# The Creation of Risk Aversion by Imperfect Capital Markets

By ROBERT TEMPEST MASSON*

In this paper I advance a rationale for risk-averse behavior by people of little wealth who face imperfect capital markets. In the literature on risk and uncertainty, risk-averse behavior is frequently postulated by assuming a concave utility function (see Irving Fisher and George Hall, and Bernt Stigum), convex indifference curves in a mean-variance model (see Martin Feldstein, Stewart Johnson, and James Tobin), or some "safety-first" criterion (see Jean-Marc Boussard and Michel Petit, and Lester Telser). In a recent article by David Pyle and Stephen Turnovsky, subsets of these criteria for risk-averse behavior are shown under many assumptions to be operationally indistinguishable. On the other hand, the implicit psychological framework underlying these models may differ. In the expected utility or mean-variance framework a psychological aversion to risk is generally implied, whereas under a safety-first criterion the individual often is seen as attempting to avoid illiquidity.

In this paper I offer an analysis which integrates imperfections in the capital markets with expected utility maximization and shows how risk-averse behavior may follow from institutional characteristics of the economy, and not necessarily from a psychological aversion to risk. The advantages of this type of analysis are evident in the policy-oriented hypotheses which it generates. Hypotheses may be formulated from this model which relate risk-averse behavior to economic institutions and policies.

I present a basic two-period model in which imperfect capital markets are assumed. Intertemporal risk neutrality (to be defined in Section I) is also assumed.[1] Considering an individual's expected utility maximization problem when there are imperfect capital markets (at least one plausible formulation of them), one arrives at the following striking conclusion: *The risk-neutral individual who faces these imperfect capital markets will behave on gambles involving present income as if he were maximizing expected utility on a Friedman-Savage type utility function* (see Milton Friedman and L. J. Savage).

After the presentation of this simple model, some conclusions and familiar examples from the model are sketched out to demonstrate its applicability.

## I. The Basic Model

The first step is to consider the case of a person who is intertemporally risk-neutral for real income and then to indicate

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[1] The assumption of intertemporal risk neutrality provides a base point. There is no reason to assume either a risk-loving or a risk-averse psychology. If I had made the assumption of risk aversion, the imperfect capital markets would create even more risk-averse behavior and even more risk-loving behavior for different asset levels than the utility function would imply with perfect capital markets. Joseph Stiglitz implies that the assumption of intertemporal risk neutrality is probably bad because we do not observe straight line Engel curves, p. 667. The rationale for my use of intertemporal risk neutrality is given in the next section. The validity of Stiglitz's inference is, however, affected by his assumption of perfect capital markets.

how imperfect capital markets[2] will make him behave *as if* he were risk-averse at any point in time.

I define intertemporal risk neutrality as follows: Give an individual a choice between 1) having the consumption stream $(c_0, c_1, \ldots, c_T)$ for the time periods 0 (the present) to T (time of death), and 2) a .5 probability of a consumption stream

$$(c_0(1+\epsilon), c_1(1+\epsilon), \ldots, c_T(1+\epsilon))$$

and a .5 probability of a consumption stream

$$(c_0(1-\epsilon), c_1(1-\epsilon), \ldots, c_T(1-\epsilon))$$

The risk-neutral individual will be indifferent between the certain stream and the gamble. If a utility function which transforms $(c_0, \ldots, c_T)$ into a von Neumann-Morgenstern type of quasi-cardinal utility function (see William Baumol, pp. 512–16) is specified, and perfect (single interest rate) capital markets are assumed, then this definition may be restated. In this case a person is risk-neutral by the above definition if he is indifferent between an income $y_i$ or a .5 probability of $y_i+\epsilon_i$ and of $y_i-\epsilon_i$ for any year $i$. This assumes that the consumption allocations for all periods are decided upon after knowing the results of the gamble.[3]

To demonstrate the process by which imperfect capital markets convert the risk-neutral individual to risk-averse behavior in the present, I shall specify a particular structure of capital markets and calculate the individual's first-period behavioristic utility function.

The definition of risk neutrality used here requires a utility function which is linear homogeneous (see Stiglitz) and has a diminishing marginal rate of substitution.[4]

I shall assume that utility is a linear homogeneous function of consumption:

$$u = u(c_1, c_2) \tag{1}$$

where: $u$ = utility level,
$c_1$ = dollars of consumption in period one, and
$c_2$ = dollars of consumption in period two

If there were only a single interest rate and endowment incomes of $e_1$ and $e_2$ given exogenously, the problem would be to:

$$\begin{aligned} &\text{maximize} && u(c_1, c_2) \\ &\text{subject to} && c_1 = e_1 + b, \\ & && c_2 = e_2 - \rho b, \\ &\text{and} && b \geq 0 \end{aligned} \tag{2}$$

where: $b$ is the money borrowed $(b>0)$ or invested $(b<0)$ measured in time one dollars;
$\rho$ is one plus the interest rate

This problem may be rewritten:

$$\underset{b}{\text{maximize}} \quad u(e_1 + b, e_2 - \rho b) \tag{3}$$

and is solvable for a reduced form or real income function:

$$u^* = u^*(e_1, e_2, \rho) \tag{4}$$

This real income function obeys the von Neumann-Morgenstern expected util-

[2] The reader should note that the term imperfect capital markets is used to mean that the interest rate paid or earned is a function of the amount borrowed or lent (see Jack Hirshleifer, p. 329). I am not stating that capital markets are indeed imperfect in the sense of the term used in industrial organization (see George Stigler).

[3] The general proof of this is somewhat longer than is worth presenting here. Just note that the first definition puts us in the class of linear homogeneous utility function. Thus, a shift in a straight line budget constraint caused by an *income* change in any one period moves the *consumption* equilibrium along a ray from the origin (see fn. 5). If a person's consumption decisions are made before knowing the results of the gamble, the stochastic nature of $\epsilon_i$ is shifted to $c_i$, which automatically creates risk aversion since decreasing marginal utility occurs in each time period (see fn. 6).

[4] The reader may note that Stiglitz tends to reject the implied homotheticity for empirical reasons. This is due to his assumption of straight line budget sets, p. 667.

ity maximization axioms for either period's income if the other income and $\rho$ are known.

It may also be solved for the borrowing function:

$$b = b(e_1, e_2, \rho) \tag{5}$$

At this point imperfections in the capital markets may be introduced. This may be done by making $\rho$ a function of $b$:

$$\rho = \rho(b) \tag{6}$$

If money capital becomes more expensive as more is borrowed, then:

$$\rho'(b) > 0 \tag{7}$$

for $\qquad b \geq 0$

For simplicity of mathematical form I shall first consider the function $\rho(b)$ to have the form:

$$\begin{aligned} \rho(b) &= \rho_\beta \qquad \text{if } b \geq 0 \\ \rho(b) &= \rho_\alpha \qquad \text{if } b < 0 \end{aligned} \tag{8}$$

where: $\rho_\beta$ is one plus the borrowing rate of interest;
$\rho_\alpha$ is one plus the lending rate of interest; and
$\rho_\beta > \rho_\alpha$

This simplifies solution because for any $b$ equal to zero, $\rho'(b)$ is defined and equal to zero.

The above utility expression may be maximized for any specific $\rho_\beta$ and $\rho_\alpha$. This in fact becomes a programming problem, but it need not be put explicitly into the programming notation. The income consumption curve, *ICC*, and the three possible types of solutions may be illustrated graphically.

Figure 1 shows successive equilibria when period two income is held constant at $\bar{e}_2$ and period one income expands. It exhibits the familiar condition for homogeneous functions that for a single price ratio (interest rate) the income consumption curve (*ICC*) (any isocline) is a straight line from the origin.[5] The *ICC* in this figure is *OABC*. The line segment *BC* if extended leftwards would intersect the origin. The kinked lines like *EFG* are budget constraints (see Hirshleifer) with a slope of $(-\rho_\alpha)$ above $\bar{e}_2$ and a slope $(-\rho_\beta)$ below $\bar{e}_2$.

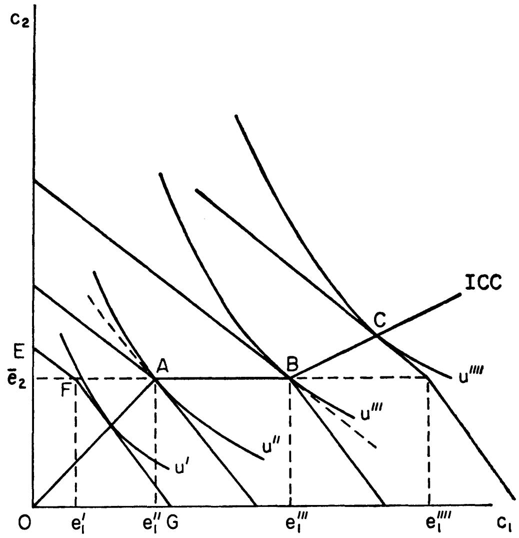


FIGURE 1

Along the line segment *OA* borrowing occurs. The consumer maximizes the expression:

$$u = u(e_1 + b, \bar{e}_2 - \rho_\beta b) \tag{9}$$

[5] That the income consumption curve is a ray from the origin may be shown easily. Using the theorem that any partial derivative of a function which is homogeneous of degree $k$ is homogeneous of degree $k-1$ we know that $u_i(x_1, x_2)$, $(i=1, 2)$ are homogeneous of degree zero. This may be written:

$$u_1(x_1, x_2) = u_1(ax_1, ax_2),$$
$$u_2(x_1, x_2) = u_2(ax_1, ax_2)$$

or,

$$\frac{u_1(x_1, x_2)}{u_2(x_1, x_2)} = \frac{u_1(ax_1, ax_2)}{u_2(ax_1, ax_2)}$$

Thus the marginal rate of substitution does not change along any ray from the origin. Since the *MRS* is equated to the price ratio (interest rate), in whatever ranges the price ratio remains fixed the *ICC* is a straight line from the origin.

This yields a solution of the borrowing function and real income function of:

$$(10) \qquad b(e_1, \bar{e}_2, \rho_\beta) \geq 0$$

$$(11) \qquad u_\beta^* = u^*(e_1, \bar{e}_2, \rho_\beta)$$

In any case where $b(e_1, \bar{e}_2, \rho_\beta) < 0$, the solution is not on the lower side of the budget constraint. Along the line segment $BC$ he lends and maximizes:

$$(12) \qquad u = u(e_1 + b, \bar{e}_2 - \rho_\alpha b)$$

and the borrowing function and real income function solve for:

$$(13) \qquad b(e_1, \bar{e}_2, \rho_\alpha) \leq 0$$

$$(14) \qquad u_\alpha^* = u^*(e_1, \bar{e}_2, \rho_\alpha)$$

Along the intermediate section, $AB$, he neither borrows nor lends. In this section the borrowing functions indicate the incompatible solutions $b(e_1, \bar{e}_2, \rho_\beta) < 0$ and $b(e_1, \bar{e}_2, \rho_\alpha) > 0$.

The utility level reached along line segment $AB$ is simply:

$$(15) \qquad u_n^* = u(e_1, \bar{e}_2)$$

The income consumption curve represented here and the utility function provide the information necessary to find utility as a function of period one income holding the other factors constant. This will be expressed as:

$$(16) \qquad u^{**}(e_1; \bar{e}_2, \rho_\beta, \rho_\alpha)$$

$$= \begin{Bmatrix} u^*(e_1, e_2, \rho_\beta) & \text{for } e_1 \leq e_1'' \\ u(e_1, \bar{e}_2) & \text{for } e_1'' < e_1 < e_1''' \\ u^*(e_1, \bar{e}_2, \rho_\alpha) & \text{for } e_1 \geq e_1''' \end{Bmatrix}$$

The function $u^{**}(e_1; \bar{e}_2, \rho_\beta, \rho_\alpha)$ obeys the expected utility maximization axioms for period one income, and it is to this function that we shall devote our attention. This function is made up of three sections and two joining points. These will be examined individually, and the results are shown in Figure 2.

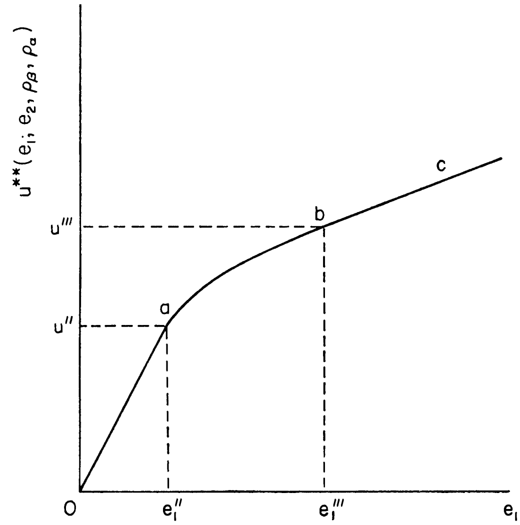


FIGURE 2

The first section, $Oa$, is for $e_1 \leq e_1''$. In this section the marginal utility of increasing income $e_1$ is a positive constant. This is a consequence of moving out a linear homogeneous function along an isocline. Thus $u^{**}(e_1; \bar{e}_2, \rho_\beta, \rho_\alpha)$ is a straight line with a positive slope for $e_1 < e_1''$.

The second section, $ab$, is for $e_1'' < e_1 < e_1'''$. In this section consumption in the first period is expanded while consumption in the second period remains constant. For a linear homogeneous utility function a diminishing marginal rate of substitution implies diminishing marginal utility.[6] This

[6] That linear homogeneity and a diminishing marginal rate of substitution, *MRS*, together imply diminishing marginal utility may easily be shown. The first step is to demonstrate that a diminishing *MRS* along an indifference curve implies a diminishing *MRS* for the expansion of a single factor letting utility vary if the utility function is linear homogeneous. That this should be true follows from fn. 5. If the *MRS* did not fall as as the factor was increased, then the good must be an inferior good, but fn. 5 proves all iso-clines to be straight lines from the origin.

Start at the points $(x_1, x_2)$ and $(x_1', x_2')$ chosen such that $u(x_1, x_2) = u(x_1', x_2')$, and $x_1' > x_1'$. Diminishing *MRS* implies that $u_1(x_1, x_2)/u_2(x_1, x_2) > u_1(x_1', x_2')/u_2(x_1', x_2')$. Take $x_2'' = x_2$ *and* $x_1''$ chosen such that $x_1''/x_2'' = x_1'/x_2'$. Then:

$$\frac{u_1(x_1, x_2)}{u_2(x_1, x_2)} > \frac{u_1(x_1', x_2')}{u_2(x_1', x_2')} = \frac{u_1(x_1'', x_2'')}{u_2(x_{1\prime}', x_2'')}$$

means that the function $u^{**}(e;\ \bar{e}_2,\ \rho_\beta,\ \rho_\alpha)$ is upward sloping and concave for incomes between $e_1''$ and $e_1'''$.

The final section, $bc$, is similar to the first section. Again the expansion is out an isocline. Thus $u^{**}(e_1;\ \bar{e}_2,\ \rho_\beta,\ \rho_\alpha)$ is a positively sloped straight line in this region.

Since $u^{**}(e_1;\ \bar{e}_2,\ \rho_\beta,\ \rho_\alpha)$ obeys the expected utility maximization postulates, three facts are known about this individual:

a) that he will be risk-neutral for any gamble which involves only incomes that require borrowing (i.e., $e_1<e_1''$ whether the gamble is lost or won);
b) that he will be risk-averse for gambles after which he neither borrows nor lends; and
c) that he will be risk-neutral if his income is high enough, win or lose in the gamble, for him to lend in either case.

There is one final step. This is to examine gambles of the following sort: Assume there is a .5 probability of getting $(e_1-\epsilon_1)$ and a .5 probability of getting $(e_1+\epsilon_1)$ where, for example, $(e_1-\epsilon_1)$ is in the neither borrowing nor lending zone and $(e_1+\epsilon_1)$ is in the lending zone. The examination must be for all pairwise choices of the borrowing zone, the lending zone, and the neither borrowing nor lending zone.

The conclusions for these gambles are best arrived at by showing that $u^{**}(e_1;\ \bar{e}_2,\ \rho_\beta,\ \rho_\alpha)$ is continuously differentiable. This may be demonstrated by showing that the left-hand derivative of $u^{**}$ at point $a$ is equal to the right-hand derivative at point $a$ and that the left- and right-hand derivatives at point $b$ are equal.[7]

This is simply demonstrated by referring back to Figure 1 where at point $A$ the individual solves the problem:

$$\text{(17)} \qquad \underset{b}{\text{maximize}} \quad u(e_1'' + b,\ \bar{e}_2 - \rho_\beta b)$$

At point $A$ the solution of this problem is $b=0$ so:

$$\text{(18)} \qquad u = u(e_1'',\ \bar{e}_2) \text{ at point } A$$

The first-order condition of the above maximization problem is:

$$\text{(19)} \qquad u_1 - \rho_\beta u_2 = 0,$$

$$\text{where} \qquad u_1 = \frac{\delta u}{\delta c_i} \qquad [i = 1, 2]$$

To find the value of the left-hand derivative at point $A$ *totally differentiate* $u(e_1''+b,\ \bar{e}_2-\rho_\beta b)$ assuming that $\bar{e}_2$ is totally parametric:

$$\text{(20)} \qquad \begin{aligned} du &= u_1\frac{\delta c_1}{\delta e_1}de_1 + u_1\frac{\delta c_1}{\delta b}db - \rho_\beta u_2\frac{\delta c_2}{\delta b}db \\ du &= u_1 de_1 + u_1 db - \rho_\beta u_2 db \\ &= u_1 de_1 + (u_1 - \rho_\beta u_2)db \end{aligned}$$

But at the point $(e_1'',\ \bar{e}_2)$, $u_1-\rho_\beta u_2=0$ so:

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Thus:

$$\left.\frac{d\left(\frac{u_1}{u_2}\right)}{dx_1}\right|_{du=0} < 0 \qquad \text{implies that } \frac{\delta\left(\frac{u_1}{u_2}\right)}{\delta x_1} < 0$$

The second step is to analyze this relationship:

$$\frac{\delta\left(\frac{u_1}{u_2}\right)}{\delta x_1} = \frac{u_{11}u_2 - u_{21}u_1}{u_2^2} < 0$$

For linear homogeneous functions $u_{11}x_1+u_{12}x_2=0$. If $u_{11}\geq 0$, then the homogeneity condition would imply that $u_{12}\leq 0$ whereas the diminishing *MRS* condition would imply that $u_{12}>0$. We may reject the possibility of increasing marginal utility with these conditions.

[7] The definition of a derivative of $y=f(x)$ is:

$$\frac{dy}{dx} = \lim_{h\to 0}\frac{f(x+h) - f(x)}{h}$$

A left-hand derivative will be defined for this limit as $h$ approaches zero from the negative numbers; for a right-hand derivative, $h$ will approach zero from the positive numbers.

$$\frac{du}{de_1} = u_1(e_1'', \bar{e}_2) \tag{21}$$

$$= \text{(left-hand derivative at } A)$$

To find the value of the right-hand derivative we need only find the partial derivative $\delta u/\delta e_1$. This is because $b=0$ in this range and $\bar{e}_2$ is parametric.

$$\frac{\delta u}{\delta e_1} = u_1(e_1'', \bar{e}_2) \tag{22}$$

$$= \text{(right-hand derivative at } A)$$

Thus the left-hand and right-hand derivatives of $u^{**}$ are equal at the point $A$. Exactly the same proof may be supplied for the point $B$ with the value $e_1'''$ used in the place of $e_1''$ above.

Graphically this means that the von Neumann-Morgenstern utility function for gambling with present income is as shown in Figure 2.

The line segments $Oa$, $ab$, and $bc$ correspond to the line segments $OA$, $AB$, and $BC$, respectively, in Figure 1. It is apparent that the intertemporally risk-neutral individual will be risk-averse for any gamble which involves more than one of these line segments. He acts as if he were risk-averse for many present gambles.

For a more complex imperfect capital market I shall present the results graphically, without proof. Two assumptions are retained: that $\bar{e}_2$ is known and fixed, and that the consumption decisions are made after the results of all gambles are known. Suppose the capital market is such that larger borrowing entails higher interest rates[8] and that larger amounts invested yield at first increasing rates of return and eventually decreasing rates of return.[9] The capital market may be characterized by the following structure of interest rates, $r(b)$, shown in Figure 3.

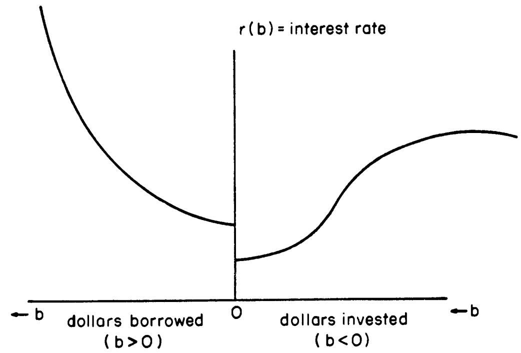


FIGURE 3

In this case the von Neumann-Morgenstern utility function of an individual who is risk-neutral for all-period consumption, as defined above, will have a form for present income very similar to the Friedman-Savage form (see Friedman and Savage, pp. 57–96.)[10]

With these two conditions I assert, without proof, that the utility function for present income looks like Figure 4. (A specific case from the risk-loving portion of this curve is shown in the Appendix.)

In such a case a person will be closer to his lower inflection point on the left as he becomes less of a net creditor. The reader may note that, in general, the individual stays near his inflection point, as shown in Harry Markowitz's article. This conclusion is strengthened as transactions costs for borrowing and lending are introduced.

Finally, an assumption may be made

[8] This may be in the form of "compensating balances" required by lending institutions or in the form of credit rationing, e.g., an infinite interest rate (see Dwight Jaffee and Franco Modigliani, and *The Wall Street Journal*).

[9] Assume that the first dollars may be invested in a bank savings account. As costs of investment decrease as a proportion of total investment, money will be invested in stocks or productive assets. The eventually declining portion of the lending curve is the familiar downward sloping marginal efficiency of *investment* curve. The eventually decreasing interest rate is not needed for the risk loving to exist. It corresponds to the eventual reestablishment of a high income (not wealth) risk-averse section.

[10] This requires the assumption of convex indifference curves. Since, if indifference curves were not convex, individuals might consume their whole wealth in only one time period, this is a weak assumption.

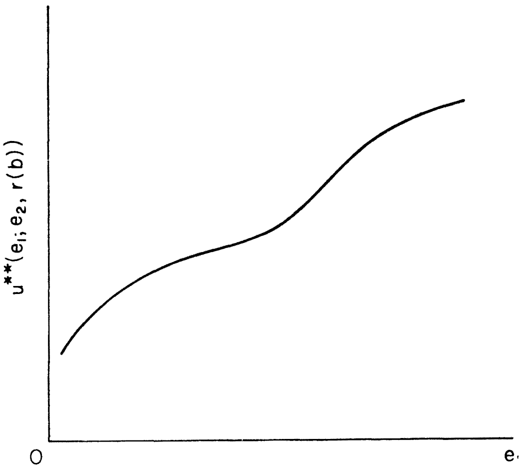


FIGURE 4

that enables us to predict behavior in addition to that predicted by the Friedman-Savage model. This assumption is that $r(b)$ for borrowing is primarily a function of future income from physical assets. This assumption is just that lending firms wish borrowers to show evidence of a high probability of repayment. Higher future incomes are made up of return from physical assets, return from human capital, and cash value of assets sold (e.g., at death.) The lower a person's asset level, the higher interest he must pay for any given absolute level of money borrowed.

The argument presented here is thus that, *ceteris paribus*, net debtors should behave in a more risk-averse fashion than net creditors. In fact, risk aversion should be more pronounced as net debt increases. This statement must of course be modified in countries with bankruptcy laws. Where declaration of bankruptcy is legal, there is a point at the left of this transformed utility function for present income where the function becomes flat, i.e., the individual becomes a risk lover. In countries without bankruptcy laws the utility function becomes flat at the lower bound given by survival. Since the first derivative of the utility function at this point *may* not exist (e.g., a kink with a flat portion to the left), risk taking *may* only be observed for the ultimate desperate move. This case I shall not consider further although we all have read of some mild hero succeeding (or not) in one final attempt.

## II. Using the Model

The model as presented relates the risk-neutral individual's utility to present period income if he faces the given structure of interest rates. Other factors which may amplify the basic results of this model are transactions costs in the capital markets and transactions costs in the markets for physical capital. The existence of transactions costs may be partly reinterpreted above as a bigger displacement between the borrowing and lending rate of interest. Thus we would expect the higher proportion of illiquid capital a firm has, the more risk-averse its entrepreneur will be.

C. M. Elliot, in his work on African development, advances a hypothesis similar to the one above. He asserts that a primary reason for the more successful cropping of cotton in Uganda than in Kenya was due to institutionally determined risk behavior, which in Uganda did a more efficient job of spreading the risk. In Kenya the individual had no good source of borrowing in the case of failure. In Uganda the tribesmen could borrow from the headman in the case of a bad year. Elliot feels that Kenya might have been similarly successful in cotton growing had a similar capital market been available.

This model may also yield some insight into the reputation of Chilean peasants who are said to be highly conservative in cropping patterns but willing to gamble with their earnings.

## III. Toward Less Risk Aversion and Greater Progressivity

One policy question of interest is how a country may promote more risk-neutral behavior on the part of its lower-asset, lower-income population. This is the problem of promoting more progressivity of the subsistence farmer or of the ghetto entrepreneur. These are important policy problems for the underdeveloped country and for the urban poor of our own country.

The policy prescriptions of this model for promoting intra-sectoral growth follow simply from the factors contributing to risk aversion. The first of these is to create more nearly perfect borrowing markets. In many instances this means a locational shift in the banking system to have a higher density near the farm areas or the ghetto areas. It may also mean a reduction in red tape surrounding loan procedure. In many cases, peasants or individuals who cannot read nor write may not feel safe borrowing from a bank under present conditions. Finally, the central government may have to insure or cosign loans for the individual farmers. Cosigners may be a scarce commodity for the low-level farmer or businessman.

The second policy prescription is to protect the individual with a welfare program. The person who loses everything if he errs is likely to be more risk-averse than the individual who goes on the welfare roles if he errs. And the person on or close to welfare will (in some income ranges) be more risk-averse than one under a system of negative income taxes. These policies must also be supplemented by a form of limited liability and bankruptcy laws. If welfare payments or if any income after leaving welfare roles is in jeopardy, then the individual must be more risk-averse.

Finally there is the use of subsidization. In the United States, government contracts are now subsidizing black entrepreneurship. Similarly, countries often subsidize agricultural innovation by decreasing the cost of inputs. Another common type of subsidy is price supports. If the government insures that it will buy a crop's output at some minimum base price, then a farmer's expected value of return from the crop is increased and the variance of the return is decreased. The government, if it properly selects innovations for this type of subsidization, will have low expected costs. The farmer's expected value of any innovation the government wishes to subsidize will be higher than the minimum payments promised to the farmer, and thus the payments for failure should, on the average, be very far below the promises to pay in the case of failure. *Of course care must be taken in such a program not to set the minimum payment too high.* If the minimum payment is above a certain level, then there will be less incentive to nurture properly the new crop.

In an underdeveloped country increased agricultural production may be a precondition for sustained growth in all sectors. In our country many people feel that growth of black entrepreneurship should be encouraged for moral, political, and economic reasons. If greater progressivity can flow from reducing risk-averse behavior (i.e., to the level of risk-neutral behavior), then the rationale and tools presented here should be used to a greater extent in economic policy.

## Appendix

### *An Example of a Gamble for an Intertemporally Risk-Neutral Individual*

I shall heuristically present the outcome of a single gambling situation. For ease of graphical construction this gamble will have an expected value at the level of income at which the individual is indifferent between borrowing his first dollar or not borrowing at all.

For simplicity of analysis the structure of interest rates will be assumed to look like Figure 5. The more general case depends upon the actual curvature of the left-hand portion of this curve, but the results here are generalizable to the case presented in Figure 3 of the text.

If the individual has endowment income in period 1 of $\bar{e}_1$ and endowment income in

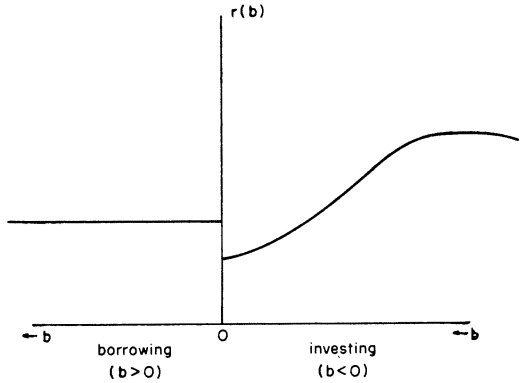


FIGURE 5

period 2 of $\bar{e}_2$, then his budget constraint has the shape shown in Figure 6:, where the slope of the budget line is $-(1+r(b))$, and $(+b)$ is the horizontal distance to the right of $\bar{e}_1$ to the constraint.

Now one gamble may be presented (see Figure 7). In this case the individual is given a 50–50 gamble between $\bar{e}_1-\epsilon$ and $\bar{e}_1+\epsilon$ and prefers the gamble to $\bar{e}_1$ with certainty. This is because the utility function is linear homogeneous. The linear homogeneity implies that the indifference curves $a$, $b$, and $c$ are equidistant in utility terms. In other words a person offered 1) a 50–50 gamble between utility levels $a$ and $c$ or 2) the utility level $b$ with certainty would be indifferent between the alternatives. Since the person given the gamble between $\bar{e}_1-\epsilon$ and $\bar{e}_1+\epsilon$ is being offered an even odds gamble between the utility levels $a$ and $d$, and the level $d$ is greater than the level $c$, he will pick the gamble in preference to level $b$ with certainty.

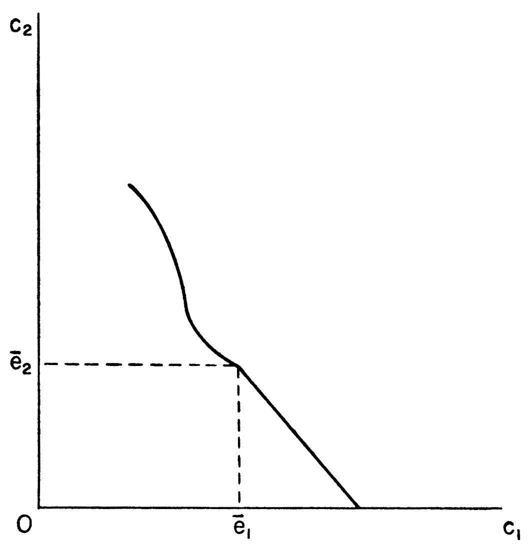


FIGURE 6

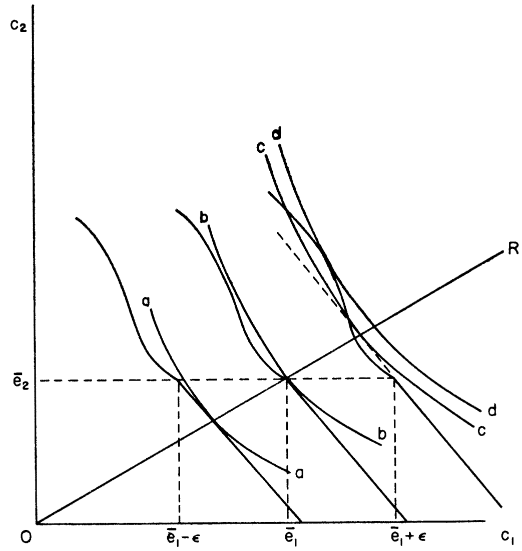


FIGURE 7

This establishes the existence of risk loving for current income given an intertemporally risk-neutral individual.

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