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POST-WAR CAPITAL ACCUMULATION AND THE THREAT OF NUCLEAR WAR

Joel Slemrod

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ABSTRACT

The hypothesis of this paper is that the performance and, in particular, the rate of capital accumulation of the post-war U.S. economy has been influenced by the changes in the public perception of the threat of a catastrophic nuclear war. An increased threat shortens the expected horizon of individuals and firms, and thus reduces the willingness to postpone present consumption in favor of investment.

The hypothesis is tested by expanding a standard savings function estimation technique to include a measure of the perceived threat of nuclear war. Four alternative measures of the perceived threat are considered, all of which are based on the setting of the clock published monthly in Bulletin of the Atomic Scientists, which reflects the editors' judgment about the likelihood of a nuclear conflict. The tests all support a large and statistically significant impact of the threat of nuclear war on the rate of private saving.

These tests are not viewed as conclusive evidence in favor of the economic impact of the perceived threat of nuclear war. Nevertheless, this research suggests that economists may have been overlooking an important source of variation in the post-war, post-nuclear U.S. economy. Conceivably, it could affect not only the private savings rate but also such things as the level of investment in human capital, the level of asset prices, the term structure of interest rates, and the rate of inflation.

Joel Slemrod
Department of Economics
University of Minnesota
1151 Business Administration Building
Minneapolis, MN 55455

(612) 373-3607

Most economists would not quarrel with the statement that desired saving by households is potentially sensitive to changes in expected life span and the ability to leave bequests. After all, life cycle saving and saving for bequests are two of the most important motives for accumulating wealth. From this perspective it is notable that recent attempts to explain variations in post-war rates of capital accumulation (Boskin, 1978; Howrey and Hymans, 1978) have failed to consider a potentially significant contribution to changes in expected life span and the perceived ability to leave bequests -- the threat of nuclear war. Popular perception of the likelihood of a nuclear war is by no means insignificant. A recent Associated Press/NBC News public opinion survey found that 76 per cent of Americans believe war is likely within a few years.[1/] Moreover, when asked if, in the event of a world war, nuclear weapons would be used on the U.S., typically 70 per cent of Americans answer in the affirmative.[2/] Finally, in 1963, 89 per cent of Americans perceived their chances of surviving a nuclear war to be 50-50 or less.[3/] Apparently, a significant fraction of Americans take the threat of a life-threatening nuclear war in the not-too-distant future to be a real possibility. There is also evidence, to be discussed later, that the perceived threat of nuclear war has varied quite a bit since the end of World War II. The hypothesis of this paper is that these changes in the perceived threat of nuclear war have had a significant impact on the rate of capital accumulation in the U.S. in the past thirty-five years.

The remainder of this paper is divided into five sections. Section I develops some simple economic reasoning about the expected impact of a threat of nuclear war. In Section II, I present a measure of the threat of nuclear war, describe a test of the hypothesis, and describe the data to be used in the test. Section III describes the results of the test, and in Section IV the plausibility of the estimated effect is considered. Some concluding remarks are offered in Section V.

I. Savings, Investment, and the Threat of Nuclear War

Consider an individual who dies a natural death at the end of T periods.[4/] At the end of the ith period there is a probability p_i of a nuclear war which kills the individual and any of his potential heirs. If the individual is still alive as of period i, there is a probability $p_i / \sum_{i=j}^{T} p_j$ that death will occur at the end of that period, unless $i = T - 1$, in which case the probability is unity.

The individual maximizes expected utility, which is given by

$$\text{(1)} \qquad EU = U(C_1) + (1 - p_1)\beta U(C_2) + \ldots + (1 - \sum_{i=1}^{T-1} p_i)\beta^{T-1} (U(C_T) + V(B)) ,$$

$$U' > 0,\ U'' < 0,\ V' > 0,\ V'' < 0$$

where C_i is consumption and $U(C_i)$ is the utility enjoyed during period i, β is a discount factor, B is the amount of bequests left, and $V(B)$ is the satisfaction dervied by the bequeathor. Let the probability that the individual survives into the ith period, $1 - \sum_{j=1}^{i-1} p_j$ $(i > 1)$, be denoted q_i. Then, equation (1) can be rewritten as

$$\text{(2)} \qquad EU = \sum_{i=1}^{T} q_i \beta^i U(C_i) + q_T \beta^T V(B) .$$

It is assumed that life insurance and annuity contracts written concerning death due to nuclear war are not available. Also it is not required that the individual at all times maintain non-negative wealth, thus allowing the possibility of dying with outstanding debts. It is, though, required that the consumer have non-negative wealth if and when he or she reaches period T. Under these conditions the sole constraint on the maximization problem is that

$$A_o(1 + r)^T + \sum_{i=1}^{T} (1 + r)^{T-i}(Y_i - C_i) - B = 0 , \tag{3}$$

where A_o is initial assets, Y_i is labor earnings during period i, and r is the rate of interest per period. Maximizing (2) subject to (3) implies the following first-order conditions:

$$\frac{U'(C_i)}{U'(C_j)} = [\beta(1 + r)]^{j-i} \frac{q_j}{q_i} \qquad \forall_{i,j} \tag{4}$$

$$\frac{U'(C_i)}{V'(B)} = [\beta(1 + r)]^{T-i} \frac{q_T}{q_i} . \qquad \forall_i \tag{5}$$

Thus, an increased probability of future nuclear war (that is, a decrease in q, if $j > i$) has the effect of increasing the effective discounting of the future. The individual will tend to substitute earlier consumption for later consumption and thus reduce the rate of wealth accumulation.[5/]

Nuclear war, as opposed to the natural death of human beings, will doubtlessly destroy capital goods. This would reduce the expected present value of investment projects, especially for long-lived projects. If the present discounted value of the project's income stream is

$$(6) \quad -C_1 + R_1 + \frac{R_2}{(1+r)} + \frac{R_3}{(1+r)^2} + \ldots \frac{R_N}{(1+r)^{N-1}}$$

(where C_1 is the cost of the project and R_i is the return in period i of a project lasting N periods) in the absence of the possibility of a nuclear war which destroys all capital goods, in its presence the expected present discounted value is

$$(7) \quad -C_1 + R_1 + \frac{(1-p_1)R_2}{(1+r)} + \frac{(1-p_1-p_2)R_3}{(1+r)^2} + \ldots \frac{(1-\sum_{i=1}^{N-1} p_i)R_N}{(1+r)^{N-1}} \quad .$$

As the probability of war increases, the expected present value of some projects goes from positive to negative. Thus, desired investment at any interest rate will decline.

Straightforward economic reasoning has led us to the conclusion that an increase in the perceived likelihood of nuclear war would reduce <u>ceteris paribus</u>, both desired saving and desired investment. In the context of an equilibrium model of a growing economy, this would lead to a reduced rate of capital accumulation. Depending on the detail and characteristics of the particular model chosen, it could also decrease the market value of long-lived assets, alter the term structure of interest rates, and have other impacts on the state of the economy. In this paper I have chosen to concentrate on the possible relationship between the threat of nuclear war and the rate of capital accumulation. In the next section I begin the task of investigating whether such a relationship can be detected in the post-war U.S. economy.

II. Data and Methodology

The approach adopted here is to compare the time series of the annual rate of capital accumulation with the time series of a measure of the perceived threat of nuclear war. The choice of this latter measure is discussed first.

Public opinion survey data seems a reasonable source of information about public perceptions of the likelihood of war. Unfortunately, although relevant questions have been posed in national surveys, in no case has the same question been asked over a long stretch of time since the end of World War II. There does exist, though, a continually available series which represents a professionally informed opinion about the state of international tensions and the likelihood of a nuclear war. Since 1947, the Editorial Advisory Board of the Bulletin of the Atomic Scientists has printed on its editorial page a clock whose hands are set at a time approaching midnight. Just how close to midnight the hands are set represents the Board's judgment about how great the danger of nuclear war is. When it first appeared in 1947, the clock stood at seven minutes to midnight. It has since been moved ten times. It has come ominously close to "doomsday": three minutes to midnight in 1949, after the first Russian atomic bomb test, and two minutes to midnight in 1953 in response to U.S. and Soviet development of the hydrogen bomb. It was then gradually moved back in appreciation of the thawing of the Cold War and, in particular, because of the Partial Test-Ban Treaty (1963), the Nuclear Non-Proliferation Treaty (1969), and the SALT I agreement (1972). From June of 1972 to September of 1974 the clock stood at twelve minutes to midnight. However, since 1974, the clock has been moved closer and closer to midnight, reflecting the intensification of the nuclear and conventional arms races and the apparent possession of nuclear weapons by a growing number of countries. The last time it was moved was in January of 1981, to four minutes to midnight.[6/]

Although this variable is not directly a measure of the average individual's perceptions of the danger of nuclear war, it does represent informed opinion and should therefore be highly correlated with the general perception. In addition, it has the advantage of being available without interruption since 1947. The average setting of the clock for each year beginning in 1947 is given in Table 1.

Table 1

"Minutes to Midnight," 1948-1979

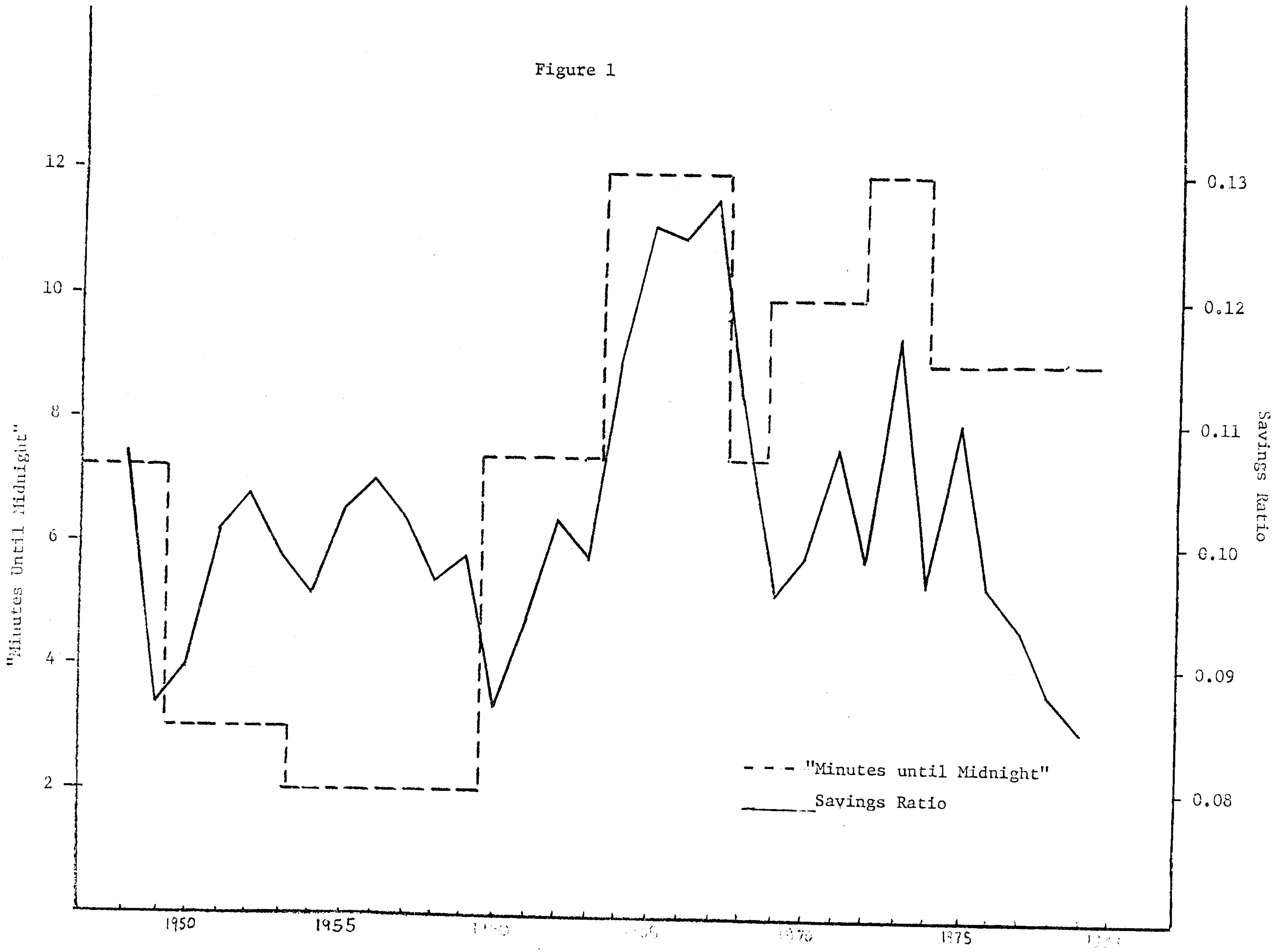
Year	Value	Year	Value	Year	Value	Year	Value
1948	7.0	1956	2.0	1964	12.0	1972	11.17
1949	6.0	1957	2.0	1965	12.0	1973	12.0
1950	3.0	1958	2.0	1966	12.0	1974	11.0
1951	3.0	1959	2.0	1967	12.0	1975	9.0
1952	3.0	1960	7.0	1968	7.0	1976	9.0
1953	2.67	1961	7.0	1969	9.33	1977	9.0
1954	2.0	1962	7.0	1970	10.0	1978	9.0
1955	2.0	1963	8.25	1971	10.0	1979	9.0

One problem with using the clock's setting as an index of the nuclear threat is that, in order to enhance its public impact, the Editorial Board seems to favor infrequent, large changes in the clock's hand. Thus, the clock's movements may lag behind the actual changes in the state of international tensions and also overstate the current escalation or de-escalation of tensions. To account for this possibility, a five-year moving average of the clock setting is considered as an alternative measure of the perceived threat of nuclear war.[7/]

Although the clock setting seems to be a reasonable measure of the likelihood of international conflict, what we are really interested in measuring is the probability of annihilation due to a war. This likelihood may be thought of as the product of the likelihood of nuclear war and the probability of death/destruction from a war. From this perspective, the clock's setting fails to account for the fact that the size of the nuclear arsenal of the Soviet Union (and the United States) has not remained constant in this period, and the probable destructiveness of a nuclear war has no doubt greatly increased since 1947. To reflect this aspect of the nuclear threat, I have constructed an index of the likely devastation of a nuclear war, which is equal to the estimated total of Soviet ICBM's, submarine-based missiles, and long-range bombers. These estimates are available annually since 1947.[8/] Using these figures, (denoted $WEAP_t$), a measure of the likelihood of destruction due to nuclear war is formed as $(\overline{MIN}-MIN_t) \cdot WEAP_t$, where MIN_t refers to the minutes from midnight the clock is set at in year t, and $\overline{MIN}$ is an arbitrarily chosen standard indicating no threat of war. This constructed variable thus increases either when the clock moves closer to midnight or the Soviet nuclear arsenal expands. The value of $\overline{MIN}$ used is 17; this implies that at the most threatening period (two minutes to midnight) the probability of nuclear war was three times as great as in the least threatening period (twelve minutes to midnight).

Figure 1 plots the path since 1947 of the first measure of the threat of nuclear war, the clock setting, shown as a dotted line. Measured on the vertical axis is the number of minutes from midnight the clock is set at; thus, higher values correspond to a lower perceived threat of nuclear war. Also plotted on Figure 1 is a measure of the rate of capital accumulation, the ratio of net private saving to disposable income plus retained earnings. According to the theory, there should be a positive association between this measure of capital accumulation and a perceived low probability of nuclear war. In fact, the two variables apparently exhibit a positive association. Both start high in 1947, decline and stay approximately constant until 1960. Beginning in 1960 there is a diminution in the threat of nuclear war and a concurrent increase in the rate of saving. Both reach a peak in the mid 1960's, decline sharply in the late 1960's and early 1970's. Another local peak is attained in both series around 1973. Beginning in 1974, the threat of nuclear war has increased, while the rate of saving has steadily declined. Clearly several of the turning points and local extrema of the two series nearly coincide. The main disparity comes from the comparison of the 1970's to the 1950's. According to the clock, the threat of war was lower in the 1970's than in the 1950's. The average savings rate in the 1970's, though,

Figure 1



12
10
8
6
4
2
"Minutes Until Midnight"
0.13
0.12
0.11
0.10
0.09
0.08
Savings Ratio
1950
1955
1975
"Minutes until Midnight"
Savings Ratio

was no higher than in the 1950's. However, in those twenty years the nuclear arsenals of both countries greatly expanded, and thus the probability of death due to nuclear war wsa no doubt higher in the 1970's than in the 1950's. This aspect of the changed international situation would be picked up by the constructed variables which include a measure of the Soviet nuclear capability.

This apparent parallel movement between the rate of saving and the freedom from the threat of nuclear war depicted in Figure 1 is tested by estimating a standard savings function. The standard specification is extended by adding one of the indices of the threat of nuclear war discussed earlier. The specifications investigated have the basic form

$$(8) \qquad \frac{S_t}{Y_t} = a_o + a_1 \, LNY_t + a_2 \, LNY_{t-1} + a_3 \, LNW_{t-1} + a_4 \, LNUNEM_t + a_5 \, NWAR_t + a_6 \, NWAR_{t-1}$$

This is similar to the specification estimated by Boskin (1978) and Howrey and Humans (1978)[9/]. The dependent variable is the ratio of net private saving to disposable income plus retained earnings. LNY is the natural logarithm of real per capita disposable income plus retained earnings.[10/] LNW is the logarithm of real per capita non-human wealth. (Non-human wealth is defined as the sum of net financial assets at the beginning of the year and noncorporate and household capital at replacement cost. The series is taken from Hayashi (1981)). LNUNEM is the logarithm of the unemployment rate, included to pick up any cyclical variation in savings behavior. The final two independent variables refer to one of the four measures of the threat of nuclear war. In the case of the unaveraged measures (MIN_t and $PWAR_t$, defined below) a lagged value is included to pick up any delayed response of saving and also to reflect the fact that all the variables are annual averages. Savings in January will not reflect changes in the explanatory variables that occur later in the year, but will respond to those changes that occurred in the previous year. For the moving average measures, only the current value is included.

III. Results

Equation (8) was estimated using ordinary least-squares for the period 1948 to 1979. The results of estimating four separate regression equations are presented below, each one corresponding to a different index of the threat of nuclear war. The four indexes are (i) the average clock setting in the current year, called MIN_t (ii) the five-year moving average of the clock setting, called $MINAV_t$ (iii) the constructed variable $(17-MIN_t) \times WEAP_t$, called $PWAR_t$ and (iv) the constructed variable using the moving average measure of the threat of war, called $PWARAV_t$. Standard errors are listed in parentheses below the estimated coefficient.

$$(9) \quad \frac{S_t}{Y_t} = \underset{(0.060)}{-0.00182} + \underset{(0.077)}{0.130}\, LNY_t - \underset{(0.084)}{0.196}\, LNY_{t-1} + \underset{(0.030)}{0.0556}\, LNW_{t-1}$$

$$-\underset{(0.0061)}{0.0165}\, LNUNEM_t - \underset{(0.0011)}{0.000533}\, MIN_t + \underset{(0.00099)}{0.00220}\, MIN_{t-1}$$

$$\bar{R}^2 = 0.447$$

$$DWS = 1.180$$

1948 - 1979

(10) $$\frac{S_t}{Y_t} = \underset{(0.058)}{0.0358} + \underset{(0.082)}{0.107}\ LNY_t - \underset{(0.089)}{0.146}\ LNY_{t-1} + \underset{(0.030)}{0.0269}\ LNW_{t-1}$$

$$-\underset{(0.0063)}{0.0172}\ LNUNEM_t + \underset{(0.00085)}{0.00189}\ MINAV_t$$

$$\bar{R}^2 = 0.398$$

DWS = 1.175

1948 - 1979

(11) $$\frac{S_t}{Y_t} = \underset{(0.120)}{0.513} + \underset{(0.059)}{0.264}\ LNY_t - \underset{(0.070)}{0.134}\ LNY_{t-1} - \underset{(0.027)}{0.0241}\ LNW_{t-1}$$

$$-\underset{(0.0058)}{0.00191}\ LNUNEM_t + \underset{(8.24 \times 10^{-7})}{(5.76 \times 10^{-9})}PWAR_t - \underset{(7.62 \times 10^{-7})}{(2.97 \times 10^{-6})}\ PWAR_{t-1}$$

$$\bar{R}^2 = 0.653$$

DWS = 1.609

1948 - 1979

(12) $$\frac{S_t}{Y_t} = \underset{(0.111)}{0.582} + \underset{(0.059)}{0.212}\ LNY_t - \underset{(0.073)}{0.0632}\ LNY_{t-1} - \underset{(0.028)}{0.0250}\ LNW_{-1}$$

$$-\underset{(0.0059)}{0.00313}\ LNUNEM_t - \underset{(6.57 \times 10^{-7})}{(3.13 \times 10^{-6})}PWARAV_t$$

$$\bar{R}^2 = 0.617$$

DWS = 1.621

1948 - 1979

In all four equations one of the nuclear war variables has the expected sign, which is positive for equations (9) and (10) and negative for equations (11) and (12). In equations (9) and (11) it is the lagged value which has the explanatory power. In all the equations, the 95% confidence interval of the appropriate variable does not include zero. Furthermore, in all cases the magnitude of the estimated effect of the threat of nuclear war on the savings ratio is large relative to the average observed ratio and its variation in the post-war period. Consider first equations (9) and (10), where the nuclear war variable has the units of a number of minutes to midnight. The estimated effect (which is the sum of a_5 and a_6 for equation (9)) of about 0.0017 implies that a change from the period of lowest nuclear threat in the post-war period (twelve minutes to midnight) to the greatest threat (two minutes until midnight) implies a decline in the savings ratio of 0.017, or 1.7 percentage points. This compares to an average post-war value of 0.102 and a standard deviation in post-war $\frac{S_t}{Y_t}$ of 0.011.

Now consider the estimated coefficients of the nuclear threat variable in equations (11) and (12), which are on the order of 3×10^{-6}. In 1979, the value of MIN_t was 9.0 and the value of $WEAP_t$ was 2582. The estimated coefficients thus imply that an increase in international tensions equal to a drop of MIN_t to 4.0 (which is where it stands as of 1981) would at the current level of weaponry be associated with a decline in the saving ratio of 0.039. At the 1979 value of MIN_t, a 50 per cent increase in Soviet weaponry would imply a decline in the saving rate of 0.031.

The estimated wealth and unemployment effects have mixed success in meeting prior expectations. The coefficient on the wealth variable is never statistically significant, and has the expected negative sign only in equations (11) and (12). The coefficient on the unemployment variable in all cases has the expected negative sign, but is significant only in equations (9) and (10).

Several variants of the basic equations (9)-(12) were investigated. Two are worth mentioning here. The first applied a first-order autocorrelation connection procedure to equations (9) and (10), the cases where the Durbin-Watson statistic indicated the presence of positive autocorrelation. The new estimates were not substantially different from those presented above. The only change of note is that the estimated coefficient of $PWAR_t$ in equation (10) had a t-statistic of 1.76, making it significantly different from zero with 90 per cent confidence but not 95 per cent confidence.

The other important extension of the basic equations entailed adding other independent variables which may be expected to influence aggregate savings behavior. The additional variables considered were (i) a demographic variable, the logarithm of the ratio of the population over 20 which are between the age of 45 and 64, the group with the highest saving propensity; (ii) the logarithm of the effective tax rate on capital income in the non-financial corporate sector[11/], included in order to pick up variations in the after-tax rate of return on a major form of investment; and (iii) the ratio of defense spending to GNP, in order to pick up any interaction between the threat of war, the level of exogenous spending, and the macroeconomic impact of that spending. When these variables are added to the basic specifications, the significance of the nuclear threat variables is not disturbed in any case except equation (10), where the coefficient of $PWAR_t$, while positive, becomes insignificantly different from zero. In the other three cases, the magnitude of the estimated nuclear threat coefficients is not substantially different from those reported above. The additional variables themselves have mixed success in adding explanatory power to the equations. The demographic variable is the most successful, always attracting the expected positive sign and always significant at least at the 90 per cent confidence level. However, the tax and defense spending variables are in all cases insignificant.

These results establish that the apparent inverse relationship between savings rates and the perceived threat of nuclear war noticed in Figure 1 survives a standard statistical test which includes other possible influences on savings. In addition, there is reason to believe that the regression analysis understates the explanatory power of the nuclear war variable. The clock setting changed only eight times during the thirty-two years sample period, and thus cannot possibly account for "within-an-era" variations in the savings rate. A more sensitive measure of the perceived threat would reduce the measurement error problem and could reasonably be expected to have more explanatory power and a larger estimated absolute effect.

IV. Are the Results Plausible?

In this section I will attempt to convince the reader of the plausibility of such variations in saving rates in response to changed perceptions of the likelihood of nuclear war. First, do people perceive nuclear war to be a likely possibility over the near future? The answer, if we are to believe the answers people give in public opinion polls, is a definite yes. During the fifties and sixties, people were asked whether they thought there would be a world war in the next five years. Of those having an opinion, the percentage answering yes ranged from forty to sixty-five. Most recently, 76 per cent of Americans said that war was likely within five years. Also, people were asked whether in the event of a world war the hydrogen bomb would be used against the U.S. The percentage answering yes to this question varied between sixty and seventy-five per cent from the mid-1950's to 1973. Combining these responses leads quickly to the conclusion that during this era it is plausible that between one-quarter and one-half of all Americans believed that a nuclear war was likely within the coming five years! The proportion who believe it likely over the next thirty years must surely be significantly higher than that.[12/]

These figures establish that nuclear war is considered to be a plausible event for the near future by a large number of Americans. The remaining question is whether variations in its perceived likelihood over the post-war period can explain significant changes in the saving rate. Of course, the analysis presented earlier above establishes a statistically significant association. But are the estimated magnitudes consistent with other evidence about the intertemporal elasticity of substitution and the degree of risk aversion?

To investigate this question, consider a two-period life-cycle model with a cardinal utility function of

$$(13) \qquad U = \frac{1}{\alpha}(C_1^{\alpha} + \beta C_2^{\alpha}) \ .$$

The implied intertemporal elasticity of substitution is $1/(1 - \alpha)$. If there is a probability p of a nuclear war at the end of the first period, the individual will maximize expected utility, which is equal to

(14) $$EU = \frac{1}{\alpha}(C_1^{\alpha} + (1 - p)\beta C_2^{\alpha})$$

subject to the constraint

(15) $$C_2 = (W - C_1)(1 + r)$$

where W is the present value of the endowment stream. It is straightforward to calculate the optimal first-period consumption, which is

(16) $$C_1^* = \frac{W(1+r)}{(1+r) + [(1-p)\beta(1+r)]^{1/1-\alpha}} ,$$

and the dependence of C^* on p, which is

(17) $$\frac{\partial C_1^*}{\partial p} = \frac{-W(1+r)^2 \frac{1}{(1-\alpha)}[(1-p)\beta(1+r)]^{\frac{\alpha}{1-\alpha}}}{[(1+r) + [(1-p)\beta(1+r)]^{\frac{1}{1-\alpha}}]^2}$$

The dependence of saving on the probability of nuclear war can be quantitatively evaluated by inserting reasonable numbers into this expression. As an illustration, I have chosen r, the interest rate for a period approximating thirty years, to be one, and β, the pure discount rate for this same time period, to be 0.75. Finally, I let the first-period endowment be equal to four-fifths of the present value of the earnings stream $(Y_1 = .8W)$. Using these parameter values, the responsiveness of the first-period saving ratio, $(Y_1 - C_1)/Y_1$, to p when p is close to zero can be written

$$(18) \qquad \frac{\partial\left(\frac{Y_1 - C_1}{Y_1}\right)}{\partial p} = \frac{5\left(\frac{1}{1-\alpha}\right)(1.5)^{\frac{\alpha}{1-\alpha}}}{\left[2 + (1.5)^{\frac{1}{1-\alpha}}\right]^2}$$

In order to judge whether a swing in the rate of saving of 0.017 or more is a plausible response to the maximum variation in the threat of nuclear war since 1947, we need to know what a reasonable value of α is and also we need to translate the variation in the threat of war into variations in the value of p. Econometric evidence on α, or the intertemporal elasticity of substitution $1/(1 - \alpha)$, has not centered as of yet on a particular value. Therefore the implications of three values of α are studied. These values are 0, -1, and -4, which imply intertemporal elasticities of 1, 0.5, and 0.2, respectively.[13/] Similarly, three values of the post-war variation in p are studied: 0.2, 0.1, and 0.05. Note that these correspond to the probability of a nuclear holocaust before the "second period" is reached, which may be conveniently thought of as lasting thirty years. Table 2 presents the implied range in the savings rate corresponding to the three elasticities of substitution and the three values for the post-war variation in p, denoted $\bar{p}$.

Table 2
Implied Changes in Saving Rate

	$\bar{p} = 0.2$	$\bar{p} = 0.1$	$\bar{p} = 0.05$
$\alpha = 0$	0.0624	0.0312	0.0156
$\alpha = -1$	0.0392	0.0196	0.0098
$\alpha = -4$	0.0152	0.076	0.0038

The pairing of the assumptions most favorable to a large shift in saving $(\alpha = 0 \;, \; \bar{p} = 0.2)$ imply a response (0.0624) nearly four times the response estimated in equations (9) and (10). The least favorable assumptions $(\alpha = -4, \; \bar{p} = 0.05)$ imply a shift of 0.0038 or about one-quarter of the estimated effect. Assumptions in the middle range imply responses quite consistent with the econometric estimates derived in (9) and (10).

Of course, these calculations ignore the behavior of individuals who have already aged one period as well as the induced shift in desired investment or any general equilibrium adjustments. Nevertheless, they are suggestive that the econometric estimates have a plausible magnitude.

V. Concluding Remarks

The hypothesis examined in this paper, if correct, has far-reaching implications for our understanding of the performance of the post-war, or post-nuclear, U.S. economy. It suggests that the threat of nuclear catastrophe has influenced the growth path of the economy and will continue to affect the willingness of individuals to postpone consumption for the sake of capital accumulation. Such behavior would be a rational response of a society faced with the changing probability of a limited future. The estimates developed here indicate that a change in the perceived threat of nuclear war from its lowest post-war level to its highest level is accompanied by a decline in the annual savings ratio of at least 1.7 percentage points, a significant amount compared to the amount of observed post-war variation. It also suggests that the increase in international tensions since late 1979 to 1981 may have caused a decline of at least 0.8 percentage points in the savings ratio.[14/]

I do not believe that the evidence presented in this paper decisively establishes the impact of the threat of nuclear war on post-war U.S. economic performance. Much more research is required, not only concerning aggregate savings behavior,but on other aspects of the economy. The perceived threat of nuclear war would, if the hypothesis is correct, influence the post-war behavior of stock market and other asset prices, the term structure of interest rates, the rate of investment in human capital, the mix of investment between long- and short-lived assets, among other phenomena. At the least, though, this research suggests that any time-series analysis of these and similar phenomena which do not treat this consideration may be ignoring a significant factor in the performance of the U.S. economy since the beginning of the nuclear age.

Footnotes

1/ Reported in The New York Times; December 22, 1981; p. 13.

2/ See the Gallup polls published in June of 1956, November of 1956, April of 1957, April of 1958, February of 1963, and September of 1973.

3/ See Gallup poll of March, 1963.

4/ The formulation and notation used in this example owes much to Barro and Friedman (1977).

5/ This model does not consider other possible responses to the threat of nuclear war which may offset the tendency to slow the accumulation of wealth. Two such responses are moving up the planned age of retirement (or, in general, changing the lifetime pattern of labor supply) and protecting oneself against the effects of a nuclear war by, say, building a bomb shelter.

6/ The account of the history of the Bulletin of the Atomic Scientists clock is adapted from the editorial in the January, 1978 issue of the journal.

7/ In order to calculate the 1948 moving average, the average setting in 1946 was assumed to be the same as in 1947.

8/ See The International Institute for Strategic Studies (1979) and Kemp, Pfaltagraff, and Ra'anan (1974).

9/ The reader will note the absense of a variable measuring the after-tax real rate of return available to savers. This omission reflects my belief that accurate measurement of this return is impossible. A more readily measurable value which affects the after-tax return, the tax rate on corporate capital income, is included in an alternate specification discussed below. On the problems of measuring the real after-tax return to saving, see Howrey and Hymans (1978) and the comments that follow.

10/ All variables reflect the revision of the national income and product accounts released by the Department of Commerce in late 1980.

11/ The tax variable is the one calculated in Feldstein and Poterba (1980). Since the tax rate series begins in 1953, this series was extended by extrapolating the trend behavior to the end of the sample period. Details of this extrapolation procedure can be obtained from the author.

12/ Hausman (1979) finds evidence that individual subjective discount rates are about 20 per cent per year. His conclusions are based on a study of household behavior concerning the purchase and utilization of energy-using durables. Although Hausman does not appeal to the perceived threat of nuclear war, such high discount rates are compatible with the evidence cited in the text which document high public concern about a future world war.

13/ Note that when α is zero expressions (10) and (11) should be interpreted in the limit sense, so that expected utility is $\alpha \log C_1 + (1 - p)\beta\alpha \log C_2$.

14/ The <u>Bulletin of Atomic Scientists</u> clock stood at nine minutes until midnight during 1979. As of January, 1981, it was set to four minutes until midnight. The estimates derived in this paper suggest that this increase in international tensions will be accompanies by a decline in the annual rate of capital accumulation of 0.8 percentage points.

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