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INFLATION, MONETARY VELOCITY, AND WELFARE

Paul R. Krugman

Torsten Persson

Lars E.O. Svensson

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Cambridge MA 02138

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ABSTRACT

This paper develops a simple general equilibrium model of a monetary economy with a capital market, in which monetary demand arises from a "cash-in-advance" constraint rather than from any direct role in the utility function. Uncertainty gives rise to a meaningful portfolio choice between money and bonds. We show that monetary velocity is increasing in the rate of inflation, and that the optimal monetary policy is that which maximizes real balances. We also show that the real rate of interest is not invariant to monetary policy: inflation lowers the real rate.

Paul R. Krugman
Massachusetts Institute of Technology
E52-254
Cambridge, MA 02139

Torsten Persson
Institute for International Economic Studies
University of Stockholm
S-106 91
Stockholm, Sweden

Lars E. O. Svensson
Institute for International Economic Studies
University of Stockholm
S-106 91
Stockholm, Sweden

and

National Bureau of Economic Research
1050 Massachusetts Avenue
Cambridge, MA 02138

INFLATION, MONETARY VELOCITY AND WELFARE*

by Paul R. Krugman, Torsten Persson and Lars E.O. Svensson

1. Introduction

The effect of expected inflation on the velocity of monetary circulation is fundamental to an understanding of both the causes and effects of inflation. In explaining how monetary expansion can - particularly in hyperinflation - cause a more than proportional rise in prices, the conventional wisdom is that expected inflation leads people to economize on their real money holdings. In analyzing the costs of high inflation an important role is assigned to the costs associated with reduced real balances; i.e., reduced "liquidity".

In spite of the importance that is attached to the idea of a demand for real balances which depends on expected inflation, however, this idea has never been given a really secure micro-economic foundation. The standard Baumol-Tobin model of the demand for money is a model of a single individual, which has never been integrated into a description of a market. Approaches which place money in the utility function, such as Brock (1975), are suggestive but essentially assume the result. "Cash-in-advance" models, like that of Wilson (1979), seem to imply that a capital market drives monetary velocity to its technological maximum independently of the rate of inflation. Overlapping generations models like that of Wallace (1980) seem to many to be inadequate in their representation of money in actual economies, in that they give money a role only as a store of value.

In this paper we develop a simple model of the effects of inflation on real balances and welfare in an economy with maximizing agents. The model draws on earlier work on the microfoundation of money, especially on Lucas (1980) and Helpman and Razin (1982). From these we take the idea of motivating the use of money by the "cash-in-advance" constraint associated with Clower (1967). We borrow Lucas' device of introducing uncertainty at the individual level which washes out in the aggregate. From Helpman and Razin we take the idea that agents must decide on their capital market transactions before they are fully informed;[1] and we also borrow their "cashing in one's chips" assumption, which allows us to work with a finite horizon. By combining these ideas, we arrive at a model which is of course very special, but which is also very simple. To a large extent we will be able to make our points with graphs and simple algebra. Yet the model has, we believe, important implications, since it may be viewed as giving a microfoundation to Friedman's (1969) famous theory of the optimum quantity of money.[2]

The paper is in eight sections. In Section 2 we lay out the model's assumptions. Section 3 then formulates the individual's decision problem. Based on this, in Section 4 we find market equilibrium. In Section 5 we find the optimal monetary policy, which we show is one which minimizes the velocity of money, i.e., maximizes real balances, and we also find the policy which maximizes velocity. These two policies are shown to define the boundaries of the region in which conventional views about inflation are roughly confirmed. In Section 6 we examine the effect of inflation on the interest rate. We show that more inflation leads to higher nominal but lower real rates of interest. In Section 7 we illustrate some of the points of the paper with a numerical example. Finally, in Section 8 we review the results and suggest directions for further work.

2. Structure of the Model

Our model is of a two-period, pure exchange economy. There is a single composite consumption good, and agents receive endowments of this good in each period. These endowments are not known by agents at the time they must make some crucial decisions, so that there is real individual uncertainty. These individual uncertainties average out in the aggregate, however, so that the model is deterministic at the macro level.

The sequence of events is crucial to the story; it runs as follows:

Step 1: Agents enter the economy. They are given a start-up sum of money M_1.

Step 2: A capital market is held. Agents can buy or sell bonds B for money.

Step 3: Agents learn their endowment. Everyone receives y_2 in the second period. In the first period, however, they may get bad news, that their endowment is y^b, or good news, that their endowment is the larger quantity y^g. The probabilities of bad and good news are π and $1-\pi$ respectively.

Step 4: Agents buy first-period consumption. They must do this with cash on hand; that is, with the cash left over from Step 2. They have not yet received the income from sales of their endowment, nor the repayment of interest and principal on bonds.

Step 5: Agents receive, in cash, the income earned from sale of their first period endowment, i.e., $P_1 y^b$ or $P_1 y^g$ for bad-news and good-news people respectively; plus repayment of bonds, $(1+r)B$, plus an additional (perhaps negative) money transfer from the government, $M_2 - M_1$.

Step 6: Agents buy second-period consumption, again constrained by cash on hand.

Step 7: Agents receive, in cash, the income from the sale of the second-period endowment, $P_2 y_2$.

Step 8: Agents must return all the money they were given to play the game with, i.e., M_2.

Even before specifying consumer preferences, we can say something about the equilibrium. At step 6, agents will have no incentive to hold money beyond what they need to meet the requirement that they cash in their chips in step 8. The obvious result is that all money is spent, so that in the second period a strict quantity equation holds:

$$P_2 y_2 = M_2 . \tag{1}$$

To simplify notation, we will assume without loss of generality that $y_2 = 1$. Also, it is apparent that an equal proportional increase in M_1 and M_2 will have no real effect, so we will set $M_2 = 1$, implying $P_2 = 1$. This lets us use the simplified notation

$$M_1 \equiv M \text{ and} \tag{2}$$

$$P_1 \equiv P , \tag{3}$$

where $(1 - M)/M$ and $(1 - P)/P$ become the rates of money growth and price change, respectively. We will regard M as the policy instrument.

The average endowment in the first period is

$$\bar{y} = \pi y^{b} + (1 - \pi) y^{g}. \tag{4}$$

Hence, the ex ante probability π of receiving bad news is equal to the ex post proportion of bad news consumers.

Finally, we turn to consumers' preferences. We assume that tastes may be represented by the Cobb-Douglas funtion

$$U = C_1^{\alpha} C_2^{1-\alpha}, \tag{5}$$

which implies risk-neutrality - an important assumption, as we will see. The problem of each agent is to choose a strategy which maximizes the expected value of (5); we now turn to this problem.

3. The Individual Problem

Each agent in our economy faces two decision points. At step 2 of the process described above he must choose how many bonds to buy or sell; at step 4 he must choose a consumption plan, given constraints which depend in part on the previous decision. The way to solve this problem is, of course, backwards: to find the optimal plan at step 4, then use the results of this optimization to find how expected utility depends on the capital market transaction in step 2.

Consider, then, the problem at step 4. Each agent originally received an endowment of money M_1, which he divided into a value of bonds B (perhaps negative) and a remaining amount of cash M'. He expects to receive $M_2 - M_1$ additional cash, plus payment of the bonds, plus income from the sale of his endowment; on the other hand, the sum of money M_2 must be returned. Thus the budget constraint has the form

$$M' + (M_2 - M_1) + (1 + r)B + Py_1 + y_2 \geq PC_1 + C_2 + M_2$$

or, substituting $M_1 = M' + B$,

$$rB + Py_1 + y_2 \geq PC_1 + C_2. \tag{6}$$

Note that money does not enter the budget constraint. In the model money is not net wealth.

The other constraint is that first-period purchases cannot exceed available cash, i.e.,

$$PC_1 \leq M'. \tag{7}$$

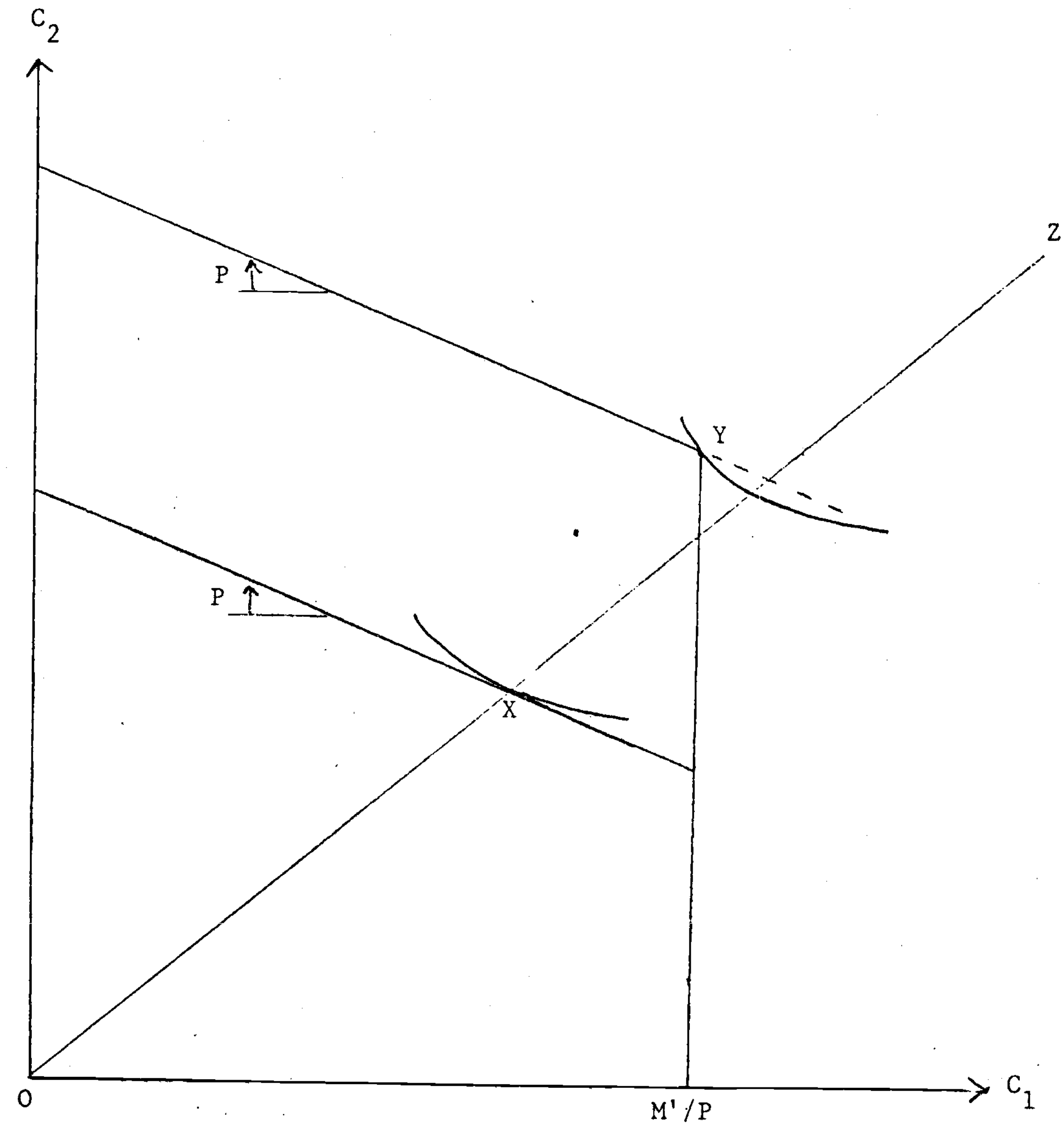
These constraints and their effects are illustrated for two hypothetical consumers in Figure 1. Constraint (6) defines a downward-sloping line in C_1,C_2 space with slope $-P$; constraint (7) a vertical line at M'/P. As the figure shows, the liquidity constraint (7) may or may not be binding. OZ is the expansion path corresponding to the relative price P. One consumer, whose consumption is at X, is not cash-constrained; he ends up carrying cash over from period 1 to period 2. The other consumer, at Y, whose budget line is further out, finds that he would like to spend more in the first period than he can; his consumption is at the kink in the consumption probability frontier.

The position of these constraints depends upon the agent's initial decision on how to allocate his endowment between cash and interest-bearing assets. Consider how the location of the "kink" changes when there is a change in this initial allocation.
If both constraints are binding, we have

$$PC_1 = M' = M - B \text{ and}$$

$$PC_1 + C_2 = rB + Py_1 + y_2.$$

Figure 1



As long as the nominal interest rate is positive, an increase in B thus shifts the liquidity constraint in and the budget constraint out, as illustrated in Figure 2. By varying the purchase of bonds, we trace out what might be called an ex-ante consumption possibilities frontier, which has a slope of $-P(1 + r)$.

Suppose that there were no uncertainty. Then agents would always choose to be on the ex-ante frontier, holding just the amount of cash needed to buy their planned first-period consumption. The result would obviously be a strict quantity equation with a velocity of one. What gives rise to a more complex notion of liquidity preference is the assumption that agents do not know which budget constraint they will face when they decide how much money to hold. If they receive bad news, that their endowment is low, they may end by having extra cash - as illustrated by point X in Figure 1. If they receive good news, that their endowment is high, they may wish they had lent less, like the agent at point Y in Figure 1. Ordinarily - we will define the range precisely below - agents will choose to hold a quantity of money which is intermediate between the amount they would have spent if they had known that the news would be good, and the amount they will spend if the news is bad. And the amount of money held will be sensitive to economic incentives.

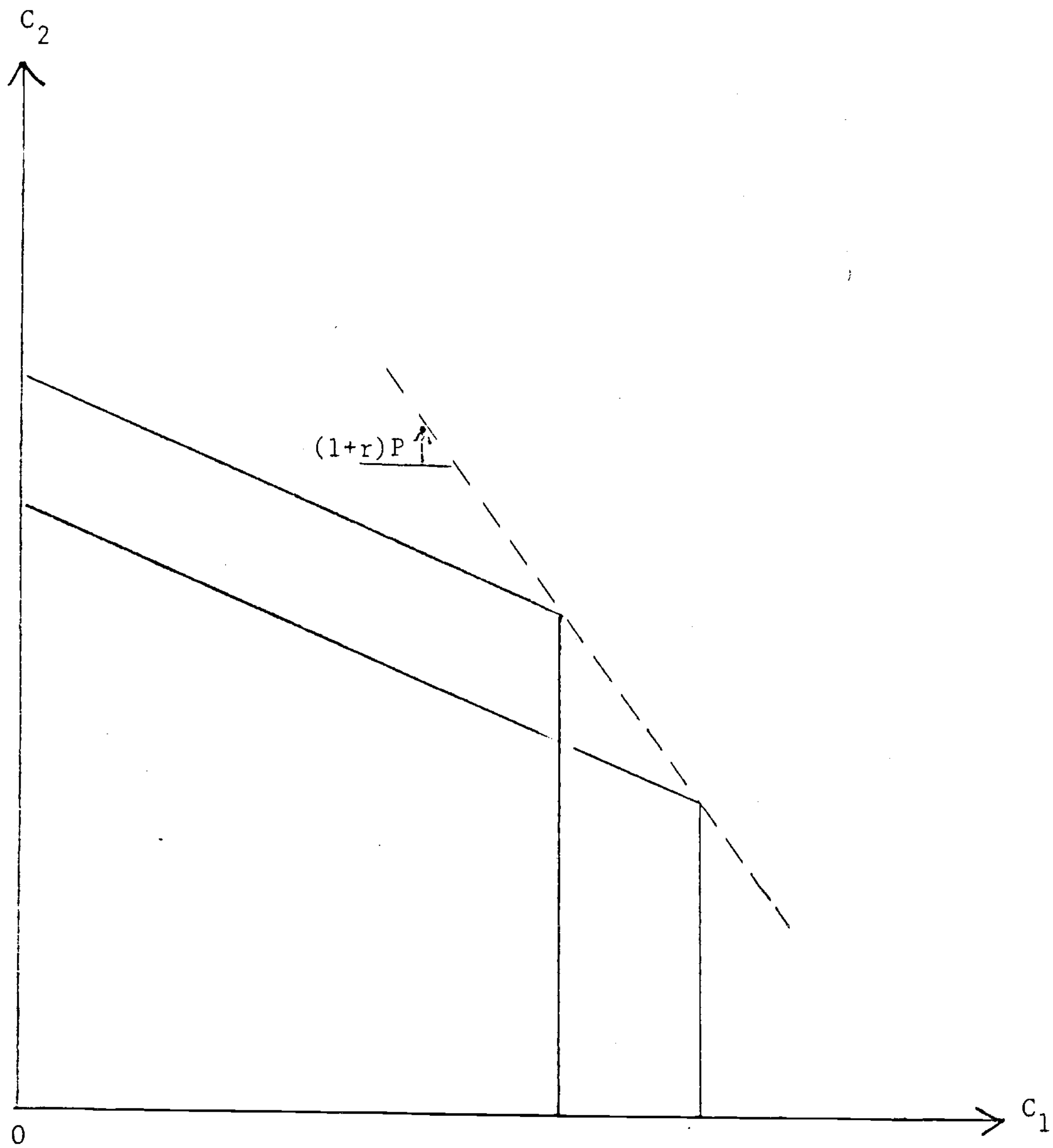
Let us assume that in fact bad-news consumers are not constrained by the cash-in-advance requirement, but that good-news consumers are. Then the actual consumption of a bad-news consumer is

$$C_1^{\ b} = \alpha \ (Py^b + 1 + rB)/P \text{ and} \tag{8}$$

$$C_2^{\ b} = (1 - \alpha)(Py^b + 1 + r\ B), \tag{9}$$

where we substitute $y_2 = 1$. The good-news consumer is off his

Figure 2



demand function; in the first period he consumes all he can:

$$C_1^g = (M - B)/P . \tag{10}$$

In the second period he spends the rest of his income:

$$C_2^g = (1 + r)B + Py^g + 1 - M. \tag{11}$$

The problem of the consumer is to choose B to maximize expected utility,

$$V = \pi (C_1^b)^{\alpha} (C_2^b)^{1-\alpha} + (1 - \pi)(C_1^g)^{\alpha}(C_2^g)^{1-\alpha} . \tag{12}$$

Obviously, an increase in B increases the first term; but it may lower the second. And the optimum B is where $\partial V / \partial B = 0$.

Surprisingly, however, we need not solve for the optimum B to find out most of what we need to know. Thus we will postpone explicit solution of the consumer's initial portfolio choice until we return to interest rate determination in Section 6. First we will determine something else: prices, consumption, and welfare.

4. Market Equilibrium

Given monetary policy, there are two endogenous prices in this model: the interest rate r and the first-period price level P. In general we would expect to solve for these simultaneously. The symmetry of this model, however, lets us take a shortcut. In equilibrium, no agent takes a position in bonds. Thus at step 4 each agent still has his initial money endowment M; and we can go on to solve the model without further reference to the bond market.

The reason for this is obvious on reflection. At the time that the capital market is held (step 2) all agents are identical - that is, they have equal endowments of cash, and each has the same prior distribution on endowments. An interest rate which clears the capital market must be one in which each agent has zero excess demand - so no bonds are actually traded. It is still interesting to know the market-clearing rate of interest. But we shall postpone that analysis until Section 6 below.

The equilibrium in the goods market is illustrated in Figures 3 and 4. In Figure 3, which corresponds to Figure 1, we show the consumption of bad-news and good-news consumers. The points E^b and E^g are their respective endowments; $\bar{E}$ is the economy average endowment. Because no bonds are held, the budget constraints pass through the endowment points. Both types of agents share the same liquidity constraint, M/P. OX is the expansion path corresponding to the price ratio P, A is the consumption of a bad-news consumer, B the consumption of a good-news consumer. The bad-news agent's liquidity constraint is not binding, and he carries cash over to the second period. The good-news agent consumes at the kink in his consumption possibilities.

The consumption demands of these agents are as derived in equations (8)-(11), further simplified by the fact that no bonds are held. Thus

$$C_1{}^b = \alpha(Py^b + 1)/P \, , \tag{13}$$

$$C_2{}^b = (1 - \alpha)(Py^b + 1) \, , \tag{14}$$

$$C_1{}^g = M/P, \text{ and} \tag{15}$$

$$C_2{}^g = (Py^g + 1 - M) \, . \tag{16}$$

Figure 3

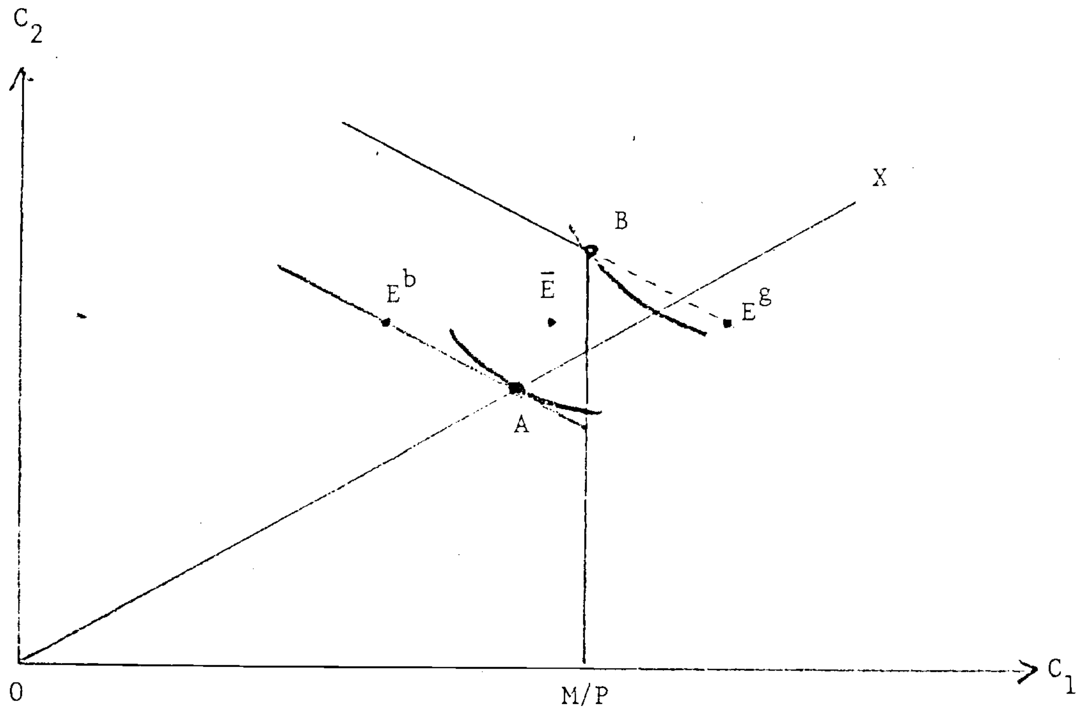
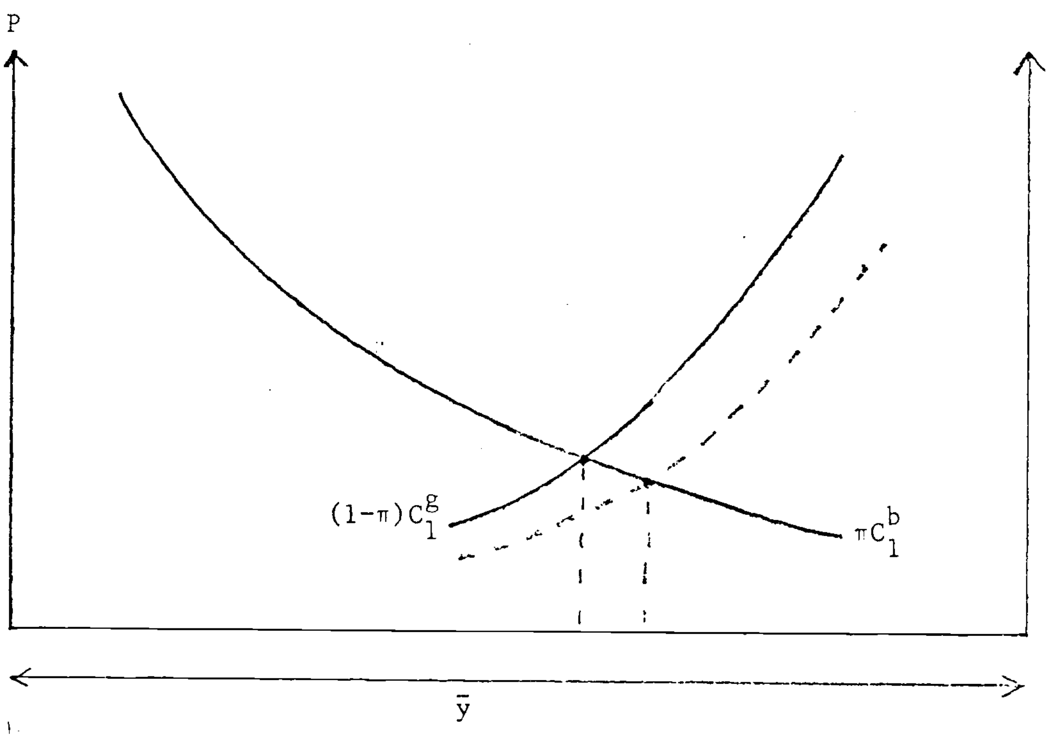


Figure 4



The market-clearing condition is that

$$\pi C_1^b + (1 - \pi)C_1^g = \bar{y} \tag{17}$$

which is illustrated in Figure 4. Equivalently, in Figure 3, the average endowment point is equal to the average of the consumption points, that is, on a line between them.

Consider, now, the effects of a change in M. Recall that M may be interpreted as a measure of monetary deflation, with the rate of change of the money supply equal to (1 - M)/M. The effect of a reduction in M - that is, a more inflationary monetary policy - is illustrated by the dotted line in Figure 4. As the figure shows, the result is a fall in P, which is a rise in the rate of inflation (1 - P)/P. But while the C_1^g line shifts down in proportion to the fall in M, P falls by less; i.e., first-period real balances fall or velocity rises. Algebraically, from (13), (15) and (17),

$$P = \frac{(1 - \pi) M + \pi\alpha}{\bar{y} - \pi\alpha y^b}, \tag{18}$$

which shows that an increase in M will raise P but will also raise M/P. In this model, anticipated inflation does lead to higher velocity, confirming the usual intuition. The next question is whether this reduction in real balances has the conventional welfare costs.

5. Inflation and Welfare

The welfare effects of monetary policy in our model arise from the way inflation changes the intertemporal allocation of consumption. As we have just shown, an increased rate of monetary expansion means that bad-news agents consume more in the first period, less in the second. Good-news consumers are cash constrained to do the reverse. The result - unless marginal utilities of consumption are equal - is a change in expected utility.

From the utility function, and from the demand equations, we can write the expression for the change in expected utility as

$$dV = \pi\alpha[(C_2^{\,b}/C_1^{\,b})^{1-\alpha} - (C_2^{\,g}/C_1^{\,g})^{1-\alpha}]dC_1^{\,b}$$
$$+ \pi\alpha[(C_1^{\,b}/C_2^{\,b})^{\alpha} - (C_1^{\,g}/C_2^{\,g})^{\alpha}]dC_2^{\,b}. \tag{19}$$

Suppose the economy is in the situation described in the previous section, where g-consumers are cash-constrained but b-consumers are not. Then $C_1^{\,g}/C_2^{\,g} < C_1^{\,b}/C_2^{\,b}$, because good-news consumers have been forced off their first-period demand. Also, $dC_1^{\,b}/dP < 0$, $dC_2^{\,b}/dP > 0$, from (13) and (14). Thus $dV/dP > 0$. A reduction in the rate of inflation increases welfare. The reason for this is basically that the liquidity constraint introduces a wedge between the marginal rate of substitution for the two kinds of consumers. The lower the rate of inflation, the smaller this wedge, and thus the greater the efficiency of exchange.

A sufficiently large M will lead to a situation in which $C_1^{\,b}/C_2^{\,b} = C_1^{\,b}/C_2^{\,b}$, so that (19) becomes zero. This is the optimum rate of inflation. It is illustrated in Figure 5. In the figure, E^b and E^g are the endowments of bad-news and good-news consumers respectively, $\bar{E}$ the economy average endowment. At the optimum $P*$, both good- and bad-news consumers choose consumption points on the ray from the origin leading through the aggregate endowment, OX. Thus we must have $C_1^{\,b}/C_2^{\,b} = \bar{y}/y_2 = \bar{y}$, implying

$$P* = \frac{\alpha}{(1-\alpha)\bar{y}} . \tag{20}$$

There are two important points to notice about the equilibrium

Figure 5

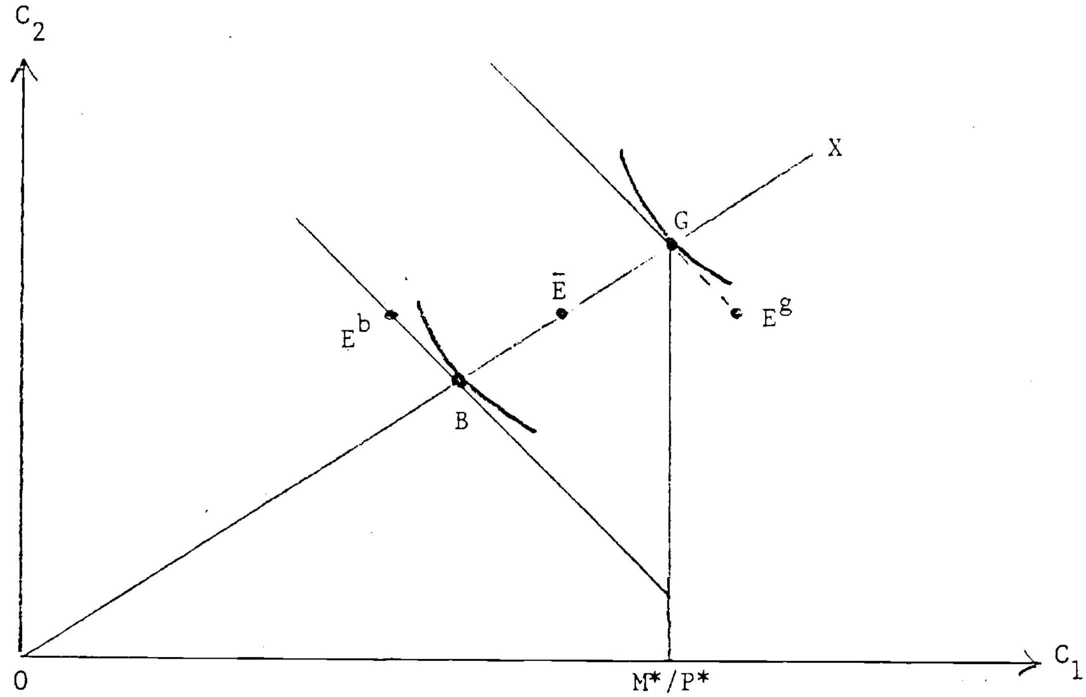
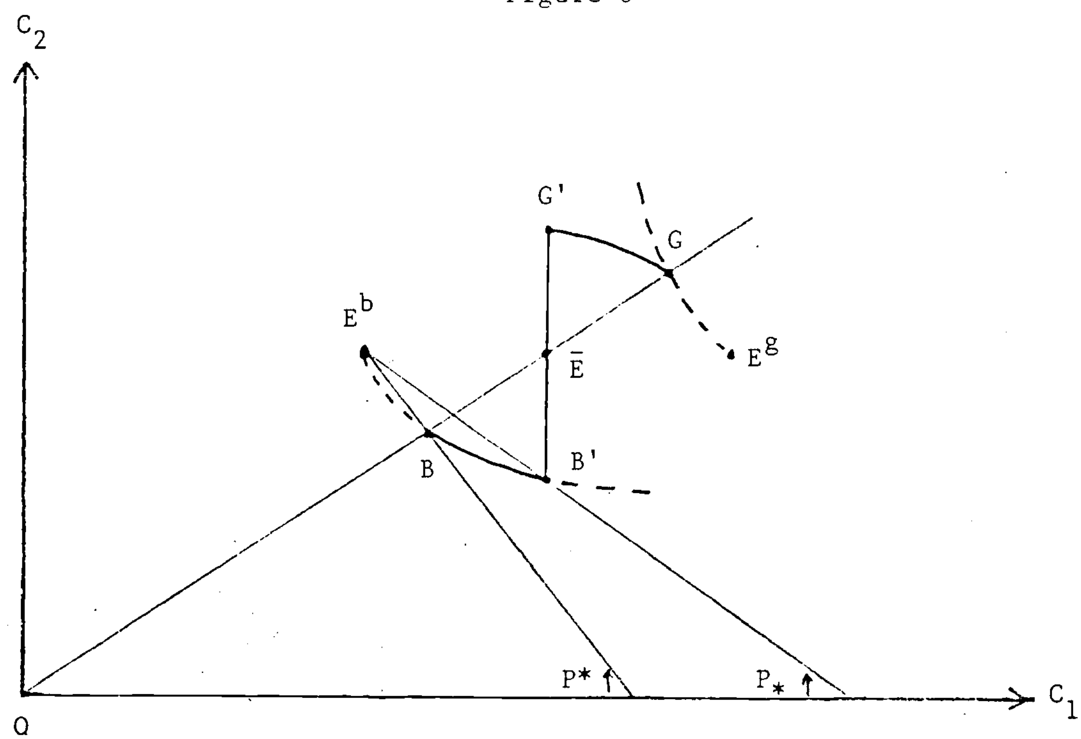


Figure 6



depicted here. First, the rate of deflation equals the marginal rate of substitution between present and future consumption for both types of consumers; since both types of consumers hence have the same marginal rate of substitution, this means that this equilibrium in effect reproduces the result of a barter economy with a perfect capital market.[3] As we will show below, this equilibrium also implies a zero nominal rate of interest. Second, although good-news consumers are at the kink of their consumption possibility sets, their indifference curve is tangent to the budget constraint - that is, they would choose the same consumption bundle even if they did not face a liquidity constraint. In effect, they are saturated with liquidity. It is obvious from these points that the situation we have depicted is very close to that of Friedman's optimal quantity of money, where the rate of deflation equals the rate of time preference and liquidity is free, because the nominal interest rate is zero. The gain from the optimal policy, importantly, in our case does not come from any direct utility attached to money balances; it comes from a better allocation of consumption over time.

What happens if we try to pursue a monetary policy even more deflationary than the optimum? The answer is - nothing. If M is increased above M*, it leaves the budget constraints of both good-news and bad-news agents unaffected, and since neither group is liquidity-constrained, behavior does not change. P remains at P*; increases in first-period money are held without effect, to be returned at the beginning of period 2.

What happens as we reduce M below M* is illustrated in Figure 6. As P falls, i.e., the inflation rate (1-P)/P increases, the b-consumers reduce their second-period consumption and increase their first-period consumption along the offer curve BB'. Cash-constrained, the g-consumers are forced to follow the mirror-image curve GG'. As we have already noted, this reallocation of consumption reduces expected utility. The process continues until P reaches the level P_*, at which b-consumers consume at B' and g-consumers at G'. Here the cash-constraint starts to bind also for b-consumers. For P below P_*, b-consumers' consumption point moves from B' towards $\bar{E}$, and g-consumers from G' towards $\bar{E}$.

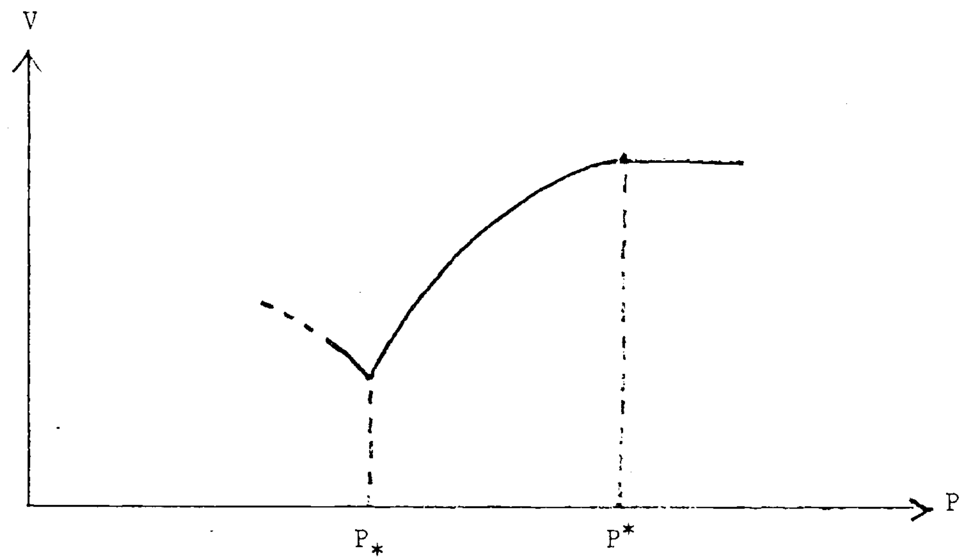
At the price level P_*, the pessimum, expected utility reaches a minimum, as illustrated in Figure 7. For price levels lower than the pessimum level, expected utility improves. Since we feel that that range of price levels where both types of consumers are constrained is of less interest, we do not examine that range in detail.

6. Inflation and Interest Rates

In the analysis so far we have been able to ignore the bond market. The reason we can do this is, of course, that the structure of the model ensures that no agent actually ends up with a net position in bonds. The mechanism which produces the result, however, implicitly involves the interest rate: the interest rate must be set at a level which gives no incentive either to borrow or lend. And even though the bond market is a sort of "fifth wheel" in our setup, it is interesting to ask how this market-clearing interest rate is affected by monetary policy.

Recall that in equation (12) we defined V as the expected utility of a consumer at the end of step 2, i.e., before she knows her endowment. Setting $\frac{\partial V}{\partial B} \equiv V_B$, what we need for capital market

Figure 7



clearing is that $V_B|_{B=0} = 0$; that is, a consumer with zero bond holdings should have no incentive to acquire any. It is straightforward if tedious to show from equations (8) - (12) that

$$V_B = \pi(C_2^b/C_1^b)^{-\alpha} \ [(C_2^b/C_1^b)\frac{\alpha^2}{P} + (1-\alpha)^2]r$$
$$+ (1-\pi)(C_2^g/C_1^g)^{-\alpha} \ [(C_2^g/C_1^g)(\frac{-\alpha}{P}) + (1-\alpha)(1+r)]. \tag{21}$$

We might suspect that at the optimum monetary policy the market clearing rate of interest is zero, since agents behave as if they were not liquidity-constrained; and this is in fact the case. We know that $P^* = \alpha/(1 \ \ \alpha)\bar{y}$ and $C_2^g/C_1^g = C_2^b/C_1^b = 1/\bar{y}$ in the optimum. Substituting these into (21), we find that $V_B = 0$ when $r = 0$.

As we move away from the optimum monetary policy, the nominal interest rate becomes positive. The change in the interest rate when the rate of inflation changes as a result of a more expansionary monetary policy may be found by

$$dr/dP = -V_{BP}/V_{Br} \quad . \tag{22}$$

This derivative is in general a very complex expression; but when evaluated in the vicinity of the <u>optimum</u> monetary policy it reduces (after considerable calculation) to

$$dr/dP = -(1-\pi \ + \pi \cdot C_2^b/C_2^b)/P < 0 \quad . \tag{23}$$

Thus in the vicinity of the optimum monetary policy an increase in the rate of inflation - a fall in P - raises the nominal interest rate.

What about the real rate of interest? The real rate is defined as

$$\rho = (1+r)P \quad . \tag{24}$$

In the vicinity of the optimum monetary policy we have

$$d\rho/dP = 1 + P\, d\, r/dP \tag{25}$$

$$= \pi(1 - C_2^b/C_2^g) > 0$$

Even though inflation raises nominal interest rates, then, it does not raise them in proportion: in our model inflation lowers the real interest rate. We have unfortunately not been able to come up with any simple intuition for this result.

These are only local results, valid near the optimal monetary policy. In general the effects of monetary policy on interest rates when we are far from the optimum are extremely complex. We have, however, constructed a numerical example which gives some suggestive results.

7. A Numerical Example

Let us look at a numerical example which illustrates some of the points we have made above. In the first period consumers receive 2 units of output while bad news consumers receive none: $y^g = 2$ and $y^b = 0$. These events have equal probability: $\pi = 1/2$. In the second period all consumers, as before, have the same endowment, $y_2 = 1$. Finally, we assume a symmetric utility function where $\alpha = 1/2$.

Directly from (20) then, $P^* = 1$, i.e., the optimal inflation rate is zero. We know that the nominal interest rate is zero in the optimum so the real rate is zero as well. From (18) we find $M^* = 3/2$. In other words we need a rather strongly deflationary policy to support the optimum rate of inflation. It is easy to verify that in the implied equilibrium b-consumers consume 1/2 units and g-consumers consume 3/2 units of output in each period. The endowment points, E^b and E^g, and consumption points, B and G, are illustrated in Figure 8, which is the analogue to Figure 6.

If M is lowered,making monetary policy more expansionary, the inflation rate (1-P)/P becomes positive and increases. Bad news consumers continue to consume according to their demand functions

$$C_1^b = 1/2P \text{ and } C_2^b = 1/2 ,$$

and hence their consumption points in the figure move horizontally from B towards B' along their (dotted) offer curve. The g-consumers, on the other hand, find themselves liquidity constrained and off their offer curve. Given C_1^b and C_2^b their actual consumption, to preserve equilibrium in the goods market has to be

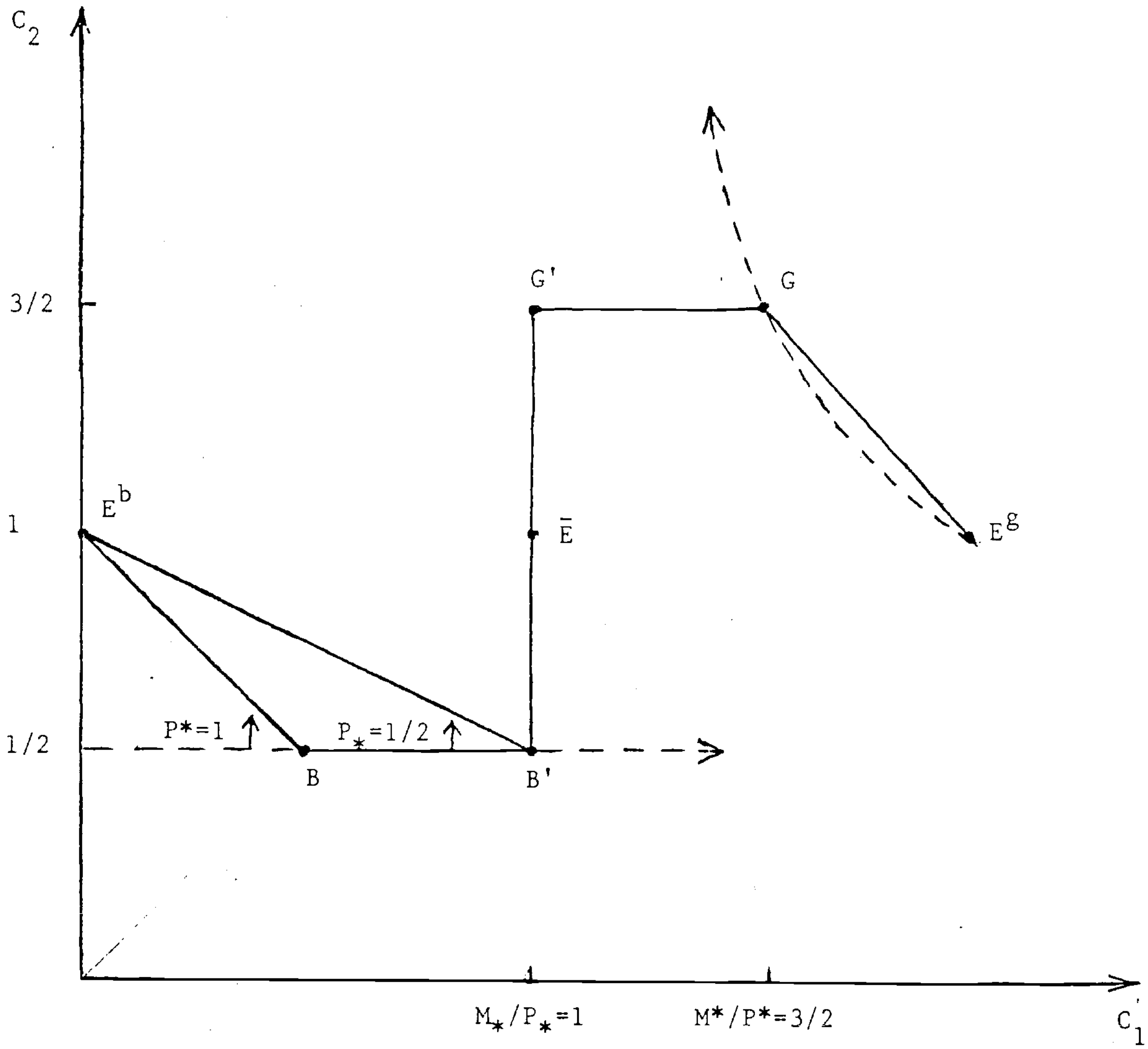
$$C_1^g = (4P-1)/2P \text{ and } C_2^g = 3/2;$$

in terms of Figure 8 their consumption point moves west along the GG'-line.

The economy reaches the pessimum at $P_* = 1/2$ when both types of consumers become liquidity constrained. This occurs when they both consume one unit of output in the first period at the points B' and G' respectively. The pessimum is sustained by a quite inflationary monetary policy since $P_* = 1/2$ via (18) implies $M_* = 1/2$.

To determine interest rates we make use of the condition $V_B = 0$. Substituting the values for C_1^b, C_2^b, C_1^g, C_2^g, we have just derived into equation (21), we find

Figure 8



$$1 + r = \sqrt{\frac{3}{4P-1}}$$

for the nominal interest rate. The real interest rate is then defined by

$$1 + \rho = (1+r)P = \sqrt{\frac{3P^2}{4P-1}}$$

It is interesting to note that the local results derived in the last section - i.e., that the nominal interest rate is increasing in the rate of inflation but the real rate is decreasing - hold globally in this example for the total range between the optimum and the pessimum, $\frac{1}{2} \leq P \leq 1$, as illustrated by Figure 9.

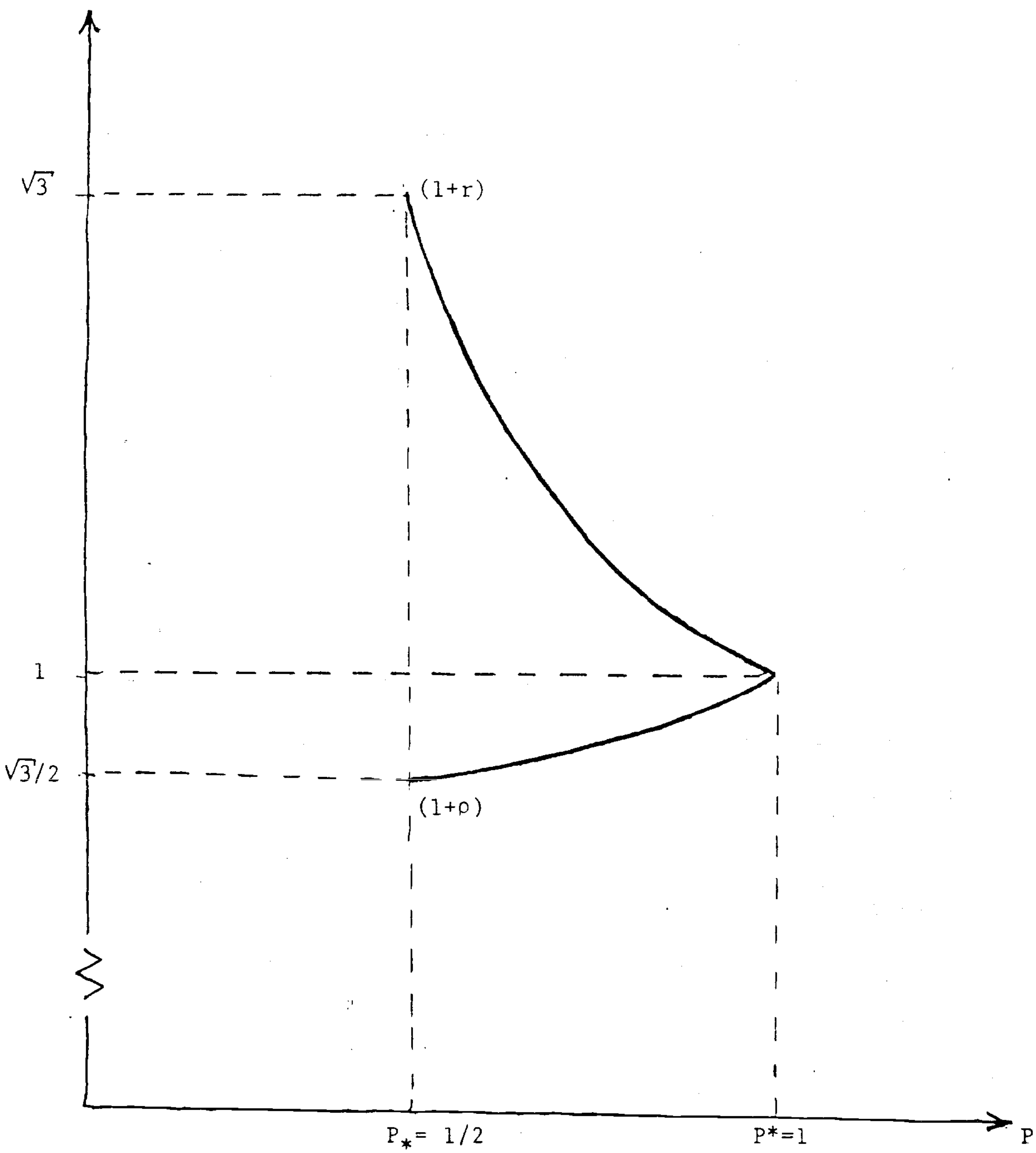
8. Conclusions

In this paper we have developed a simple model of the effects of inflation in a monetary economy. Although the setup is rather unusual, the results correspond to conventional wisdom: inflation leads to lower real balances and to lower welfare because of reduced "liquidity". In a sense, then, we took a longer road to arrive at the same place. We believe, however, that our paper provides new insights, in two directions:

(i) The welfare cost of inflation: In our model, money does not yield utility in its own right, but is held because it is needed for transactions. Inflation has a welfare cost only because it leads to a misallocation of consumption.

(ii) The determination of the interest rate: The real interest is not the intertemporal marginal rate of substitution in this model. Indeed, this rate differs between agents. What we have suggested in this paper is thus a "liquidity preference" rather than a "loanable funds" theory of interest,

Figure 9



where the proximate choice which determine the interest rate is between money and bonds, not between current and future consumption. It is true that liquidity preference in turn depends on tastes and expected consumption streams; but the theory of interest rate determination is non-Fisherian, as shown by the fact that the real interest rate is not independent of the inflation rate.

We do not seriously propose this model as a substitute for the ad hoc models which still constitute most of monetary theory. The setup is still far too artificial, and the range of questions we can ask still far too narrow. But we believe we have made some progress on the long road to a satisfactory microfoundation for monetary theory.

Footnotes

*This paper was initiated when we were visiting Tel Aviv University. We thank Elhanan Helpman and Assaf Razin, as well as participants in the Stockholm Theory Workshop and an M.I.T. seminar for useful comments.

1. Hence, we assume the absence of complete Arrow-Debreu contingent markets.

2. Grandmont and Younès (1973) and Wilson (1979) also discuss optimum monetary policies in cash-in-advance models with maximizing agents. They arrive at the well-known result that the optimum policy is such that the nominal interest rate is zero but for different reasons than ours. Since agents in their models act under subjective certainty the velocity of money is independent of the rate of inflation. Therefore agents' choice of money holdings is not important in deriving the optimal policy as it is in our argument.

3. Alternatively, we could start from the Pareto optimal barter equilibrium where marginal rates of substitution are equal and then reproduce that equilibrium in our monetary economy. Note that risk neutrality is crucial here, since it implies that expected utility is independent of distribution of utility between good and bad states, once marginal rates of substitution are equal.

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