some date at which the household becomes unconstrained. While this is not a general solution technique, it works well for commonly observed lifetime wage patterns.

Polish households face a wide range of minimum retirement ages, depending, for example, on the industry in which they work or their health status. For the purpose of simulating the model, I shall assume that households can retire when their age is in the range 57 to 65 years old. It should be recalled that the rules on retirement do not oblige pensioners to cease supplying labor after retirement, although full-time working is not possible. I, therefore, assume that there is a limited loss of earnings upon retirement, say, because of the need to change industries or places of employment. Thus, the wage profile is assumed to shift down after retirement by a factor of 0.7 compared to what it would be if the household had not retired. In principle, this cut in wages could induce households to retire after the age of 57, but in practice, for most simulations, the lower bound on retirement ages binds and they retire at 57. Some of the measures I review below, most notably benefit cuts for households that retire early and income tests on total retirement income, do induce later retirement and indeed this is the principal mechanism through which they influence total lifetime tax payments net of benefits.

One may compare the above framework with other models that have been developed for the study of savings behavior and pensions and unemployment benefit systems. The main strength of the model described above is the inclusion of a range of constraints upon household choices, over and above the budget constraint equating expenditures to total lifetime wealth, most notably the limits on borrowing and labor supply. Given the deteriorating labor markets and primitive state of consumer lending in Eastern Europe, these features are clearly important. Hubbard and Judd (1986) set up a relatively simple model of a liquidity constrained household in order to study the impact of such constraints on savings and consumption decisions. The present model, with numerous complications such as endogenous retirement decisions and bequests, concentrates more on public finance aspects.

Table 3: Baseline Parametrization

Utility Function Parameters		
Parameter	Symbol	Value
Subjective discount rate	δ	0.04
Elasticity of intertemporal substitution	α	0.80
Consumption-leisure elasticity of substitution	ρ	0.80
Consumption-leisure parameter	α_0	0.20
Bequest-full-consumption parameter	α_1	0.10
Bequest substitution elasticity	μ	0.80
Maximum life-span (assuming adult life begins at 20)	T	80.0
Tax Parameters		
Parameter	Symbol	Value
Tax on consumption goods	τ_c	0.08
Wage tax rate	τ_w	0.25
Savings tax rate	τ_s	0.23
Inheritance tax rate	τ_h	0.00
Social security contribution rate	τ_p	0.31
Prices		
Parameter	Symbol	Value
Real interest rate	r_t	0.05
Average per period wage rate	$\overline{w}$	2.79
Consumer goods price	P_t	1.00
Official average wage	w_{av}	2.23

Probably the greatest weakness of the model employed in this paper is the limited role played by uncertainty. Time of death is stochastic in this model but no other sources of randomness are introduced. The study by Rust (1989) (and the slightly less rigorous implementations of similar ideas by Lazear and Moore (1988) and Stock and Wise (1990)) shows just how stringent are the simplifying assumptions required if one is to incorporate stochastic elements. The largely deterministic nature of the model is particularly a problem in the treatment of unemployment which is here treated simply as a constraint on labor supply. Fears of future unemployment among households still fully employed have probably contributed greatly to the surge in early retirements mentioned in the introduction. Here these can only be examined through fully anticipated employment constraints.

IV. Simulations and Policy Analysis

This section describes the simulation results. I shall first examine the impact of liquidity constraints and then discuss three possible sets of policy reforms. These are (i) changes in the current method used in calculating the wage base by averaging over wage income received earlier in life, (ii) cuts in unemployment benefits, and (iii) cuts in pension benefits or income tests for post-retirement income.

Liquidity Constraints

The simulation results are presented in two forms. First, Tables 4 and 5 summarize total lifetime quantities such as utility and consumption of goods and leisure. Second, Charts 5 to 21 show the profiles for these same variables over the adult life of the household. Eight basic simulations were performed, in each case with and without liquidity constraints.

The presence of liquidity constraints did not affect optimal retirement dates, nor did it influence the total lifetime tax payments in a systematic way. However, liquidity constraints had a very substantial impact on savings and welfare. The relative generosity of the Polish retirement income system effectively removes the standard life-cycle motive for saving, i.e., that of providing for retirement consumption. In the absence of liquidity constraints, high pension benefits together with upward sloping lifetime wage profiles typically lead to consumption patterns that require heavy borrowing early in life. Thus, in our eight simulations without liquidity constraints, households only begin to have positive net financial wealth late in life, after the age of forty. 1/

Imposing constraints on borrowing restores the more conventional hump-shape for life cycle saving, with liquidity constraints ceasing to bite when households are in their early thirties. An important implication of this analysis is that the current Polish benefit system, with its relatively generous replacement ratios, would have an extremely deleterious impact on

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1/ Note that the simulations assume that households receive no bequests. Including bequests would probably not change matters since these would normally be received around the age of fifty.

aggregate saving if consumer credit were freely available. Since financial liberalization, while not yet achieved, will presumably be implemented before too long, one could expect aggregate savings to suffer greatly unless changes are made in the current system such as some reduction in the generosity of retirement benefits relative to pre-retirement incomes.

The magnitude of these effects can be seen by comparing the total lifetime savings in Tables 4 and 5. If the population was stationary, then one could regard the volume of savings in these tables as scaled down versions of those pertaining in steady state equilibria for the economy as a whole. Comparing simulation 1 with and without liquidity constraints, one can see that the total level of savings is roughly six times larger in the latter case. While such differences clearly exaggerate the actual impact of liquidity constraints, they still point to the potential seriousness of the problem.

As a last point, the presence of liquidity constraints radically alters the time profile of household consumption which instead of declining monotonically as in the unconstrained case, rises sharply through the twenties before falling from the early thirties onward. Liquidity constraints also have spill-over effects in the labor market since households supply more labor in an attempt to alleviate the constraint on liquid resources.

Averaging Periods

Turning now to the individual model runs, the first three simulations analyze the impact of different averaging periods for the derivation of the wage base from which pension entitlements are calculated. As noted in a previous section, the Polish authorities intend to increase the averaging period gradually from the best three of the last twelve years before retirement to the best ten out of the last twenty. Simulation 1 assumes an averaging period of the whole working life, 1/ while simulations 2 and 3 suppose three and ten year averaging periods. Note that the principal economic impact of calculating pension entitlements based on labor income earlier in life is to reduce the effective tax rate on wages. Given the heavy burden of taxation on wage income in Poland, this would seem to be highly desirable.

Comparing Charts 6 and 7 with Chart 5, it is clear that averaging over a short period provides a strong incentive for intertemporal substitution of labor supply. Tax payments are significantly boosted during the short averaging periods. 2/ The simulation result summaries in the tables show, however,that cutting the length of the averaging period significantly reduces the household's total lifetime tax payments less benefits. In the liquidity constrained case, net taxes less benefits paid over the life cycle fall from 27.65 to 26.98 and 25.02 respectively for ten and three year averaging

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1/ This is the approach taken in the US social security benefit system.

2/ Although effective tax payments are, of course, cut since the household receives extra pension benefits in reward for extra supply of labor.

periods. The decline occurs for the simple reason that the household's wage base calculated as an average of the best three years of labor income is higher than an average based on a larger number of years. Total lifetime leisure falls for shorter averaging periods while consumption rises slightly, as does total utility.

To assess the welfare impact of the change, one may use the figures for the average marginal utility of wealth also given in Tables 4 and 5. To illustrate such a calculation, consider the rise in lifetime utility of 0.12 units for a switch from lifetime to three year averaging. Using the average marginal utility of wealth for simulation 1, this translates into a money equivalent of 17.05x0.12=2.05. In weighing the utility change by the lifetime average marginal utility of wealth, we are effectively calculating what sum of money that, if spread evenly over the household's life in the form of a flow of lump sum income, would give the same change in lifetime utility. Given that expenditure on consumption over the life cycle is 74 in simulation 1, 1/ this represents a significant welfare gain.

The welfare gain for a shorter averaging period may be attributed, first, to the fact that tax net of benefits paid over the life cycle is lower. This effect is partly illusory since we have not included in the model any role for exhaustive public spending which would presumably be cut if the government's tax receipts fell, reducing utility derived from public goods output. Second, the welfare gain is an example of the increases in *steady state* utility that are always available to governments in overlapping generations models when the interest rate exceeds the growth rate of the economy. To see this, suppose the economy has zero population growth with a stationary age structure and that r>0. Then the government can obtain the same steady state net tax revenue while switching tax from young to old, whereas steady state household utility will increase with such a switch since discounted lifetime income will rise. Again, such steady state welfare gains are somewhat illusory since they ignore the welfare losses of the transitional generation that is old when the new policy is enacted.

These caveats about the welfare effects implied by our analysis of averaging periods suggest that, from a practical, policy perspective, it is more important to consider the positive effects of cutting the averaging period, namely a sharp fall of 15.2 percent in aggregate saving in the more empirically relevant liquidity-constrained case, and the 15.1 percent decline in total tax receipts net of benefit payments. Both effects run counter to what one could regard as sensible policies given Poland's current predicament. Thus, averaging over a longer period would be preferable in the current Polish situation.

Unemployment

Simulation 4 shows the impact on the household of unemployment. Unemployment takes the form of a constraint on per-period household labor

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1/ Recall that goods prices are normalized to unity and that the consumption tax rate is assumed to be 8 percent.

supply of 0.7. One way to think of this is to suppose that the household contains two working individuals of whom one works part-time. When the labor supply constraint binds, we assume that the full-time worker supplies zero labor and the household receives unemployment benefit from the state.

The charts for simulation 4 show that being unemployed depresses savings as the constrained household dissaves in an attempt to maintain its consumption level, in anticipation of the pension benefits it will receive after retirement which significantly exceed unemployment benefit. However, *anticipation* when young of unemployment later in life generates substantial extra saving by households at the start of the life cycle leading to a large positive impact on total saving. To some degree, this result points to a weakness in our modelling of unemployment which here is taken to be fully anticipated by households in their youth. In the current Polish case, households now unemployed are very unlikely to have anticipated their present situation and hence to have build up savings balances. Nevertheless, in the newly reformed Polish economy with unemployment that is likely to persist for the foreseeable future, it *is* reasonable to expect quite significant precautionary saving by households, and the model is at least useful in underlining this fact.

The two other substantial effects of unemployment are, as one would expect, first, a big shift from consumption to leisure expenditure (one could think of this as due to a large fall in the shadow price of labor) and, second, a big decline in net tax payments. Unemployment, of itself, does not affect the retirement date, but this is only because the household already retires at the minimum age of 57. Simulations not reported here in which rule changes such as benefit cuts for early retirees induce later retirement show that unemployment can shift the retirement date back in time quite significantly.

Simulation 8 shows the effect of cutting the unemployment benefit level by 20 percent and introducing the current system of income tests (i.e., reductions in benefits when a retired household's income exceeds 60 and 120 percent of the average wage. This package of measures has little impact on total tax revenue net of benefits which rise from 13.6 to 14.0 in the liquidity constrained case. Lifetime welfare falls by a monetary equivalent of 1.4 while consumption and leisure show small movements in intuitively reasonable directions.

Pension Benefit Cuts

Simulations 5, 6 and 7 look at different approaches to cutting pension benefits. Simulation 6 is a simulation of the current system with step reductions in benefits at earnings thresholds of 60 and 120 percent of the average wage. As one may see by comparing simulations 2 and 6 in Tables 4 and 5, for the household considered here, the income tests do not bite very much whether or not liquidity constraints apply. In the liquidity constrained case, taxes rise by 1.2, while savings are up 5.8 and utility falls by a monetary equivalent of 4.1.

Simulation 7 yields what might appear a surprising result. Imposing a 50 percent taper on total retirement income (i.e. an additional 50 percent tax on pension income over and above existing taxes) actually reduces total tax revenue in the case without liquidity constraints (compare 7 with simulation 2). Adding a 50 percent additional levy to what is already a quite high burden of taxation on labor income generates Laffer effects as the very large decline in labor supply swamps, in its effect on tax receipts, the gains due to the higher tax rate. The magnitude of the distortionary effects may be gauged by looking at the charts for simulation 7 which show both substantial declines in labor supply by the old and a quite distorted pattern of consumption as the higher tax rate on interest income induces intertemporal substitution. Note that despite its small impact on total tax receipts, the taper in simulation 7 significantly reduces the attractiveness of early retirement, pushing the optimal retirement age up from 57 to 62.

Simulation 5 shows what appears to be the preferred way of cutting pension benefits, namely reducing benefit levels for each year before the age of 65 that the household is retired. A 5 percent cut in benefits for each year of early retirement has a big impact on retirement decisions, increasing the optimal retirement age to 65. Total taxes paid increase by 4.8, a quite significant amount. Total lifetime savings rises by 30 percent. Although welfare, of course, decreases, it does so by less than in the case of simulation 7.

Sensitivity Analysis

Table 6 shows a sensitivity analysis for the simulations with binding liquidity constraints. I report the elasticities of the Table 5 simulation results with respect to various utility function parameters. Since these parameters are hard to guess given the paucity of econometric evidence, it is important to examine the impact changes in their levels have on the results.

What is perhaps reassuring is that, changing most of the parameters affects all the simulations in a uniform manner. So, for example, a perturbation in the rate of subjective time preference, δ, alters all the simulation results proportionally in the same way.

There are a few exceptions to this, however. For example, perturbing the coefficient of intertemporal substitution, α, has much less of an effect on saving in Simulation 7 than it does on other simulations. Hence, if α is much lower than the baseline level, the savings impact of the Simulation policies might appear rather better than they do in Table 5.

Another example of a case in which parameter perturbations affect simulations differently is with the leisure-consumption substitution parameter, ρ. Leisure is less sensitive to changes in this parameter in Simulations 4 and 8. But, of course, this is because these simulations include binding constraints on labor supply as an approximation to unemployment so this is not surprising.

In general, the sensitivity results do not lead us to question out basic conclusions and are reassuring about the robustness of our findings.

Conclusions

The title of this paper echoes that of Diamond's seminal (1977) paper on the analysis of social security. That paper set out arguments to justify state intervention in the savings market through the provision of social security. Diamond's arguments of wealth redistribution, market failure, inadequate voluntary saving and administrative efficiency remain convincing. However, budgetary constraints are forcing numerous countries and particularly the reforming economies of Eastern Europe to reassess the liabilities of their welfare systems. If cuts are to be made, those cuts should be designed as carefully as possible so as to limit the welfare impact and avoid aggravating poverty. Building on past work by Perraudin and Pujol, this paper aims to develop a framework of analysis for pension and benefit reform based on a realistically complicated computer simulation model of a household facing alternative rules and regulations.

This study has three main findings. First, the authorities should increase the averaging period used in the calculation of pension benefit entitlements. This is effectively a way of reducing the total benefit since averaging over a long period will provide a lower pension base than simply averaging over the best years of a period relatively late in life. It will also spread over a larger number of periods the reduction in effective marginal wage tax rates that such an averaging system generates. Currently, in any year outside the averaging period, the high social security tax rates constitute dead-weight, distortionary taxes. Since tax distortions generally rise with the square of the change in rate, spreading the reduction in effective taxes over a longer period should in itself increase efficiency. While increasing the averaging period is not feasible for older workers since information on their incomes earlier in life is not available to the social security authorities, younger workers could be included immediately in a system with long term averaging.

Second, further reductions in unemployment benefits do not seem advisable. Such benefits are already very low especially for the long-term unemployed. Although in the simulations reported here, unemployment does not lower optimal retirement ages since these are already at a lower bound, there is every reason to expect that lowering unemployment benefits will induce higher earlier retirement for those households who are at an "interior optimum" in their retirement date choice. Even in the simulations reported here unemployment benefit cuts generate negligible extra total net taxes less benefits and such early retirement effects would reduce these gains even further.

Third, and perhaps most important, of the various ways in which the authorities might seek to reduce benefit payments, the best option appears to be penalizing households for their early retirement. This approach has the advantage of generating fairly substantial extra revenue while providing a fillip to savings. The welfare losses consequent upon early retirement benefit cuts are not negligible but they are at least lower than those incurred if, say, a large pension income taper is applied. Note that while I have not discussed the policy suggested by some commentators that households should simply be obliged to cease supplying labor upon retirement, such an approach is actually similar to a very high income taper.

Table 4: SUMMARY SIMULATION RESULTS (W/O Liquidity Constraints)

	Goods Cons.	Leis. Cons.	Life Util.	Total. Sav.	Tax Paid	M.U.of Wealth	Ret. Age
Simulation 1.	74.09	25.85	-114.33	46.35	28.18	16.49	57
Simulation 2.	74.50	26.04	-114.14	13.77	25.71	16.37	57
Simulation 3.	74.54	26.27	-114.05	-5.05	23.93	16.36	57
Simulation 4.	70.70	34.44	-114.62	98.60	12.21	17.48	57
Simulation 5.	72.95	25.90	-114.63	80.06	30.83	16.81	65
Simulation 6.	74.11	25.96	-114.29	23.85	26.82	16.48	61
Simulation 7.	68.84	28.83	-114.81	1.49	25.41	17.28	63
Simulation 8.	70.48	34.42	-114.71	101.60	12.65	17.55	57

Details of Simulations	
Simulation 1.	Averaging Over Whole Pre-Retirement Period
Simulation 2.	Averaging Over Ten Best Years Out of Last Twenty
Simulation 3.	Averaging Over Three Best Years Out of Last Twelve
Simulation 4.	Ten Year Averaging With Unemployment
Simulation 5.	Ten Yr. Avg. +Benefit Cuts for Early Retire.
Simulation 6.	Ten Yr. Avg. +Existing Income Tests
Simulation 7.	Ten Yr. Avg. +50% Taper on Retire.Income
Simulation 8.	Ten Yr. Avg. +Unemp.+Inc.Tests+Unem.Ben.Cut

NB: lifetime utility is the subjectively discounted sum of period by period utilities. Other variables are simply period by period quantities summed over the lifetime.

Table 5: SUMMARY SIMULATION RESULTS (With Liquidity Constraints)

	Goods Cons.	Leis. Cons.	Life Util.	Total. Sav.	Tax Paid	M.U.of Wealth	Ret. Age
Simulation 1.	77.94	26.55	-114.63	155.04	27.65	17.05	57
Simulation 2.	78.44	26.58	-114.60	151.56	26.98	16.98	57
Simulation 3.	78.51	26.84	-114.51	131.52	25.02	16.97	57
Simulation 4.	73.65	34.36	-114.94	188.88	13.60	17.86	57
Simulation 5.	76.34	26.37	-115.03	197.02	31.78	17.34	64
Simulation 6.	77.79	26.46	-114.75	157.33	28.24	17.08	61
Simulation 7.	72.00	29.58	-115.22	123.54	26.30	17.78	64
Simulation 8.	73.38	34.33	-115.02	190.22	14.01	17.92	57

Details of Simulations	
Simulation 1.	Averaging Over Whole Pre-Retirement Period
Simulation 2.	Averaging Over Ten Best Years Out of Last Twenty
Simulation 3.	Averaging Over Three Best Years Out of Last Twelve
Simulation 4.	Ten Year Averaging With Unemployment
Simulation 5.	Ten Yr. Avg. +Benefit Cuts for Early Retire.
Simulation 6.	Ten Yr. Avg. +Existing Income Tests
Simulation 7.	Ten Yr. Avg. +50% Taper on Retire.Income
Simulation 8.	Ten Yr. Avg +Unemp.+Inc.Tests+Unem.Ben.Cut

NB: lifetime utility is the subjectively discounted sum of period by period utilities. Other variables are simply period by period quantities summed over the lifetime.

Table 6: SENSITIVITY ANALYSIS WITH LIQUIDITY CONSTRAINTS

	Goods Cons.	Leis. Cons.	Life Util.	Total. Sav.	Tax Paid	M.U. of W
Elasticity w.r.t. α						
Simulation 1.	0.03	0.00	6.76	0.46	0.04	-0.89
Simulation 2.	0.04	0.00	6.76	0.49	0.03	-0.89
Simulation 3.	0.03	0.00	6.77	0.50	0.02	-0.88
Simulation 4.	0.06	-0.01	6.74	0.49	0.13	-0.90
Simulation 5.	0.04	0.00	6.73	0.35	0.03	-0.90
Simulation 6.	0.04	0.00	6.75	0.46	0.03	-0.89
Simulation 7.	0.00	0.02	6.72	0.12	-0.03	-0.90
Simulation 8.	0.06	-0.01	6.73	0.49	0.12	-0.90
Elasticity w.r.t. ρ						
Simulation 1.	0.27	-0.60	1.58	-0.14	0.84	1.59
Simulation 2.	0.27	-0.60	1.58	-0.27	0.81	1.59
Simulation 3.	0.27	-0.60	1.58	-0.17	0.93	1.59
Simulation 4.	0.19	-0.25	1.59	-0.11	0.85	1.61
Simulation 5.	0.26	-0.59	1.58	-0.10	0.73	1.59
Simulation 6.	0.27	-0.60	1.58	-0.26	0.77	1.59
Simulation 7.	0.24	-0.50	1.58	-0.90	0.78	1.59
Simulation 8.	0.19	-0.25	1.59	-0.11	0.83	1.61
Elasticity w.r.t. δ						
Simulation 1.	-0.03	-0.00	-0.16	-0.58	-0.07	-0.14
Simulation 2.	-0.04	-0.01	-0.16	-0.50	-0.03	-0.14
Simulation 3.	-0.04	-0.01	-0.16	-0.60	-0.04	-0.14
Simulation 4.	-0.05	0.00	-0.16	-0.48	-0.12	-0.14
Simulation 5.	-0.04	-0.01	-0.16	-0.42	-0.03	-0.14
Simulation 6.	-0.03	-0.01	-0.16	-0.51	-0.04	-0.14
Simulation 7.	-0.03	-0.02	-0.16	-0.57	-0.02	-0.15
Simulation 8.	-0.05	0.00	-0.16	-0.48	-0.12	-0.14
Elasticity w.r.t. α_0						
Simulation 1.	-0.17	0.37	0.22	-0.14	-0.52	0.21
Simulation 2.	-0.17	0.37	0.22	-0.09	-0.51	0.21
Simulation 3.	-0.17	0.37	0.22	-0.21	-0.60	0.21
Simulation 4.	-0.13	0.14	0.21	-0.28	-0.56	0.18
Simulation 5.	-0.17	0.37	0.22	-0.12	-0.46	0.21
Simulation 6.	-0.17	0.37	0.22	-0.09	-0.49	0.21
Simulation 7.	-0.17	0.39	0.22	-0.08	-0.70	0.21
Simulation 8.	-0.13	0.14	0.21	-0.27	-0.55	0.18

Appendix: Parametrization

This appendix discusses the choice of parameters for the baseline simulations. In setting the tax parameters, I draw on the fairly detailed discussion of recent reforms in the Polish income tax system in Gorecki and Wisniewski (1992). At the start of 1992, the Polish authorities introduced a new personal income tax system according to which income is taxed in three bands at the rates 20, 30 and 40 percent. 1/ The bands are wide, being almost three times the average wage so it might seem reasonable to take the 20 percent rate as the baseline case. The bands are imperfectly indexed so the current flatness of the income tax structure is likely to change in the future. Also, labor income is taxed quite substantially through the excess wage tax levied on firms. While the authorities regard this tax as temporary, it may well be around for quite a long time and the total revenue it raises is very substantial. Hence, I adopt a baseline wage tax level of 25 percent and a baseline savings tax rate of 22 percent. Social security taxes are paid directly by firms through a 45 percent levy on the pre-tax enterprise payroll translating into a proportional tax rate of 31 percent. 2/ On consumption goods taxes, the Polish authorities intend to replace the current system of turnover taxes with a Western-European-style Value Added Tax. This tax is likely to be introduced in mid-1993, although the implementation date has slipped back several times. This tax would have a reasonably wide coverage of different goods but the effective rate for consumption goods as a whole is unlikely to exceed 8 percent. Lastly, I assume a zero inheritance tax rate.

Utility function parameters for Poland are a matter of educated guesswork. There are almost no significant empirical studies and what past studies do exist used data from before a very substantial regime change involving a relaxation in quantity constraints on consumption, savings and labor supply behavior. The best approach is, therefore, to use reasonable values, suggested by the literature on other economies. I set the elasticity of intertemporal substitution, ρ, at 0.8.There is some controversy on reasonable values for this parameter in the US where a well-known study by Boskin found high substitution elasticity while other work, e.g. Carlino (1982), suggests lower values. The figure here is fairly high but still lower than Boskin's estimate. I choose a subjective discount rate, δ, of 4 percent. The important figure is in fact the difference between δ and the after tax real interest rate. Since, I set the pre-tax interest rate at 5 percent, choosing 4 percent for δ implies a gradually declining path for full consumption (given the fact that marginal utility is decreasing in consumption). I set the consumption-leisure elasticity of substitution also at 0.8. This figure implies a very small elasticity of labor supply, in line with estimates in other countries. It is hard to judge what a sensible value would be for the bequest substitution elasticity so, for simplicity, I set it

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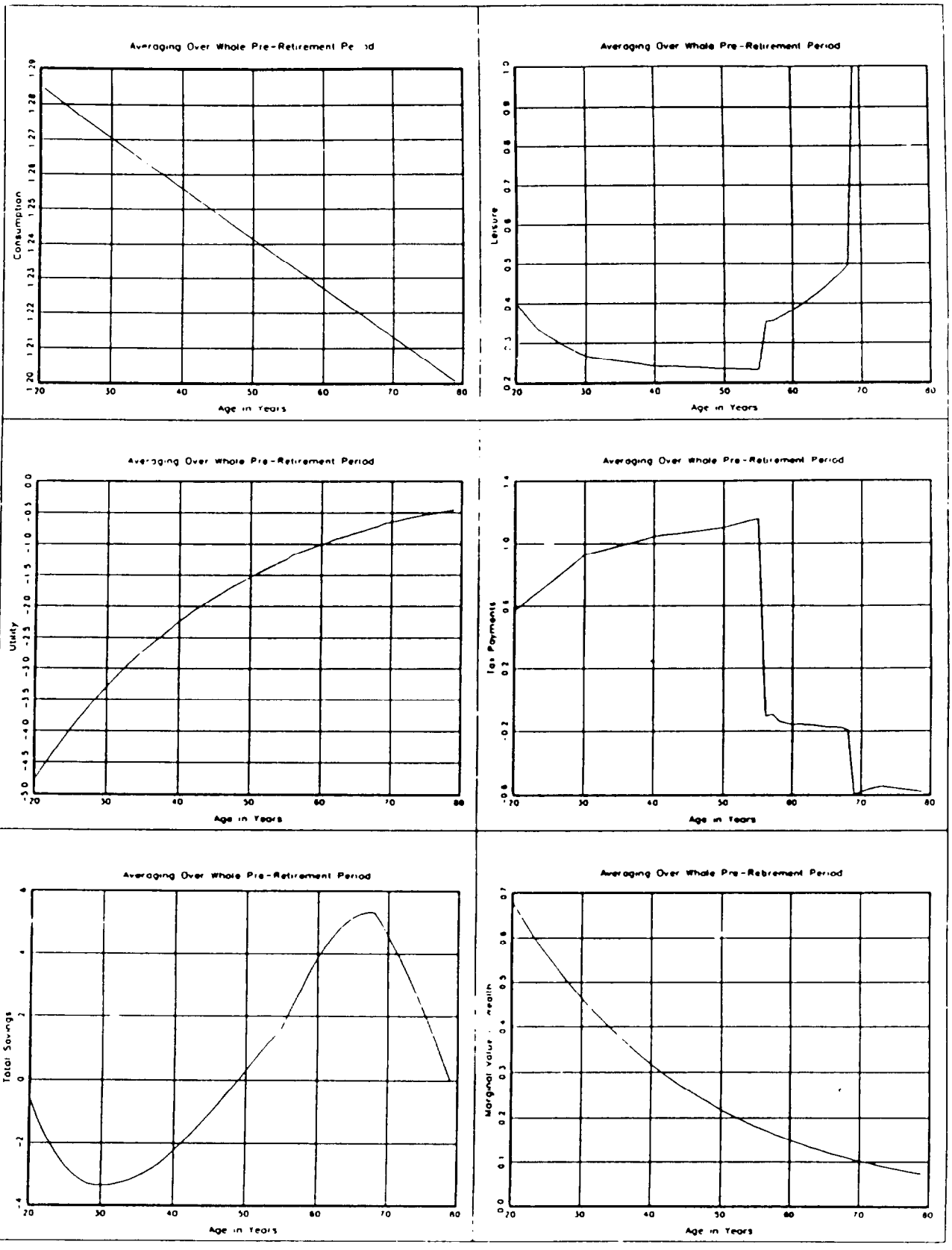
1/ The tax replaced the old payroll tax as well as the less important income equalization tax and various small taxes on individual crafts and small manufactures.

2/ Of the 45 percent, 43 percent goes towards the social insurance expenditures of the ZUS, while 2 percent is used as a contribution towards the costs of unemployment benefits.
This distinction makes no difference to the economic effects of these taxes.

at 0.8, the same as the elasticity of intertemporal substitution. The last utility parameters, the consumption-leisure parameter, α_0, and the bequest-full-consumption parameter α_1, largely determine what the household's expenditure shares devoted to leisure and bequests. α_0 especially is fairly arbitrary since we normalize leisure endowment to unity and have little idea what proportion of leisure is actually consumed. It is reasonable to expect Polish households to attribute relatively low priority to bequests given expectations of rising living standards. In sum, it seems reasonable to set α_0 and α_1 in the baseline to 0.2 and 0.1.

SIMULATION 1 WITHOUT LIQUIDITY CONSTRAINTS



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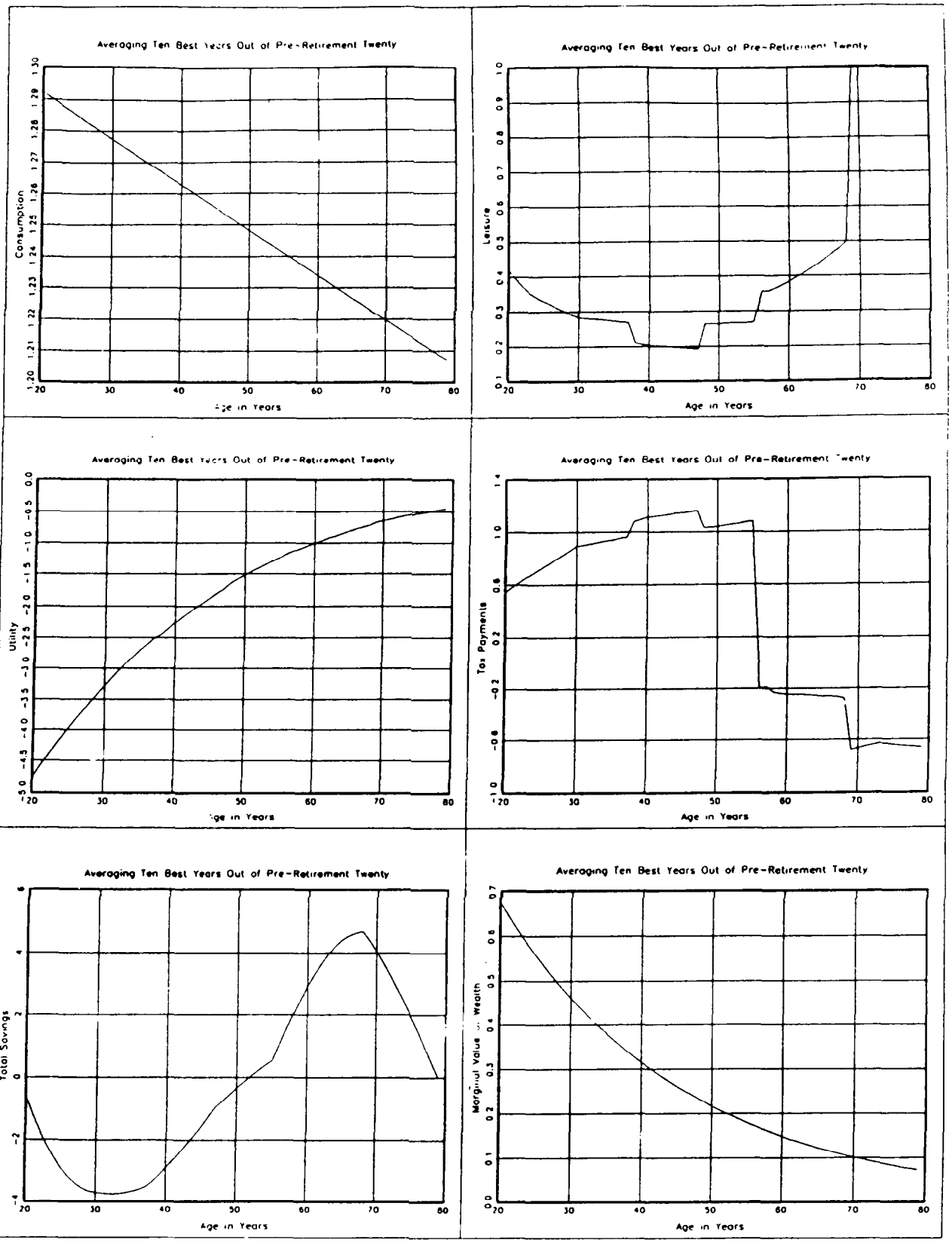

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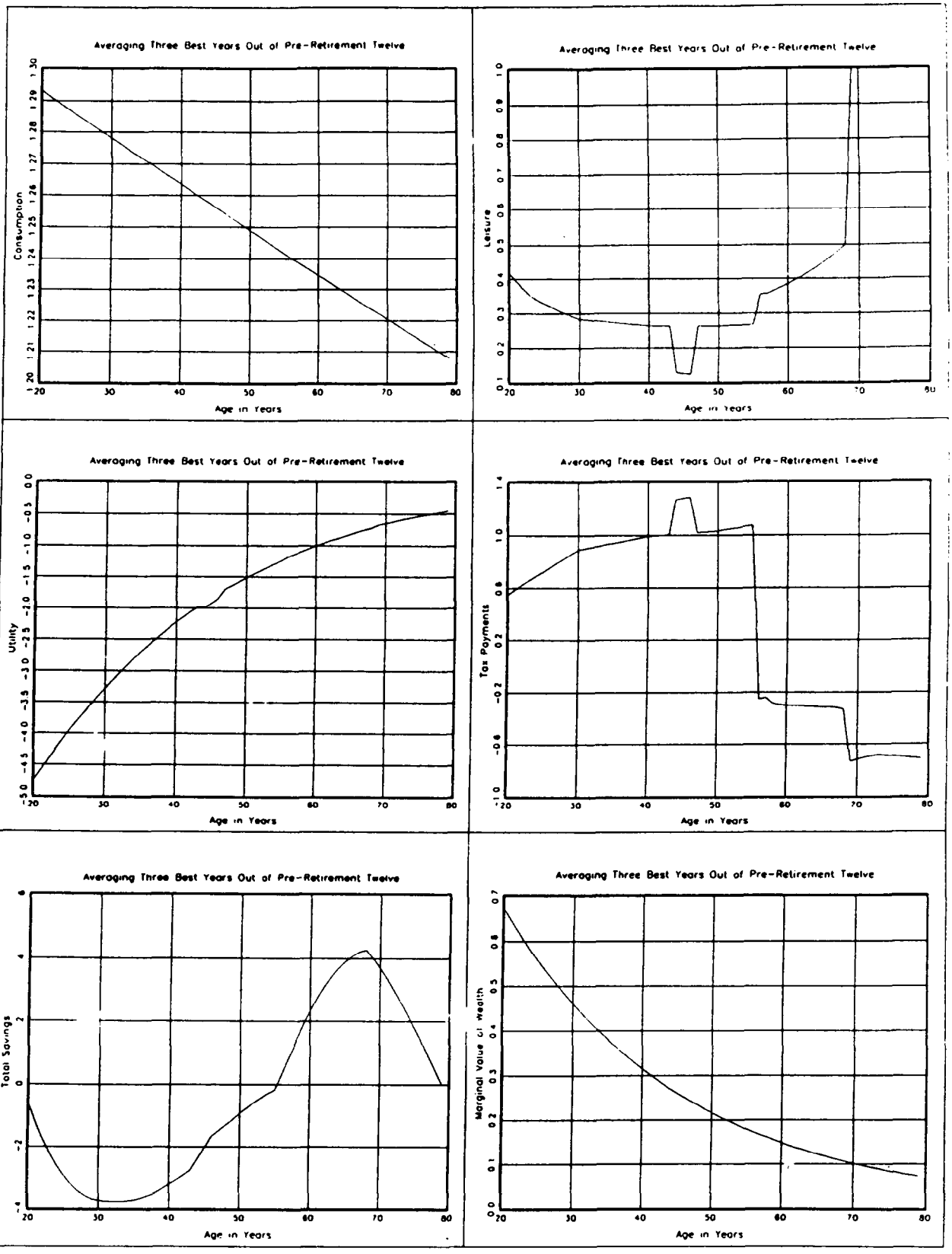

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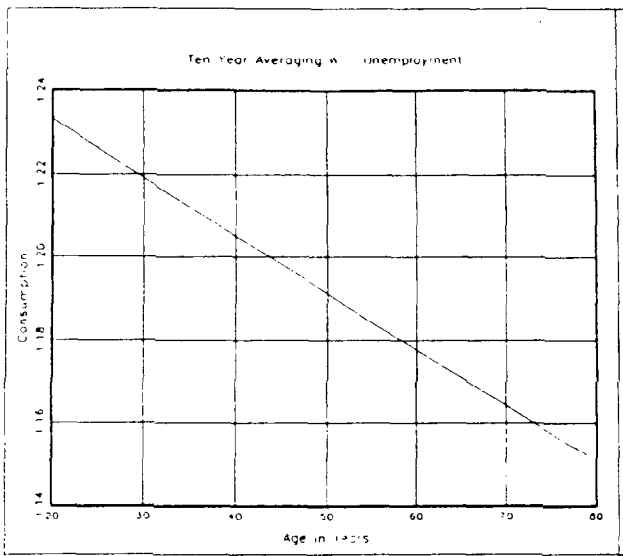

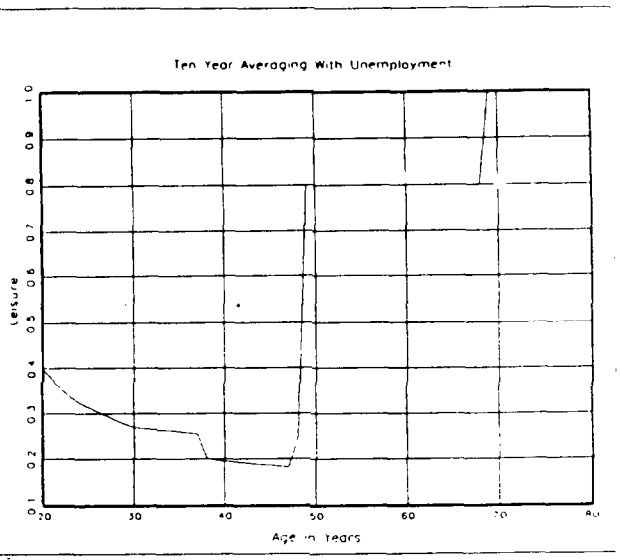

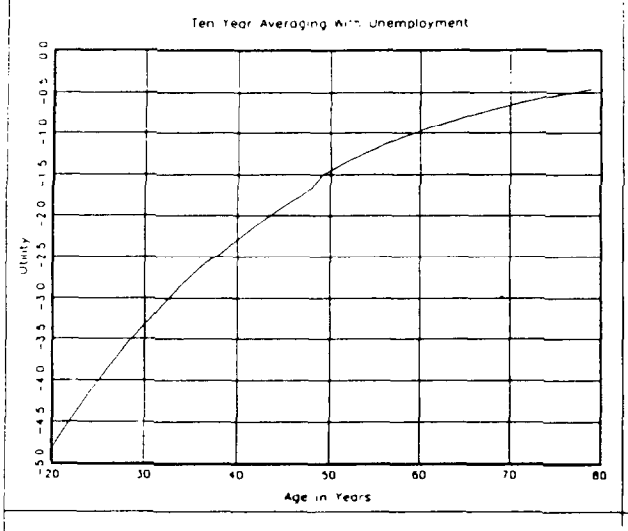

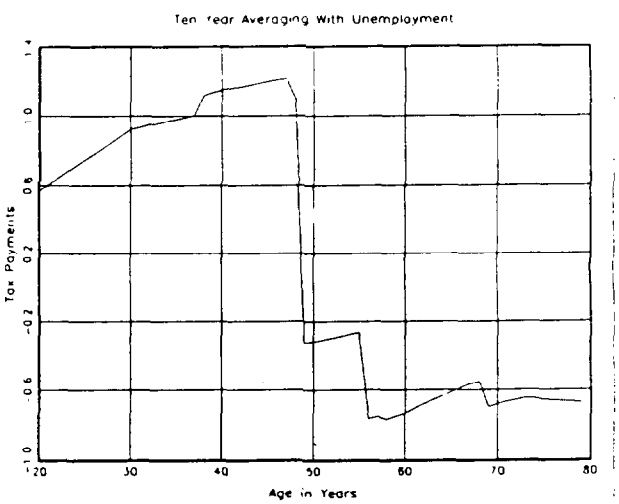

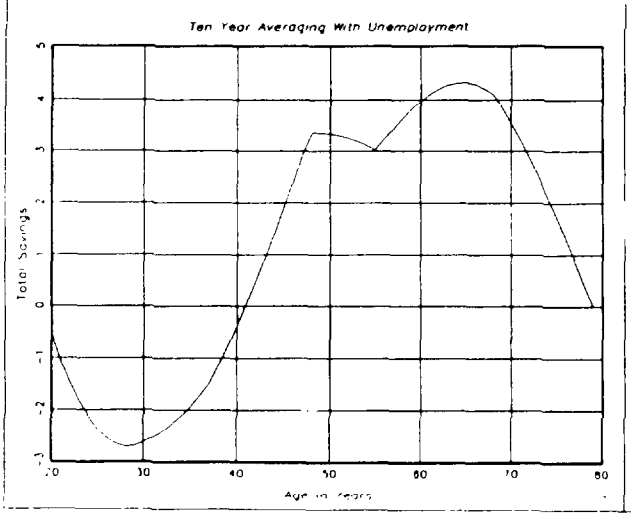

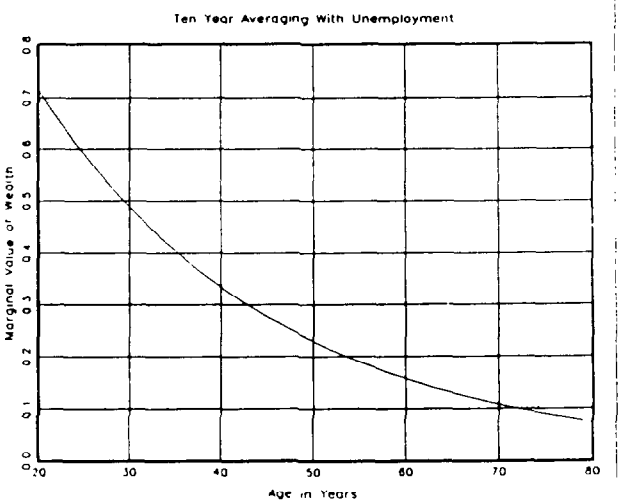

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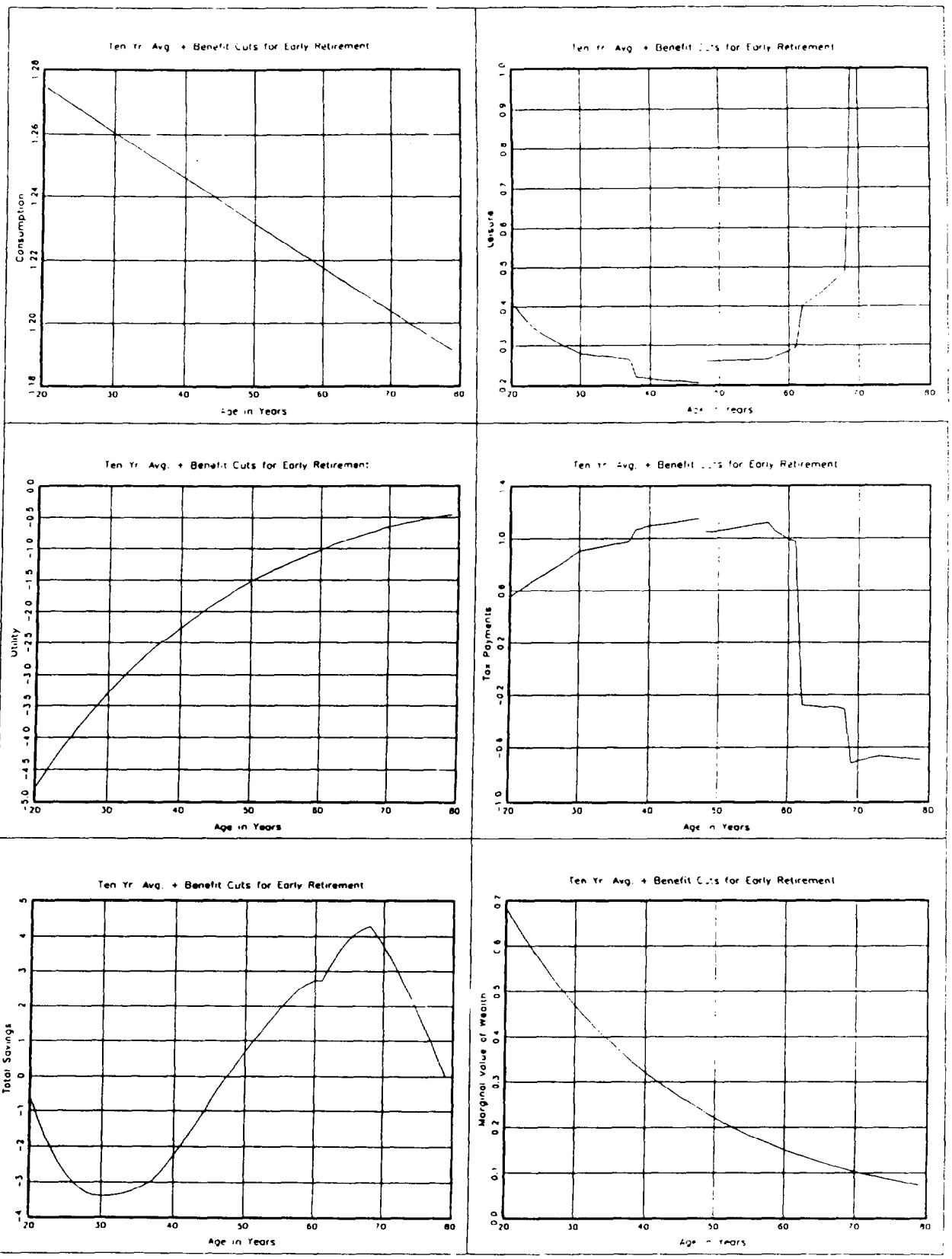

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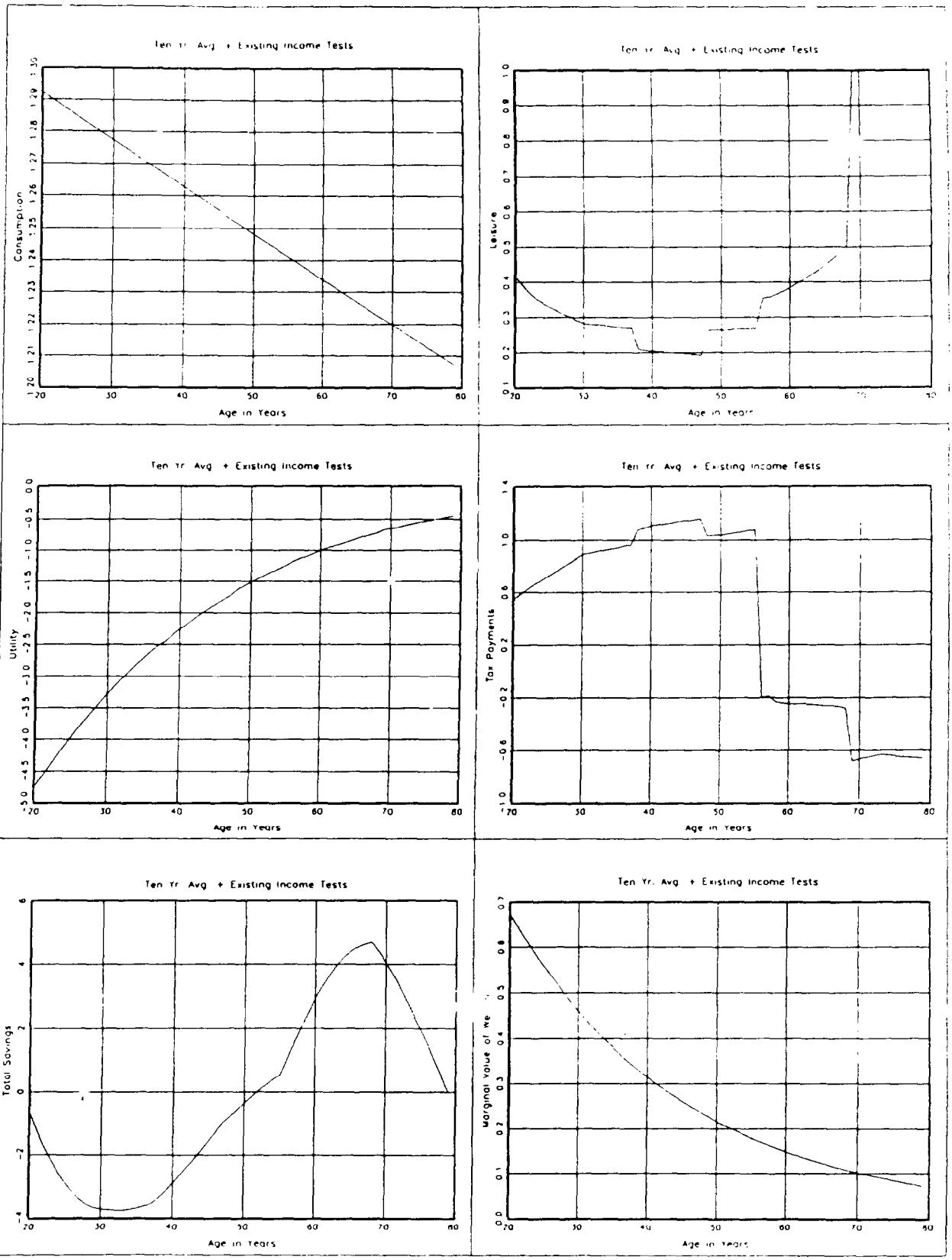

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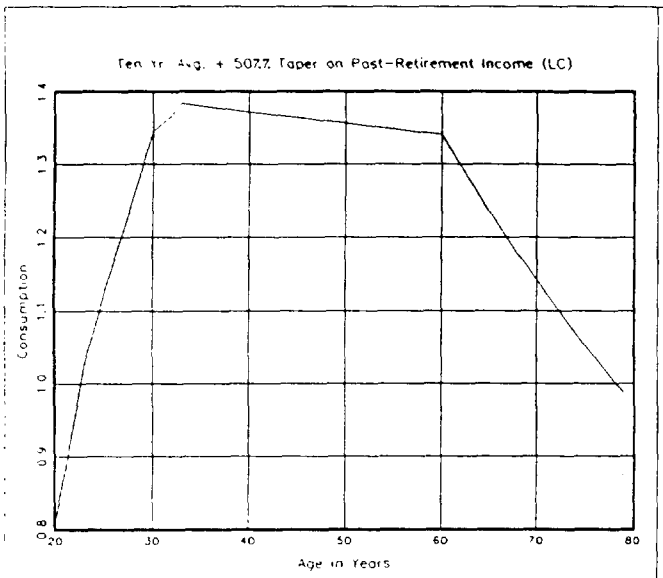
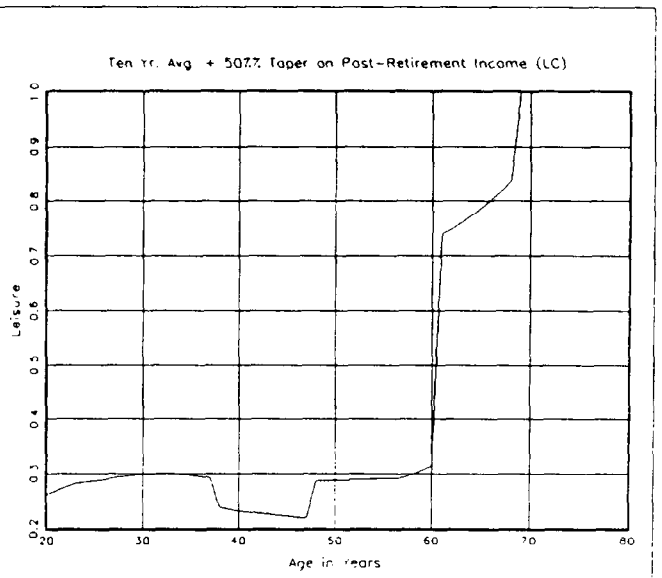
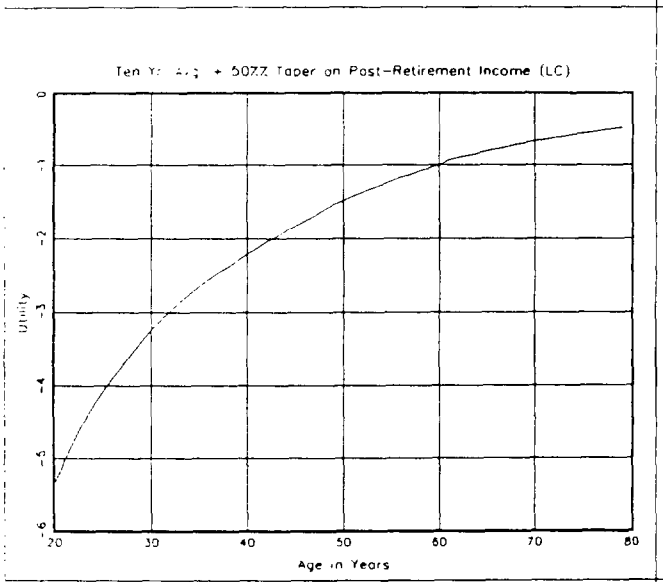
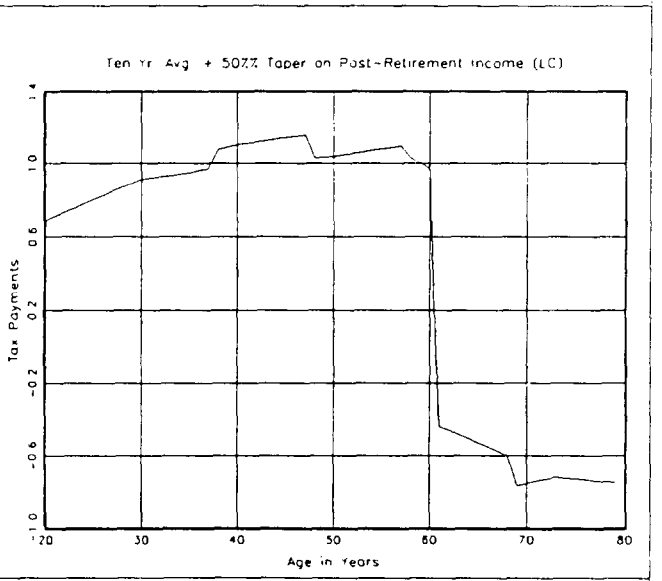
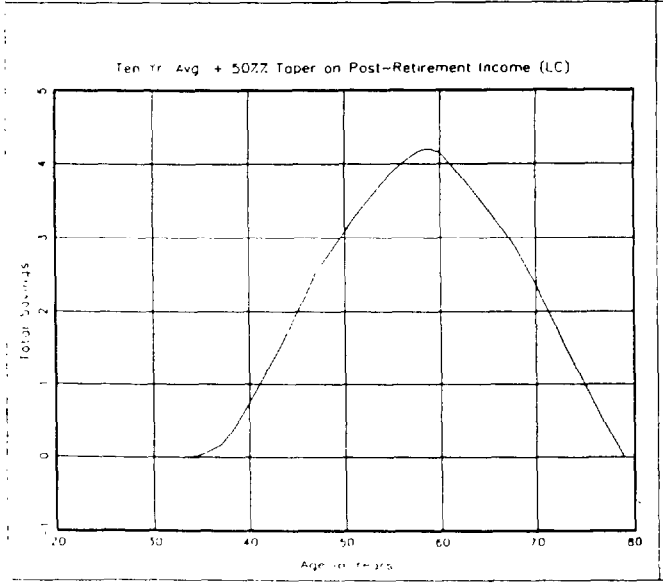
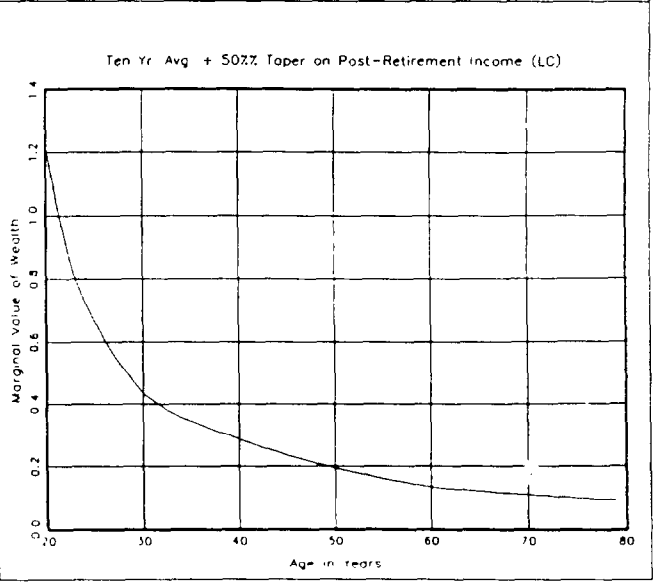




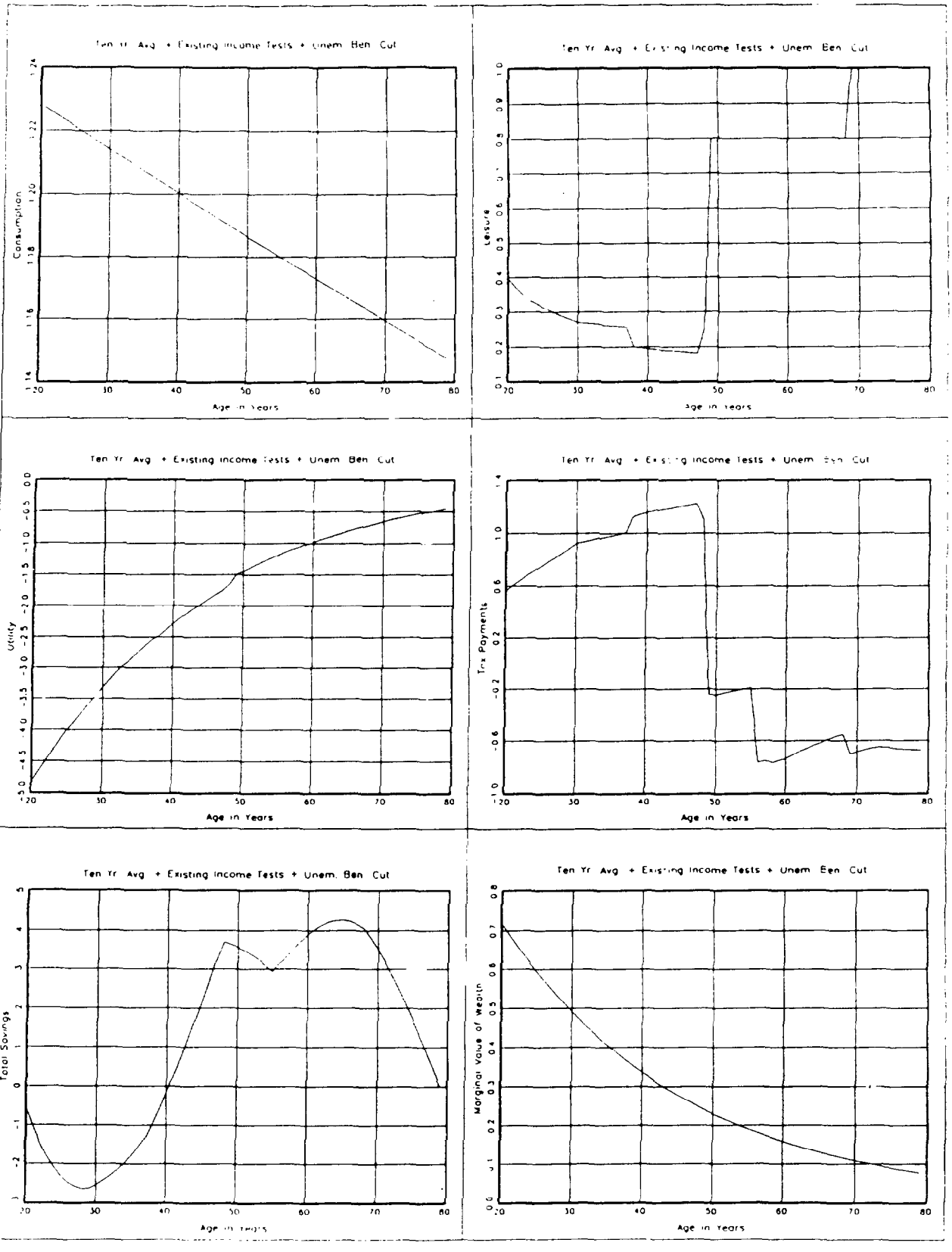




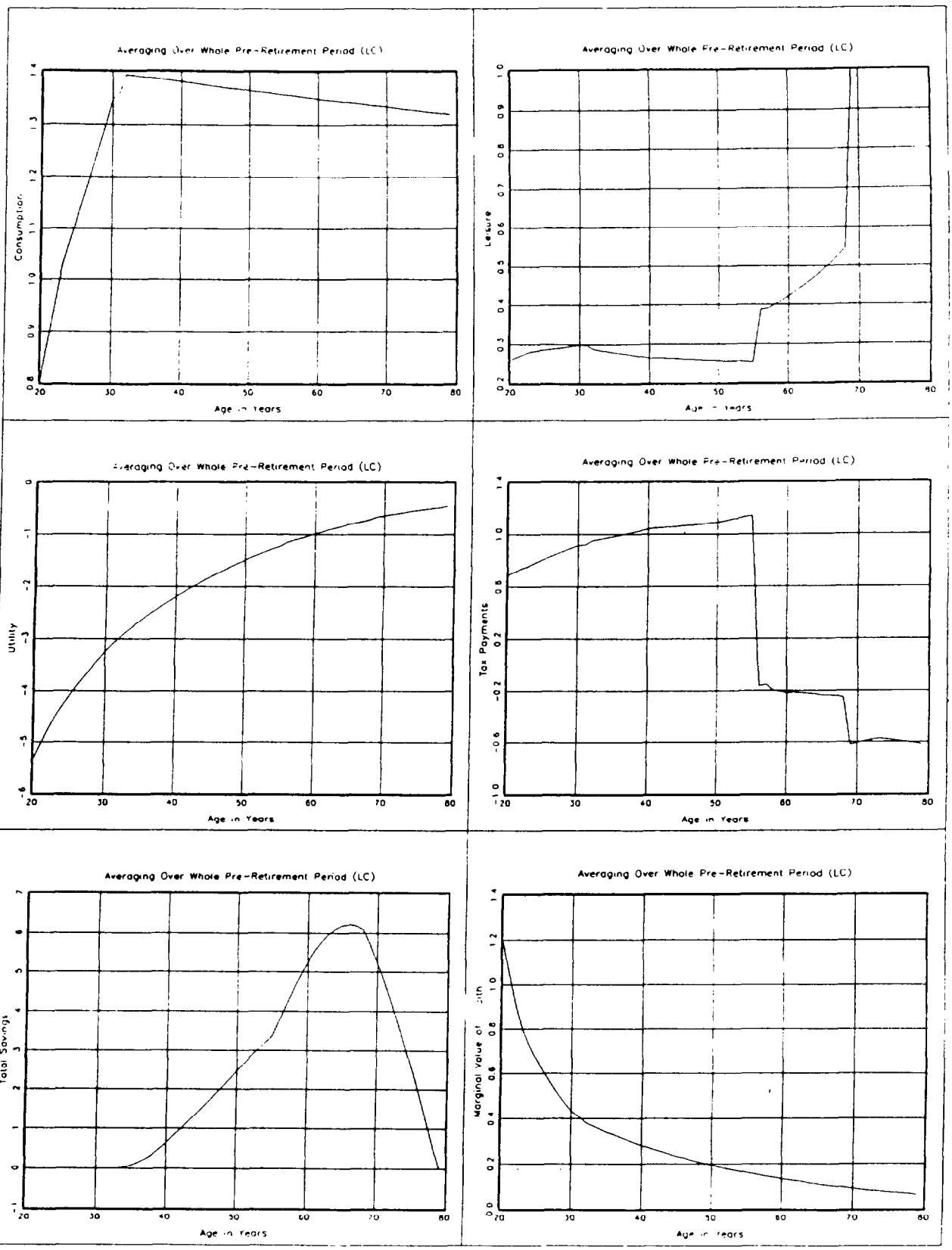




SIMULATION 8 WITHOUT LIQUIDITY CONSTRAINTS



SIMULATION 1 WITH LIQUIDITY CONSTRAINTS



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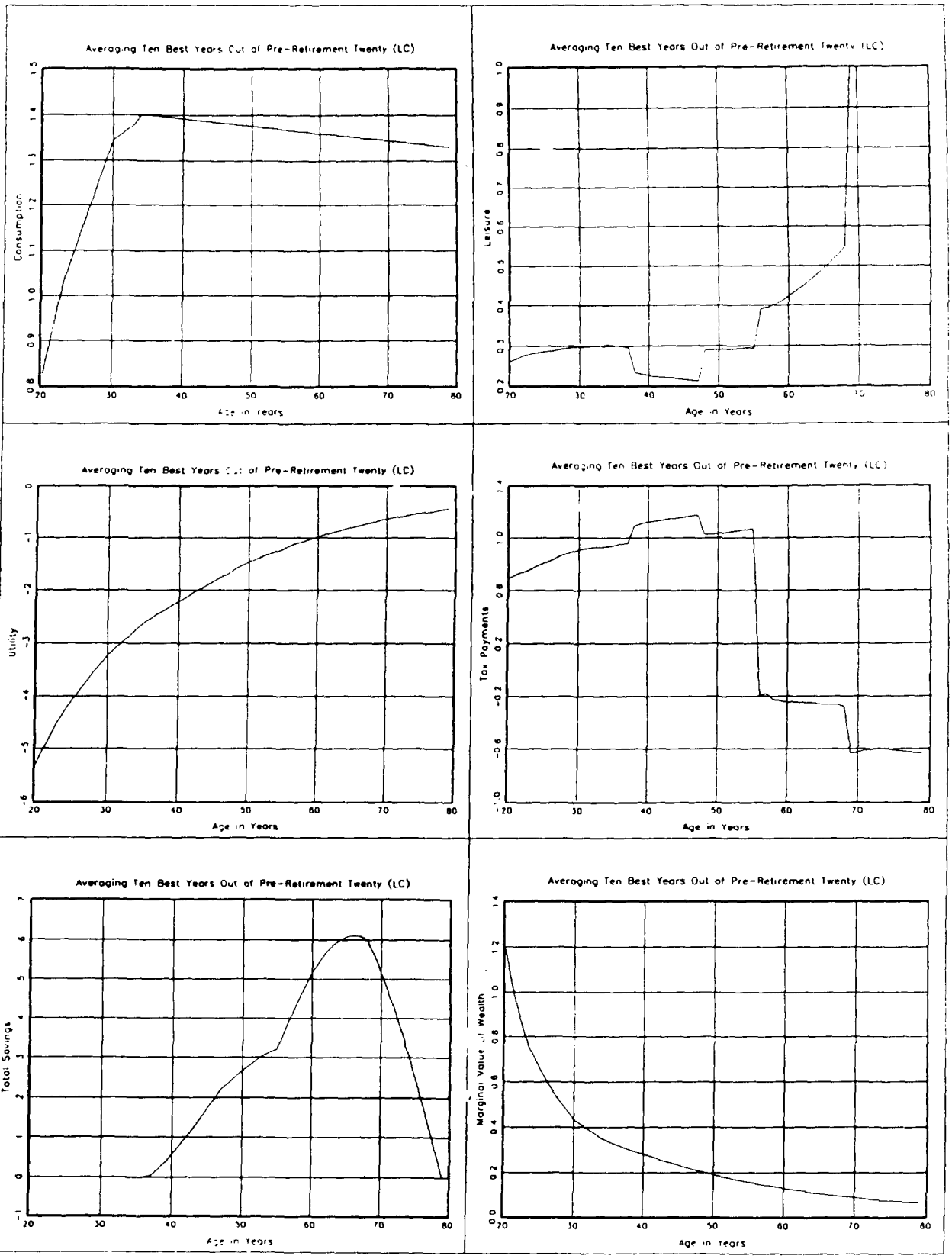
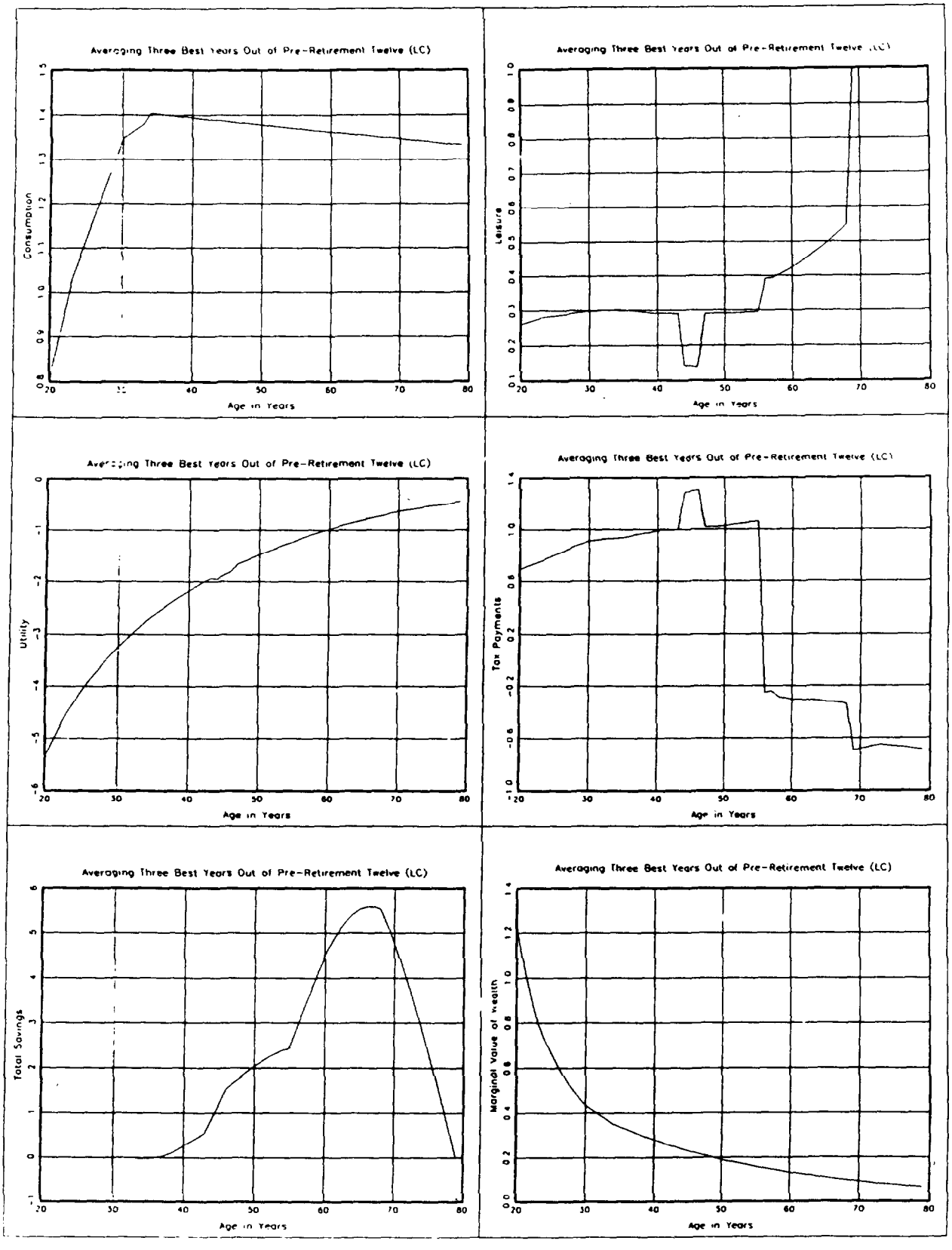
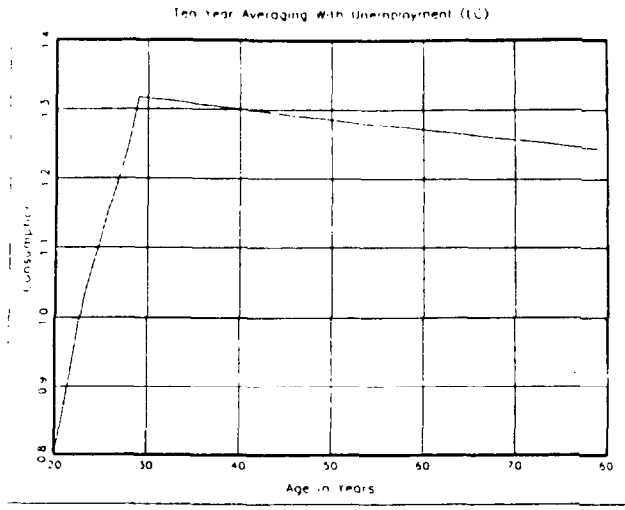
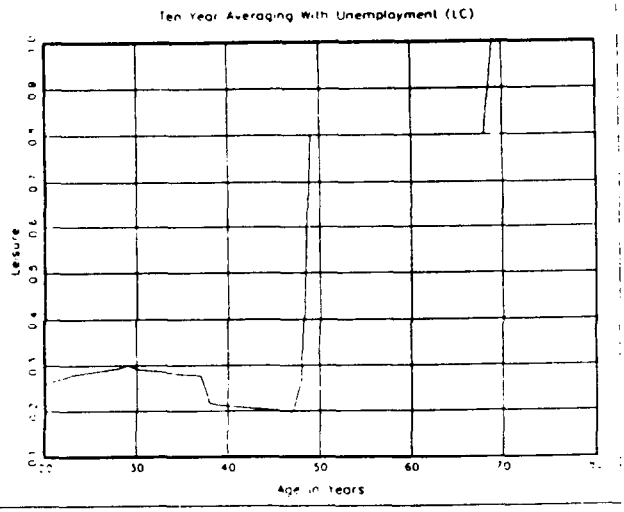


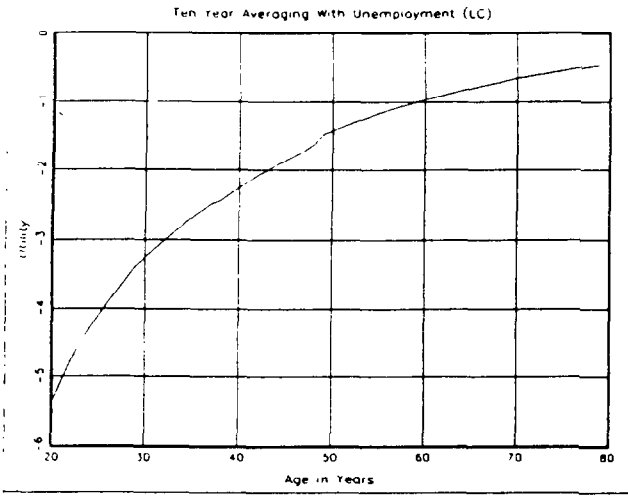
SIMULATION 3 WITH LIQUIDITY CONSTRAINTS

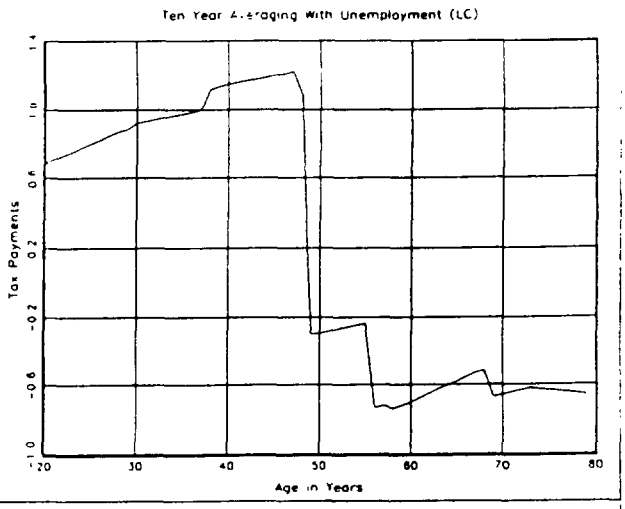


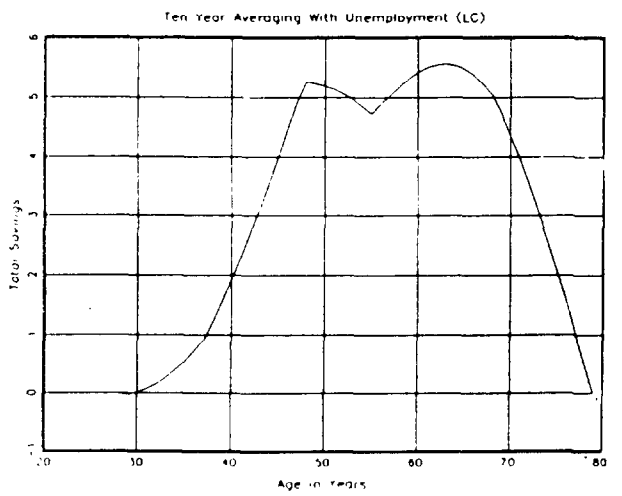
SIMULATION 4 WITH LIQUIDITY CONSTRAINTS

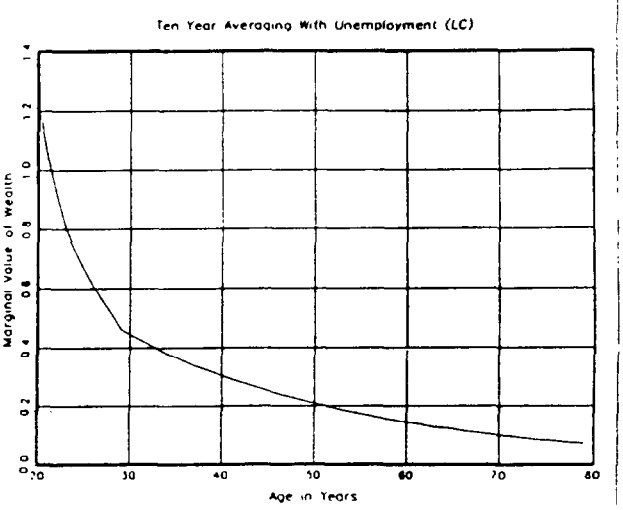




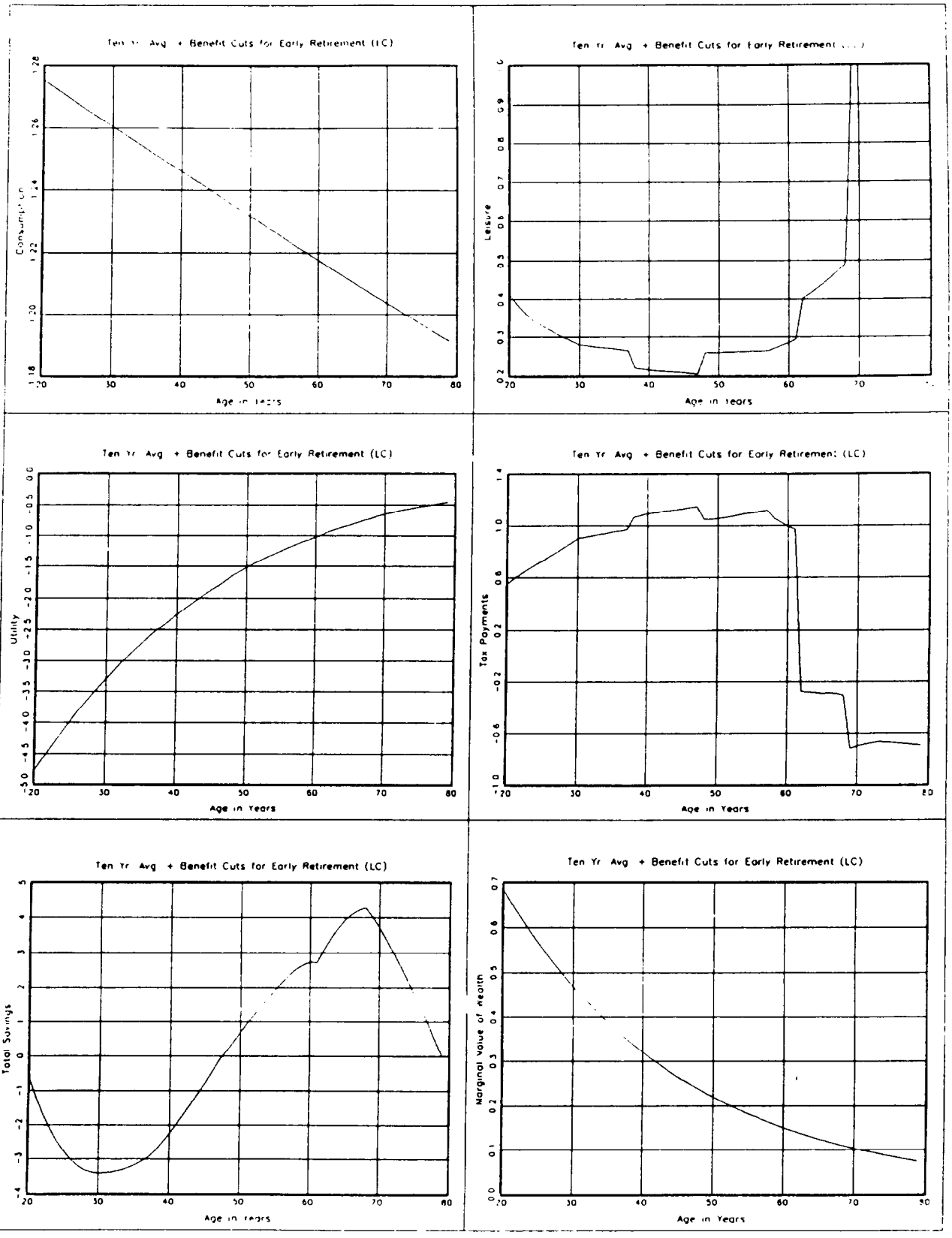




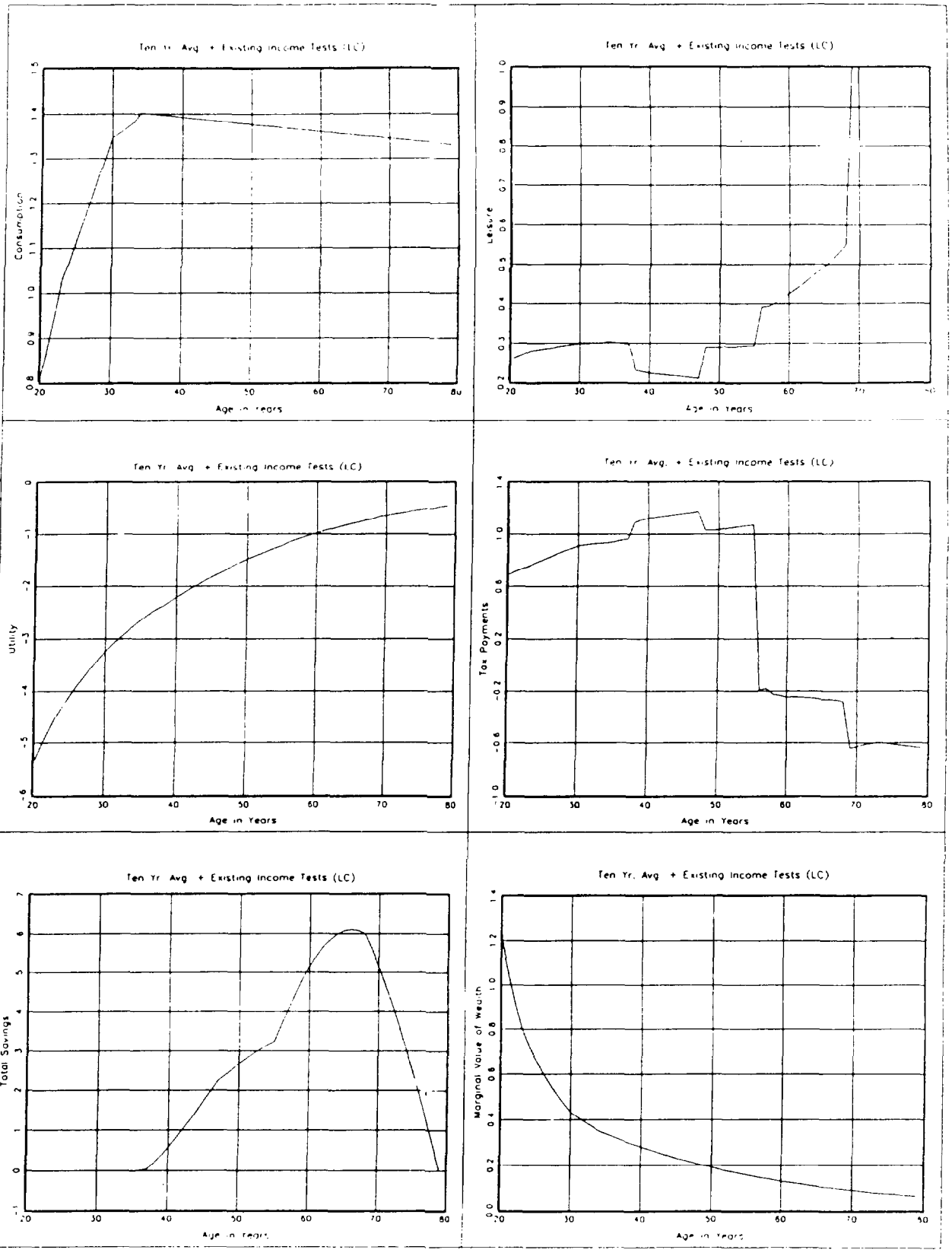




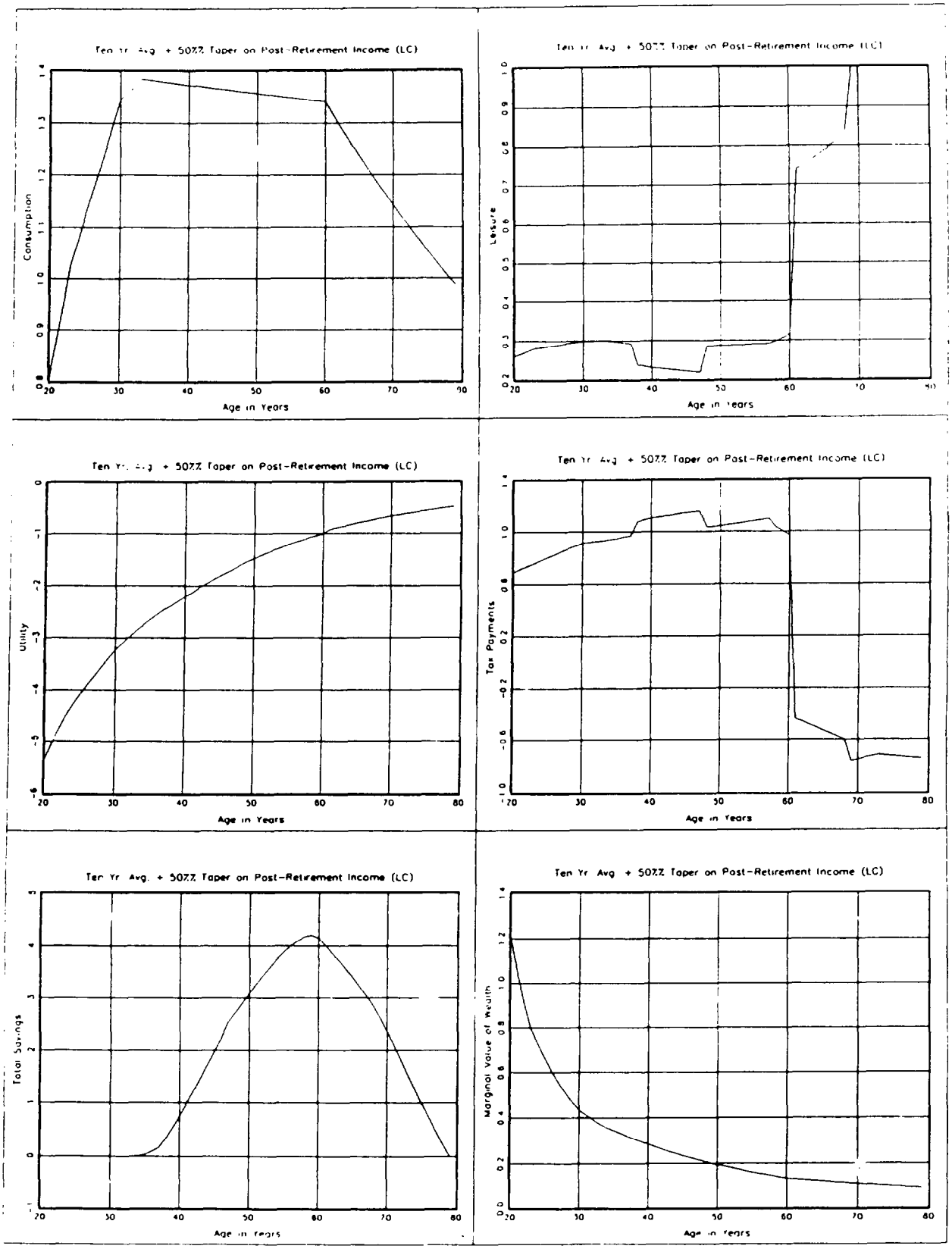
SIMULATION 5 WITH LIQUIDITY CONSTRAINTS



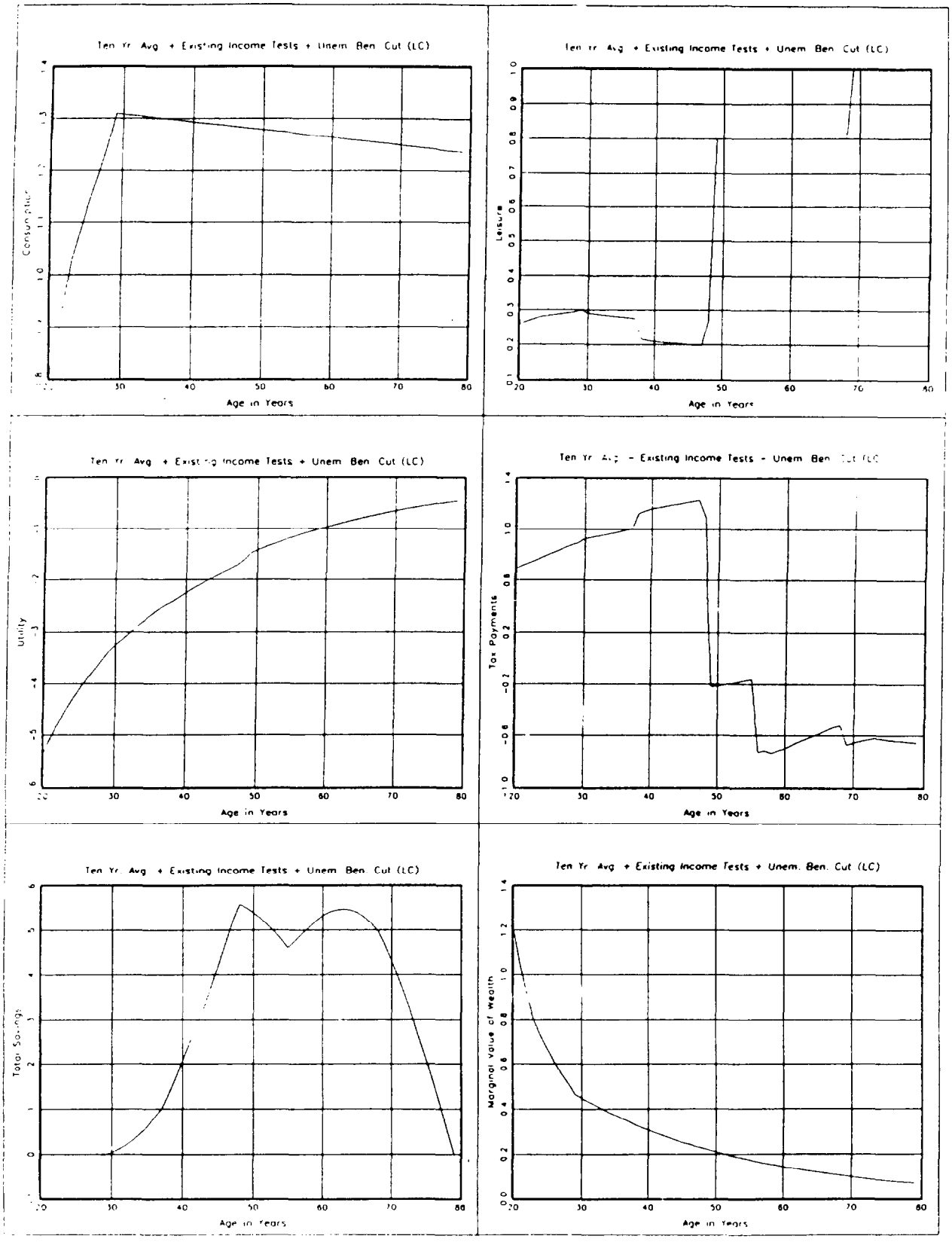
SIMULATION 6 WITH LIQUIDITY CONSTRAINTS



SIMULATION 7 WITH LIQUIDITY CONSTRAINTS



SIMULATION 8 WITH LIQUIDITY CONSTRAINTS



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