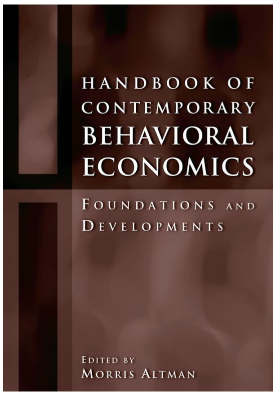

Handbook of Contemporary Behavioral Economics Foundations and Developments

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Elements of Behavioral Monetary Economics

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CHAPTER 35

ELEMENTS OF BEHAVIORAL MONETARY ECONOMICS

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Many surveys on behavioral economics start with a reference to Herbert Simon. Certainly Simon has been the single most important innovator in the field of behavioral economics, the approach to economics that takes into account the cognitive limitations (i.e., the bounded rationality) of human decision makers. However, monetary economics has obviously not been one of Simon's priorities.[1] This has very likely to do with the fact that monetary economics has always been a rather pragmatic mixture of deductive theorizing, on one hand, and rationalizations of empirical regularities (such as the relation between money growth and inflation), on the other (see Friedman and Hahn 1990). Although rarely explicitly tied to bounds of rationality, economic science traditionally links the raison d'être of money and the effects of money to various frictions in economic life, such as uncertainty and transaction costs. As a theorist who gave economic agents' judgment errors an important role in his analysis of monetary issues, Irving Fisher must be seen as one of the first behavioral monetary economists (see Fisher 1928; Thaler 1997).

The approach pursued in this essay is to describe elements of behavioral economics within monetary economics. Hence, the essay looks for insights concerning the functioning of monetary economies that have been gained by exploring the notion of less than perfect decision making. This does not mean that results based on the assumption of unbounded rationality will be excluded from the discussion. On the contrary, studies based on unbounded rationality have often preceded behavioral analyses and have thereby set a standard that proves to be useful as a benchmark. Thus, this text attempts an evaluation and an integration of contributions that start from different assumptions rather than a description of a new type (or school) of monetary economics. Along the way there will be several opportunities to point out open questions and possible extensions where the behavioral approach could yield further interesting insights into monetary economics.

Monetary economics deals with the medium of transactions of an economy. The field can be characterized by outlining its two major sets of issues. The first set of questions turns around the problem of why monetary exchange comes (or came) to replace barter arrangements and what good (or goods) plays the role of medium of exchange. The second set of issues deals with the effects of money in a monetized economy. Here the attention focuses on the effects variations in the supply of money have on nominal and real variables, the nominal variables being the price level, exchange rates, and the nominal interest rate. Among the real variables are relative prices, employment, the real rate of return, and output. While there are links between the two sets of issues in monetary economics, much theorizing and empirical work are based on the notion that the two sides can be analyzed separately.[2] A survey of studies in the two outlined subfields of monetary economics shows that the field addressing the more fundamental issue relating to reason and forms of monetization of an economy has so far generated fewer contributions that can be labeled "behavioral economics" as compared to the latter field, which deals with the effects of money. Hence, I will start by reviewing this more fundamental—and, from a behavioral viewpoint, less developed—field. Next I ask why and how money affects the economy. After that comes an analysis of the control of the money supply and monetary policy, followed by the conclusion.

WHY IS THERE MONETARY EXCHANGE AND WHAT FUNCTIONS AS MONEY?

The reason for monetary exchange is typically located in the difficulty of barter exchange to solve the problem of double coincidence of wants. This means that for a voluntary exchange of goods to take place, both potential trading partners have to want (i.e., value) the good the other side has to offer. Take the extreme example where goods perish quickly (i.e., where goods have very high storage costs). In this case exchanges would take place only between traders who want to *consume* the good the other part is offering. Under these circumstances the potential for trade would indeed be very limited. Fortunately, reality does not resemble this extreme example.

Commodity Money

In reality some goods both are durable and change hands at low (transaction) costs. Hence, these goods (or a subset of them) come to be accepted as a means of payment and are used not only for direct consumption. These goods are valued and accepted because people can use them in future exchanges to acquire the goods they want for consumption. The emergence and properties of commodity money (or many parallel commodity monies) have been studied and modeled by a succession of theorists such as Wicksell (1934) and Kiyotaki and Wright (1989), to name just a few (see Ostroy and Starr 1990 for a survey). The general insights from these models are that (1) monetary (i.e., indirect) exchange is likely to emerge and replace barter and (2) a change in the supply of commodity money (e.g., gold) affects relative prices in the economy. Hence, with commodity money there is no basis for analytically separating the monetary side of the economy from the real side. For the case of commodity money the classical dichotomy between real and nominal economic variables is thus at best a pragmatic simplification. In experimental studies predictions more specific than the two listed above of modern general equilibrium models of commodity money have fared rather poorly (see Duffy 1998 for a survey). It remains a matter of debate and ongoing research to settle whether these difficulties are due to the rationality assumptions underlying these models.

Comparing the system of barter trade with arrangements using one or several commodities serving as money, an argument based on limited computational power of agents is often made to motivate the step toward a unique exchange medium. Specifically, calculation costs have been referred to as one way to rationalize the transition from barter exchange (where potentially every good is exchanged for every other good) to a system where all exchanges are conducted against a single good, which is accepted as payment. The argument for a single medium of exchange is straightforward. With n goods there are $n(n-1)/2$ prices under a barter regime. Compare this to a monetized economy where only $n-1$ prices (all expressed in money terms) exist. Clearly, an agent attempting to maximize utility has to process a large number of comparisons and trade-offs. With prices of all goods expressed in one common unit, it becomes simpler to assess the optimality of consumption plans, for example, by comparing the marginal utility of one weight unit (or coin) of gold in different uses. This argument, however, is valid only in a world where only transactions in terms of money (i.e., the good serving as generally accepted medium of exchange) are costless. If all barter exchanges could be conducted without transaction costs, one could just as well pick any good (e.g., tomatoes) to economize on agents' computational resources.[3] Hence, the noted cognitive advantage of monetary exchange is the result of monetization rather than a reason for it.

Fiat Money

It is clearly a significant step for an economy to move from commodity money (e.g., gold) to a system with an intrinsically valueless medium of exchange such as paper money. Historically this development has taken time and has seen the government as a central player. In fact, the expression "fiat money" describes a medium of exchange that has no intrinsic value and exists by virtue of the state making it legal tender. Fiat money is related to but is not synonymous with paper money. In Europe banknotes were first issued in 1661 as a product of commercial activity: the Stockholm Bank in Sweden offered pieces of paper indicating the amount of copper deposited with the bank and thus created a light and mobile place holder for metal that was regularly used in transactions (see Weatherford 1997).

As Selgin (1994) and Dowd (2001) point out, fiat money has historically always emerged from convertible currency (or commodity money) and not directly from barter. Two elements have played key roles in the development of the modern paper money system. First, governments highly value the income that the supplier of the medium of exchange can generate (as emperors did controlling the supply of gold coins).[4] Second, the replacement of gold by paper money saves society the opportunity cost of gold, which can be used for nonmonetary purposes. These resource savings would be largest in a society running a system of paper money without it being backed by any gold (or other commodity) reserves at all. However, there is a substantial conflict between governments' need for revenue from money creation and the public's preference for stable money and hence a danger of overissue of money.[5] While modern monies are no longer convertible into gold, central banks still hold substantial amounts of gold reserves. This points toward an issue behavioral economics is only now beginning to address: the psychology of trust in institutions. It is remarkable to see the vague references to psychology by traditional economists when arguing that central banks should continue to hold gold reserves and to note the void of formal analysis by experts in bounded rationality.

WHY AND HOW DOES MONEY AFFECT THE ECONOMY?

It is common to divide the effects of changes in the supply of money into effects on nominal and real variables.[6] Among the nominal variables, the price level (and inflation, its rate of change) features prominently. In the sphere of international money, exchange rates (and their course over time) clearly are of concern. Among real variables, output, unemployment, relative prices, and the real interest rate are central. A set of classical propositions in monetary economics states that when all adjustments have run their course, a change in the supply of money leaves all real variables unchanged, whereas the price level and exchange rates change proportionally to the change in the money supply. These statements are called (1) the long-run neutrality proposition with respect to real variables, (2) the quantity theory of the price level, and (3) the purchasing power parity theory of the exchange rate, respectively.[7] In the short run the well-documented regularity that changes in the supply of money cause changes in real variables is due to the fact that prices and wages are sluggish (or sticky, to use the Keynesian term). The last thirty years have brought significant advances regarding the determinants of this sluggishness.

Dynamics of Wages and Prices

One side of the nominal sluggishness concerns the dynamics of wages. Fischer (1977) and Taylor (1979) presented models in which the type of staggering of wages empirically observed leads to nominal inertia and hence to real effects of monetary policy. From the point of view of behavioral economics it is interesting to note that the adjustment dynamics in these models is seen as depending on a comparison of currently set wages with wages that have been set in the immediate past. This indicates that sluggishness of wages is partially attributed to social comparisons and possibly considerations of fairness. Detailed empirical investigations of the implications of the staggered wage model have demonstrated that the initial model specifications by Fischer and Taylor have to be corrected. Fuhrer and Moore (1995) document that a model with a nominal wage setting where wage comparisons are made in real rather than nominal terms (contrasting with Fischer's and Taylor's assumption and also contrasting with approaches discussed below) significantly outperforms the older formulations in statistical tests. Moreover, Fuhrer and Moore's notion of wage dynamics generates empirically plausible effects of changes in monetary policy.

The other side of nominal sluggishness directly concerns goods' prices.[8] Here the incorporation of imperfect competition has furthered coherent modeling. The starting point of many approaches in this field is the insight that for price-setting firms, a change in their output price has only second-order (i.e., small) effects on profit (see Akerlof and Yellen 1985; Mankiw 1985). In Akerlof and Yellen's model some firms (termed near-rational) do not change their price (and wage), while some fully rational firms do. It turns out that the lack of optimal adjustment is not very costly for the sluggish actors, but output and employment react strongly (and for several periods) to a change in the money supply. In a more recent analysis Akerlof, Dickens, and Perry (2000) extend the near-rational behavior to the side of workers and their influence on wages. At low levels of inflation workers appear to be pressing less intensively for an inflation adjustment of wages. The interplay of rational firms, boundedly rational firms, and workers motivated to work harder by rising wages implies—even in the long run—a trade-off between inflation and employment. The econometric estimates by Akerlof, Dickens, and Perry (2000) seem to support their theoretical prediction: their model explains well the co-movement of inflation and unemployment (the so-called Phillips curve) in the United States over the period from 1954 to 1999.

The channel by which money affects real economic variables described by Akerlof, Dickens, and Perry (2000) is just one of several channels that have been proposed that originate in what is called *money illusion.* Money illusion (see Fisher 1928; Leontief 1936; Howitt 1989; Shafir, Diamond, and Tversky 1997) is present when economic agents decide differently when a higher nominal payoff is offered (e.g., for goods or labor services) but the general level of prices rises in proportion so as to make the payoff expressed in goods (i.e., in real terms) unchanged.[9] In experimental work Fehr and Tyran (2001) indicate that the magnitude of price sluggishness in a monopolistically competitive economy may strongly depend on agents' expectations that *others* are prone to money illusion. With some agents afflicted with money illusion, any change in the money stock necessitates a process in which decision makers iteratively recoordinate their expectations. Psychological reasons such as money illusion or concerns regarding fairness may also contribute to a downward rigidity of wages (see, e.g. Akerlof, Dickens, and Perry 1996). While sluggishness of wages (as discussed above) suggests that a high level of inflation should be corrected downward only gradually, downward rigidity of wages would imply that inflation should not be reduced to zero. I will return to this issue later, when the question of optimal long-run inflation will be addressed.

Inflation Expectations

An issue where behavioral economics has been particularly important is the study of inflation expectations. Before the advent of rational expectations, the formation of expectations was by theoretical necessity modeled as extrapolative or adaptive (see Nerlove 1958). After Muth (1961) introduced the rational expectations hypothesis the study of inflation expectations became one of the early and important fields for testing rationality of foresight. Figlewski and Wachtel (1981), Lovell (1986), and Bonham and Cohen (1995) used survey data to document that inflation expectations of a wide class of economic agents were not adequately explained by the rational expectations hypothesis. Instead, adaptive expectations seem to do more justice to the data. Inflation expectations are particularly relevant since they can play a crucial role in the transmission process determining the effects of monetary policy. In fact, the first generation of applications of rational expectations claimed that with rational inflation expectations, monetary policy would be without any effects on real variables. Not only has this claim been proven wrong (see Fischer 1977; Taylor 1979) but *deviations* from rational expectations have been documented as playing an important role in the effects of monetary policy on real variables (see Naish 1993; Ball and Croushore 1995; Roberts 1997; Rötheli 2000).

The International Side

Exchange rates connect the domestic economy to the international sphere. Behavioral modeling of exchange rate movements—in the light of difficulties of models based strictly on macroeconomic fundamentals and rational behavior—started in the 1980s. Frankel and Froot (1986) proposed the first model where chartists buy and sell currency alongside agents who base their actions on the analysis of fundamentals such as differentials in real output growth, interest rates, and money growth between countries. Pattern extrapolation by chartists has the potential to make the exchange rate deviate from its long-run (purchasing power) equilibrium value for extended periods. Empirically, such extrapolative or noise trading behavior seems to at least account for the slight tendencies of various currencies to exhibit bandwagon dynamics (see Rötheli 2004). Bandwagon dynamics arise when extrapolating traders induce the exchange rate (or another variable) to continue to change in a direction once taken (see also Hong and Stein 1999).

In recent years the behavioral modeling of exchange rates has also made use of tools developed in artificial intelligence. Following the analysis of closed-economy macroeconomic questions relating to rationality and learning by Marimon, McGrattan, and Sargent (1990) and Sargent (1993), researchers such as Arifovic (1996) and Lawrenz and Westerhoff (2003) have modeled decision makers (specifically traders on the foreign exchange market) as genetic algorithms (see Holland et al. 1986; Holland and Miller 1991). Such agents do not from the outset have perfect understanding of their market environment but rather learn in a hypothesis-evaluating and hypothesis-adapting way from their experience. Under certain conditions simulated markets populated by such trial-and-error learning agents converge in their functioning to markets populated by rational agents. However, many alternative outcomes are also possible, and the noise trader literature (see DeLong et al. 1991) has shown that market competition will not in general eliminate traders who stick to simple heuristics.

Transactions, Money Demand, and the Price Level

Much research on the effects of variations in the quantity of money on nominal and real variables has been conducted on the basis of a concept of money demand developed and extended over many years. In its Cambridge representation the demand for money balances is proportional to the level of transactions in an economy. The factor of proportionality (the so-called Cambridge *k*) was early on seen to depend on the customs and techniques of making payments in an economy. Hence, changes (e.g., innovations) in the payment system were understood to change the relation of the value of overall transactions to the money stock (also called the velocity of circulation). As operational factors influencing the demand for money, the rate of interest (suggested in Keynes 1936) and a number of other variables capturing in greater detail the opportunity costs and risk characteristics of money were proposed (see Baumol 1952; Friedman 1956; Tobin 1958; Goldfeld and Sichel 1990).

Over the last fifty years a great deal of intellectual effort has gone into developing theories that show money demand as the outcome of rational action and interaction of economic agents. In the process analysts have explored different notions that explain why the asset money that is dominated in return by other forms of wealth is actually held. One notion is to see money balances as yielding direct utility and hence being a variable belonging directly into the utility function of the consumer (see Patinkin 1950–51). Another approach sees money as a productive factor and hence gives money balances a place in the economic agent's production function (see Dornbusch and Frenkel 1973). Some economists (see Goodfriend and McCallum 1987; Wang and Yip 1992) have investigated under what conditions such modeling can be consistently linked to economizing behavior given the costs of transferring interest-bearing assets (such as bank accounts) into cash. While some of these theoretical developments have led to insights that have furthered the understanding of empirical observations, it seems fair to say that this process has neither led to an integrated theory of money demand nor provided a fully satisfactory empirical account of the relation between money balances and their suggested determinants. On the empirical level too many cases of "missing money" and "demand instability" keep intriguing analysts. On the theoretical level there is a widely felt unease with a metaphorical approach to monetary theory (see, e.g., Niehans 1978, 1). It is undoubtedly unsatisfactory for economic theory to treat the demand for money balances similarly to the demand for TV sets and automobiles. These are assets—just like money—that provide services some of the time, and holding them leads to opportunity costs. However, the analogy has its limits in that money provides its service only because it can be given away in return for a good.

Instead of studying the effects of money in models where a money demand function is stated as the building block, several researchers have chosen to build models with a different premise. These models start with the assumption that the economy under investigation is *fully monetized,* meaning that all goods are paid for in the general medium of exchange.[10] Examples of this type of analysis are, among others, Clower 1967; Niehans 1978, chs. 2–4; Krugman, Persson, and Svensson 1985; and Shubik 1990.[11] This type of analysis describes the distribution of goods among agents, their preferences, market forms, and conventions regarding the timing of market events. Shubik (1972, 1990) even proposes the use of model economies that are playable, that is, models in which actors, their roles, and institutions are so explicit that the economic processes captured can be enacted with subjects. I take up this suggestion here to illustrate how this type of modeling opens interesting possibilities for experimentally studying the role of agents' decision making in important issues of monetary economics. I use a new and simple playable monetized economy to analyze the determination of money prices and their relation to the stock of money as well as the role of uncertainty in this quantity theoretic framework.

Consider a world populated by two types of agents: A-types are assumed to be endowed every period with a fixed amount (100 units) of A goods, while B-types receive 100 units of B goods per period. While endowments are specialized, both types of agents have the desire to acquire the good that is not in their endowment. This desire is modeled by having each agent *i* produce a final (consumer) good called *C* with a production function:

$$C_i = \sqrt{A_i B_i} \ .$$

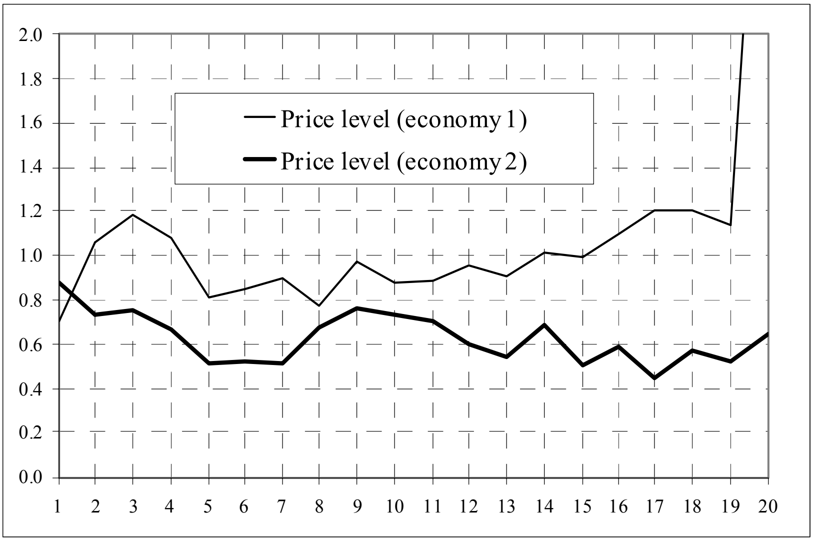
As indicated before, the model economy is a monetized economy. This means that agents buy and sell goods against money. Hence, an A-type wanting to acquire B-goods has to offer money, and the same holds for a B-type desiring A-goods. The transactions (goods against money) take place on *two* markets, and revenues from sales in one market cannot be allocated toward purchases in the other market within the same market period.[12] Each subject is endowed with an identical amount of cash: 100 cash units. In the basic setup the aggregate supply of money remains fixed over time. I simplify the selling and buying behavior by giving agents just one dimension for varying their behavior in each of these markets. The selling behavior is determined by agents deciding over the amount of their commodity endowment they want to sell in each period. The buying behavior is determined by agents deciding over the sum of money they are willing to spend on the good that is not yet in their possession.

An anonymous market mechanism then determines equilibrium prices and flows of goods and money. For any unit of good given away there is a quid pro quo in money. The equilibrium price in any market is determined on the assumption (also communicated to subjects) that the sum of money offered by them for purchases is understood as a unitary elastic individual demand function. This implies that the equilibrium price is the sum of all money amounts offered for a specific good divided by the total of all offered units of that good. The assumption is that goods are perishable, that is, they cannot be stored. In the experiment subjects are asked (and financially motivated) to maximize their cumulative output of the consumption good. Hence there is no discounting. A positive value of money in the final period of the experiment is ensured by offering to exchange the remaining cash against A- and B-goods in equal proportion at the average of the two prices in the final period. This ensures that (at the average price) subjects receive the maximum possible amount of C-goods for their remaining balances.[13]

This model has interesting theoretical features. First, it is obvious that the maximum output per period in this economy is 1,000 units of the consumption good in the aggregate, that is, an average of 50 units per subject. This maximum output can be reached only when the endowments are equally split among the agents. This happens when each agent offers 50 units of his good (i.e., keeps 50 units) and purchases 50 units of the other type of good. What trading strategy could possibly bring about this outcome? The answer is that very many strategies are capable of generating this outcome. All these strategies have in common that each subject offers 50 units of the good in the endowment. What makes them different is the sum of money offered for purchases. Any positive amount of money between 0 and 100 offered is a feasible strategy if every player offers this amount. Hence, the efficient output of 1,000 units of the final good can be produced and the necessary transactions carried out with very different amounts of money changing hands. The flip side is that in this economy, considering only situations where all agents offer 50 good units, the price level (i.e., the average of the two prices of the A-good and the B-good) can be anything larger than 0 and up to a value of 2.

So what is the rational agent to do? What amount of money should he offer? Here is the proposed equilibrium concept: it can be argued that a rational agent should (and will) offer 50 money units because every number between 0 and 100 is equally likely and 50 is thus the expected value. Under this strategy the prices of the two goods are both 1. If all agents follow this strategy, it can be shown that no subject has a motive to deviate from this strategy. More precisely, in this case the individual is indifferent between following this strategy or any other strategy that shares the feature that the sum of expenses for goods purchased and number of goods offered for sale is 100.[14] So much for the reasoning about rational behavior; we will see how human subjects decide in this setup.

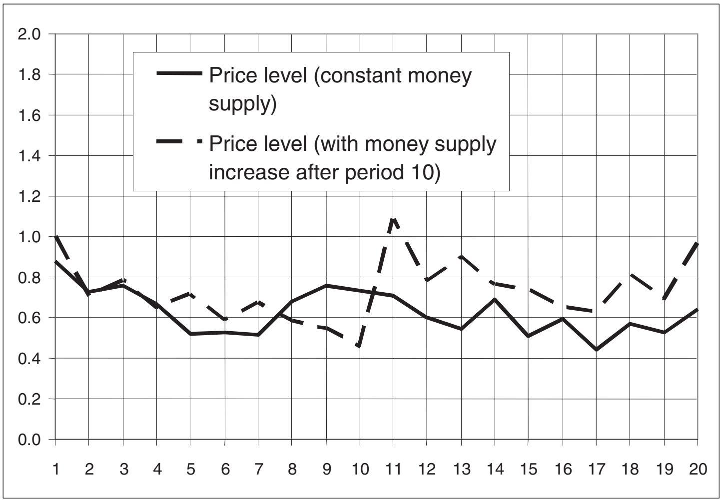
Figure 35.1 **Different Price Level Paths for Different Groups of Subjects**



I enacted this playable economy as an experiment with students at the University of Erfurt who had studied (and successfully completed) economics courses at least one year previously. In an anonymous laboratory setting, an economy with ten A-type and ten B-type subjects was realized. Subjects were informed that they would receive one euro cent per consumption good. Once the experiment started, subjects had three minutes per market period to make their decisions. Before the actual experiment three trial periods were allowed in order to acquaint subjects with their task. After this learning phase the basic treatment was run. In this treatment no external changes impacted on the laboratory economy. The basic treatment was run with two different groups of subjects. Figure 35.1 shows the resulting two paths of the price level over twenty periods. It is evident that the two series differ systematically. Excluding the last period (for an apparent end-of-experiment effect in the second economy), the price level with the second group of subjects was on average 56 percent higher than with the first group of subjects. With the second set of subjects the price level does not significantly differ from a value of 1 (i.e., the level predicted on the assumption of rationality of all agents). With the first set of subjects, however, the price level is significantly below this value. While these results should not be overstated, the findings indicate that an experimental economy (and possibly actual economies as well) can operate on different price levels.

The second treatment for the two groups addresses two separate issues: for group one the supply of money was increased (by way of a transfer of 50 cash units to every subject) after the tenth market period. After this expansion the money stock remained on its elevated (by 50 percent) level for the rest of the experiment. Figure 35.2 shows the course of the price levels in the basic treatment (i.e., with a constant aggregate money supply) and in the treatment with the monetary expansion after the tenth period. It is obvious that the price level increases after the infusion of money. Tests indicate that the price levels for the two treatments during the first ten periods (i.e., with the same money supplies) do not differ significantly. However, after the money infusion the difference is statistically significant. The quantity theory of money would predict that for periods eleven to twenty the price level should be higher than in the first ten periods proportionally to the increase in the money stock (that is, by 50 percent higher). This theoretical prediction

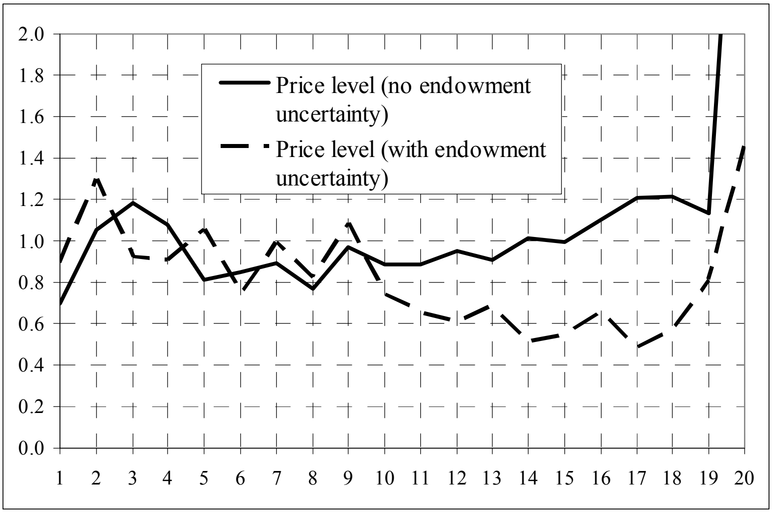
Figure 35.2 **The Effect of a Monetary Expansion on the Price Level**



is statistically supported. This result is particularly interesting given the fact that for this group the price level paths in both treatments differ systematically from the prediction based on unbounded rationality. One interpretation of this result would suggest that the quantity theory of money may be one of the economic relationships that are robust to agents' deviations from perfect rationality. Another interpretation would point toward the fact that on average the price level with the increased money supply is only 38 percent higher, rather than the 50 percent that the quantity theory would predict. With a view to the policy issues to be taken up later, this deviation (while statistically insignificant) is substantial and should caution policy makers attempting to stabilize the price level (rather than the rate of inflation) by way of monetary control.

Let us turn now to studying the effect of endowment uncertainty. This was investigated with the second group of subjects, who had a different second treatment than group one. Here, subjects were exposed to randomly varying commodity endowments. Subjects were advised that their endowments would on average be 100 per period and that in any period this endowment (E_i) could fluctuate with a standard deviation of 10 units. In the experiment the endowments were selected such that there was no aggregate risk: that is, in any period the total endowment of *A*-goods and *B*-goods was 1,000 each. What can we expect to happen under these circumstances? Individually, in every period the rational agent should offer half of his good endowment (i.e., $E_i/2$). Moreover, expecting both prices to be one he should offer the same number of money units (also $E_i/2$) for the purchase of the other good. Therefore, given that the total endowments of goods do not fluctuate in the aggregate, nothing should change compared to the basic setup. However, it turns out the experimental evidence is at variance with this prediction. The data show that it takes time for subjects to adapt their behavior to the new environment. But once this adjustment has been made (about ten periods into the second run), the average sum of money offered for purchases is markedly lower in the stochastic environment as compared to the scenario with deterministic endowments. Hence, endowment risk appears to lead to a higher level of money balances not used up for transactions when—based on the assumption of rationality—we would not expect such extra (precautionary) money holdings. The counterpart of this effect can be seen in the course of the price level in the stochastic treatment. Figure 35.3 documents that the level of prices

Figure 35.3 **The Effect of Endowment Uncertainty on the Price Level**



tends to be lower with endowment uncertainty. Again with a view to policy making, this effect indicates that shifts in the equilibrium price level can occur for reasons not accounted for by models based on perfectly rational decision making. The experimental setup developed here has the potential for further interesting analyses that are, however, beyond the limits of this essay.

MONEY SUPPLY AND MONETARY POLICY

In the analysis of the money supply process economists have traditionally given much attention to institutional detail, particularly on the financial side of the economy (for surveys, see Brunner and Meltzer 1990; Modigliani and Papademos 1990). Clearly, the assumption of economizing (or optimizing) behavior on the side of owners of assets (i.e., households and firms) and banks has always been an important tool for the analysis of the money supply process and related policy questions. However, the notion of substantive (i.e., unlimited) rationality of economic agents is more controversial here than in many other parts of economics. There is a tension between researchers who, acknowledging the present limited insight into the interplay of rationality and institutional settings, prefer not to be overly specific about rationality and those who would rather have only models in which rationality of behavior can be fully and clearly assessed. This tension is sometimes framed as a controversy between macroeconomics and micro-based modeling. However, such an assessment is very questionable: anyone who examines, for example, Brunner's and Meltzer's or Modigliani's work on the subject will acknowledge that their behavioral functions relating monetary and financial variables to policy variables (such as reserves and interest rates) are based on microeconomic reasoning. Hence, this critique of macroeconomics has no basis.

On substantive issues Brunner and Meltzer (1993, 173–82) question the relevance of many micro-based rational expectations models with much the same arguments that behavioral economists find important: the neglect of the costs of information acquisition, information heterogeneity, and the assumption that agents have a full understanding of policy rules. Moreover, these authors are deeply skeptical with respect to Lucas's (1976) demand that all policy recommendations should be based on empirical estimates of time-invariant parameters of tastes and technology. As Brunner and Meltzer (1993) point out, there is no basis to the belief that economics has as yet identified (or will ever be able to identify) these time-invariant parameters. Hence, monetary policy advice will very likely continue to be based on models that rely on regularities that do not depend on the assumption of perfect rationality: negatively sloped demand curves, diminishing marginal productivity, and the relation of money to output and the price level. Besides these general remarks three issues will be discussed in more detail: (1) the choice of instruments of monetary policy, (2) the debate of rules versus discretion, and (3) the question of the socially optimal long-run level of inflation. All three of these themes have a long history in monetary economics (for surveys, see Friedman 1990; Fischer 1990).

The Choice of Instruments of Monetary Policy

The analysis of the choice of the instrument of monetary policy has been much advanced by Poole's (1970) approach of framing the question as an optimization problem. When monetary policy attempts to minimize the variance of output, it turns out that the optimal instrument of policy (control of either the money stock or of an interest rate) depends in simple forms of this type of analysis on the relative magnitude of the unexplained variability of money demand (i.e., the variance of the error term of the LM curve) and aggregate goods demand (i.e., the variance of the error term of the IS curve). This approach in itself (as Poole suggested) can be seen as based on limited knowledge (or we could say bounded rationality), particularly on the side of policy makers: the fact that there are unpredictable changes in key macroeconomic relationships implies that the analyst and hence the policy maker have imperfect knowledge of the economy. On a more specific level the identification of the conditions favoring one instrument over the other or suggesting the precise form of their optimal combination (such as an interest rate rule with feedback from money growth) depends on empirical estimates. As Fair (1988) has shown, this assessment depends on assumptions regarding the rationality of private sector decision makers. When a macroeconomic model for the United States is estimated to serve as the basis for the assessment of rules in Poole's sense, it turns out that imposing rational expectations results in estimates of variances and co-variances that tend to favor money stock targeting as the optimal rule of policy. When, however, the hypothesis of adaptive expectations is entertained (alongside the hypothesis of rational expectations) it turns out that expectations in some markets are indeed formed adaptively and that an interest rate rule is superior to a money supply rule.

Rules Versus Discretion in Monetary Policy

Kydland and Prescott (1977) provided a new analytical basis for the debate of rules versus discretion. Their case for rule-based monetary policy rests on the phenomenon of time-inconsistency of optimal plans. Given that the policy maker and the public both value low inflation and a smooth path for output, it would be optimal to choose steady and moderate money growth. If, however, there is a short-run output (and employment) gain from engineering surprise inflation, the policy maker will be systematically tempted to increase money growth given the public's inflation expectation. This inconsistency of motives—policy favoring low inflation but then, given low expected inflation, preferring an increase in money growth—will affect the public's inflation outlook. Expected inflation and hence also actual inflation will be higher compared to a situation where the policy maker could commit himself to low and steady money growth. This is the loss associated with discretionary policy, since no output gains will come from this elevated level of inflation. The balancing of short- and long-run gains by monetary policy makers (i.e., policy makers having their reputation at stake) may under certain conditions solve this inefficiency, as Barro and Gordon (1983) have pointed out. However, a clear commitment in the form of an institutional (and possibly constitutional) restriction will be more likely to eliminate the inflationary bias. This argument for rules over discretion in monetary policy is analytically derived from the assumption of rational expectations of the public. It will be interesting to see how this result holds up when boundedly rational (and heterogeneous) expectations are considered. Future macroeconomic models in the tradition of behavioral economics should explore more behavioral and institutional detail and benefit from assessments by policy-experienced researchers such as Blinder (1999) and Poole (2000). Furthermore, new research will likely be done on the question of whether targets (like inflation targets) and central bank independence are effective enough as tools to eliminate the described inflation bias. Here behavioral economics can add insights in many ways. For example, it is an open question whether policy targets much affect the public's short- and medium-run expectations when a broad range of behaviorally plausible expectations schemes outperform the policy targets in forecasting accuracy (see Rötheli 1999).

The Optimal Long-Run Rate of Inflation

The question of the optimal steady-state level of inflation is linked to issues of wage stickiness and money illusion, as discussed earlier. If in fact institutional and behavioral restrictions on wage setting weigh as heavily as some believe (such as Akerlof, Dickens, and Perry 1996, 2000), it would be beneficial to accept a moderate level of inflation (say, around 3 percent per year) instead of aiming at zero inflation. This position for moderate secular inflation could be summarized as follows: if workers are happy with increasing wages as long as inflation is moderate, and if they are willing to work harder, then pushing inflation to zero is wrong because it diminishes output and welfare. A number of researchers are skeptical of this analysis (see Crawford and Harrison 1997, Smith 2000, and the positions reported in Kopcke, Little, and Tootell 2004). These observers see the possibility of downward real wage adjustments even with close to zero inflation (e.g., by labor accepting a wage freeze for some years into the future) and judge the costs of inflation to be too high (notably because of intertemporal distortions and accounting costs).

Instead of aiming for a certain level of inflation, some researchers have argued that monetary policy should stabilize the *price level*. Recently, Ball, Mankiw, and Reis (2005) have renewed this claim within a model where at least some agents slowly absorb macroeconomic information. However, the case for a price level target depends critically on monetary policy's ability to control the price level. Scores of studies questioning the stability of money demand and experimental analysis of the type proposed previously cast doubt on this assumption. Moreover, after, for example, a rise in the price level due to an unforeseen decrease in money demand, holding to a price level target would necessitate a phase of deflation. The alarms that went off when only the possibility of negative U.S. inflation rates was considered in 2003 indicate that the dangers of deflation have to be taken seriously (see Kumar et al. 2003). From this perspective, it seems unrealistic to propose price level targeting as a rule for monetary policy given the perceived dangers of deflation.

CONCLUSION

This essay documents that monetary economics has both a behavioral tradition and a behavioral future. Bounded rationality plays an important role in understanding monetary phenomena, and it also affects the design of optimal monetary policy. In particular, deviations from rational expectations are important for understanding the size and the persistence of real effects of monetary policy. These insights are important, for example, when assessing the possibilities of monetary stabilization policies and the cost of reducing inflation. Deviations from rationality are also important with regard to the choice of monetary instruments and targets. Notably, behavioral economics adds doubts to the proposal that monetary policy should target the price level rather than the rate of inflation: too many behavioral determinants of the equilibrium price level remain insufficiently understood and beyond the control of policy makers.

Based on the work presented here, it is safe to assume that behaviorally enriched analysis of monetary issues will continue to yield significant insights. A subject that is particularly likely to see extensions and revisions of results is the issue of rules versus discretion in monetary policy. Here, the assumption of rationality of foresight has so far played a dominant role in research. On one hand, the analysis of behaviorally more realistic models may well weaken the case for strict rules; on the other hand, it may lead to the design of new guidelines for policy intervention. Beyond the selective issues discussed here, it is possible that behavioral monetary economics will even make fundamental contributions to economic theory. Who would deny that a monetized market economy greatly helps to efficiently allocate cognitive resources such as attention, memory, and the capacity for reasoning?

NOTES

I would like to thank Morris Altman, Sean Flynn, and Mathias Zurlinden for comments.

1. Simon 1983, e.g., shows no reference to monetary economics at all.
2. Kiyotaki and Wright (1989, 1992), among others, attempt a joining of these issues.
3. The optimality of a consumption plan may then just as well be ensured by equating the marginal utility of one tomato exchanged directly for any other good. In reality, transaction costs in tomato barter trades vary depending on which good tomatoes are traded against. Hence, assessing optimality by comparing "tomato utilities" necessitates comparing utilities resulting from the least-cost barter sequences leading to the acquisition of any consumption good.
4. Ritter (1995) shows that the need for the government to raise income (seigniorage) by printing money can theoretically provide the basis for rational agents to support the transition from barter to fiat money. The promise not to overissue money receives its credibility from the self-interest of the government to raise revenue. From a behavioral perspective it appears that limited foresight would be both more realistic (historically considering the many cases of hyperinflation) and more robust. Even boundedly rational central banks are likely to be able to launch a fiat money when dealing with boundedly rational private agents.
5. I cannot treat here in any detail the interesting issue of whether a competitive supply of money (i.e., a system of paper money without government intervention) is feasible and desirable. White (1999, ch. 12) reviews and discusses the role of rationality of expectations in the highly controversial field of free banking.
6. I will not cover in any detail effects of changes in second moments of the money supply. This means that we are not dealing with changes in monetary regimes that change the risk characteristics of an economy, as analyzed in the work of Lucas (1982) and Helpman and Razin (1982). This sort of analysis dealing with behavior toward risk may be particularly sensitive to rationality assumptions. Rötheli 1997 experimentally documents that the effects of exchange rate risk are at variance with normative theory based on substantive rationality.
7. Moreover, when a variation in the rate of change of the money supply leaves real variables (notably the real interest rate as the difference between the nominal interest rate and expected inflation) unchanged, we speak of superneutrality of money (see Sidrauski 1967).
8. Blinder (1994) is an attempt to investigate the reasons for price sluggishness by way of interviewing firms. Saint-Paul (2005) offers an explanation of how sluggish nominal price adjustment emerges evolutionarily given price setters with bounded rationality.
9. Whether behavior of workers as modeled in Akerlof, Dickens, and Perry 2000 qualifies as an illusion in the common usage of the word is questionable. If workers are happier with a situation with modest wage increases (compared to a situation with no or lower wage increases) even when they understand that inflation erodes their purchasing power, the term *illusion* seems misplaced.

10. In my view Hicks (1969, 1989) gives some of the clearest historical and theoretical justifications why monetary models should start with descriptions and assumptions regarding the use of money rather than trying to incorporate explanations for the use of money.

11. This does not preclude that in some of these models payments can be deferred and that there exists credit.

12. One can think of these markets as operated in trading (or transactions) posts. There, the goods supplied and the money amounts offered are deposited. Once the equilibrium prices are determined, goods and money are distributed to the respective recipients. Clearly, this setup also takes care of the solvency requirement. That is, it guarantees that all contracts are honored.

13. Ensuring that money has a value in the final period of the game is an important aspect of experimental analyses of money (see Duffy 1998).

14. Call x the expenses for goods purchased and y the number of goods offered for sale. In this case the per-period level of consumption is $C = \sqrt{(100-y)x} + (y-x)/2$ where the term $(y-x)/2$ is the value of the money balances exchanged into consumption goods at the end of the experiment. Optimizing consumption with respect to x and y leads to the condition $x + y = 100$. Hence, a strategy with $x = 50$ and $y = 50$ is just as good as one with $x = 0$ and $y = 100$, that is, a strategy where all endowments are sold and cash is accumulated to be exchanged for goods in the final period of the experiment.

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