WHAT HAVE WE LEARNED FROM EMPIRICAL TESTS OF THE MONETARY TRANSMISSION EFFECT?

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Abstract: The transmission effect of money has been a frequently debated issue. This paper discusses the empirical literature examining the effect of money on real output. In contrast to the commonly held belief that money has a powerful effect on output, most empirical tests of money shows relatively minor, but persistent effects. This is especially true for the extensive VAR literature. The paper focuses on the potential problems and issues that researchers have to account for when designing the empirical tests of the effects of monetary policy. Hopefully this paper will help in generating some discussion about the future direction of the empirical literature.

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1. Introduction

Most practicing economists believe that money has real effects on the economy. Therefore Wall Street economists, brokers, and foreign exchange traders are concerned when the Federal Reserve meet to discuss its monetary policy objectives. Thus people have readily accepted the idea that monetary policy affects the economy. However, academic economists are not in such an agreement about the effects of monetary policy changes.[1] Two questions are debated. The first is the transmission process of monetary policy. That is how does money actually translate to real effects. Here economists have come up with several appealing theoretical arguments that have been tested using empirical methodologies. Strong disagreement exists over the relevance and importance of each of these methodologies. Most of the theoretical arguments touch on some debated issues, where little agreement exists. For example, the interest rate channel involves the issue of liquidity effects, and the exchange rate channel involves the debate on what causes exchange rates to move. Therefore each one of the channels is associated with difficult empirical topics. However, due to the lack of precise data and problematic endogeneity questions, much disagreement still exists even after numerous tests of these theories.

A second question, that is debated among economists, is what the empirical regularities of a monetary policy effects are. These studies approach the problem from a different perspective. Instead of focusing on testing a particular theory, these studies capture the empirical regularities, and then compare them to what would be expected of theories. This approach avoids the direct tests and allows the empirical system of equations to find statistical regularities that may be consistent with the theoretical channels. The major debate herein is how to identify monetary policy. Most of the empirical work has been performed using exogenous monetary injections, and then tracing out the response of the economy to these monetary injections. Most of the exogenous monetary injection literature has been done using VAR or VECM models. Two

[1] For a more detailed discussion contrasting academic and practical economists' views see Friedman (1995).

major ways of identifying the shocks in these VAR models have been Choleski decompositions and structural VARs. Most studies of the transmission effects of monetary shocks have been done for the U.S., but more recently studies of other countries have been performed to verify the robustness of the results for the U.S.

To be able to discuss the effects of monetary policy changes one needs an exogenous policy variable. Unfortunately major disagreement still exists on how to define an exogenous monetary policy. Comparing competing theories cannot be accomplished until agreement exists on how to define an exogenous monetary shock. This also means that most of the direct tests of competing theories are subject to the criticism that they have not properly identified exogenous monetary policy changes. Some of this criticism has led to the use of the Romer and Romer (1989, 1990, 1994a, 1994b) "narrative" procedure for identifying shocks. This procedure involves dating monetary shocks by examining actual discussion by the central banks about when they actually intend to change policy. This alternative definition of an exogenous monetary policy results in stronger effects of monetary policy on output.

In contrast some economists argue that identifying policy shocks is a pointless exercise because a very small part of monetary policy constitutes action that can be labeled as a shock. Clarida, Gali and Gertler (1997), Rotemberg and Woodford (1997), and McCallum and Nelson (1997) measure U.S. policy shocks to be between 2-5% of the policy instrument changes since 1979. This means that a large majority of the fluctuations in the policy variables may be from systematic changes. Hence identifying the economy's response to a very small fraction of policy changes may be undesirable. Therefore one might argue that the empirical tests should emphasize the reaction of real variables to the systematic portion of the monetary policy changes. The problem with this approach is clearly how to extract a plausible time-series of shocks for a given policy reaction function.

The first part of this paper will briefly discuss the competing theories and a few empirical tests that have been performed to assess the importance of these theories. Then, we will continue

by examining the empirical modeling literature. As was just mentioned the empirical literature has a major VAR literature on how to identify shocks. The identification literature will briefly be discussed, but the focus will be on the discussion of the more recent criticism of the exogenous policy shocks. The VAR discussion will finish with an overview of the small open economy studies performed to verify the empirical regularities found in US data. Finally, we provide some concluding thoughts on some of the issues and concerns of the empirical literature on monetary transmission effects.

2. Types of Theoretical Transmission Channels

Economists have discussed many different varieties of transmission mechanisms of monetary shocks on real variables.[2] The following four have been some of the more commonly discussed channels, namely: the interest rate channel, the credit channel, the asset channel, exchange rate channel. These transmission mechanisms allow a change in the money supply to affect real output. In this section we will briefly discuss each one of the channels, and discuss some of the associated empirical tests. We will show that much disagreement exists concerning the relevance of each one of the theoretical channels, which has led to a search for empirical regularities.

2.1 The interest rate channel

The interest rate channel is the traditional interest rate increase associated with a real money supply decrease (or increase). The real money change causes a liquidity effect on nominal interest rates causing them to move in the opposite direction to the money supply change. Thus a tightening of the money supply would cause nominal interest rates to increase. By itself this should not result in any particular action unless nominal contracts are set so that they cannot

[2] The following discussion draws from Mishkin (1995, 1996).

avoid this increase. However, if we combine the nominal interest rate change with a model where prices are slow or costly to adjust, (e.g. see Taylor (1995)) then the liquidity effect results in a real interest rate increase, and thus a potential real effect on the economy.

(1) $M\downarrow \Rightarrow r\uparrow \Rightarrow I\downarrow$ and $C\downarrow \Rightarrow Y\downarrow$

where M, r, I, C, and Y are money supply, the real interest rate, investment, consumption, and real output, respectively. This real interest rate change results, in a world of only two assets namely: money and bonds, into a decrease in investment. The transmission mechanism crowds out the investment with the lowest expected returns. Clearly investment may here be considered in the broad sense as including housing and other durable consumer purchases. Thus the interest effect would here affect both aggregate investment and consumption as both are interest sensitive. The driving mechanism in the interest rate channel is the liquidity effect. The literature on liquidity effects has, however, found mixed evidence. Early studies, such as Cagan (1972), found some evidence of liquidity effects, using single-equation models. However, later work cast some doubt on the length of the size of the liquidity effect. Melvin (1983), for example, argued that the liquidity effect almost disappeared completely in the 70's. Some have even argued that monetary policy announcements have led to higher interest rates through increased inflationary announcements.[3] Recently the testing procedure of liquidity effects have turned to general equilibrium models and VAR models, but also here a lot of disagreement exists on the size of liquidity effects. For example, Bernanke and Mihov (1998) find evidence of sizable liquidity effects, whereas Christiano (1995) argues that much of these effects have disappeared in the 80's. Schlagenhauf and Wrase (1995) identify a liquidity effect in a small open economy model. Thus the literature has been inconclusive on the size and importance of the liquidity effects.

[3] For a review of the early literature see Cornell (1983).

The interest sensitivity of both investment and consumption has also been debated. Investment demand may not be highly sensitive to the cost of funds as much as the availability of funds (see Bernanke and Gertler, 1995). They argue that allowing for a variable external finance premium improves the explanatory power of monetary policies effect on durable goods spending. Cooley and Quadrini (1999) evaluate an economy where open market operations lead to interest rate movements due to changes in liquidity. In this model the liquidity mechanism works through a rigidity in the ability of the agents, in the general equilibrium model, to adjust their stock of deposits. The model is able to mimic that empirically observed persistent output effects, when both monetary shocks and real shocks are included in the model.

2.2 Credit channel

A related effect of a money supply change is the credit channel. Instead of viewing the effect as an aggregate effect from an interest change, this view argues that real quantity constraints on lending will affect investment and hence the economy. Two forms are common, namely: the bank lending channel and the balance sheet effect.

The balance sheet effect can be thought of as the case when a firm's balance sheet is reduced in net value due to the falling value of equity prices. As money supply is contracted agents need to spend less, and therefore lower the willingness to pay for equity. The decreased net worth causes the firm to reduce their net borrowing, thereby resulting in real effects.

(2) M$\downarrow$ $\Rightarrow$ $P_{equity}\downarrow$ $\Rightarrow$ adv. select. & moral hazard$\uparrow$ $\Rightarrow$ bank lending$\downarrow$ $\Rightarrow$ I$\downarrow$ $\Rightarrow$ Y$\downarrow$

As the price of equity falls the adverse selection problem increases and the moral hazard problem for firms increases. The latter means that firms are more likely to invest in risky projects if little of their own capital is invested. Here the largest effect will be on firms with weak or cash-poor

balance sheets. Thereby younger or expanding firms that are heavily indebted will be most affected.

The credit crunch literature is similar in that it also works through the bank lending channel.[4] This literature emphasizes the possibility that a reduction in bank reserves by the Central Bank reduces the banking systems' loanable funds. Assuming that firms cannot turn to close substitutes for loans this effect will again reduce the ability of firms to fund their investment.

(3) M↓ ⇨ bank deposits↓ ⇨ bank lending↓ ⇨ I↓ ⇨ Y↓

Due to asymmetric information and high monitoring costs banks will curtail their loans to certain small companies. Here the affected firms are going to be the ones that are small and regional, and therefore unable to enter the global markets for funds themselves. This channel is likely to be less important lately due to the decreased reliance on bank lending (see Bernanke and Gertler, 1995). Direct access to bond and stock markets have increased in the last few decades, and now even relatively small companies are quite successful at entering the stock market directly. Furthermore, loan bundling practices have increased giving small borrowers access to bond markets.

Empirical evidence is mixed on the credit channel. Early studies, such as Kashyap, Stein and Wilcox (1993) found some evidence of a credit channel effect on output. This relationship is confirmed by Hallsten (1999) for Swedish data. However, other studies have found the credit channel to be relatively unimportant. Fuerst (1995) and Fisher (1996) found real effects to be very small using US data. Yuan and Zimmermann (1999) finds monetary policy effects to be of

[4] The lending and credit crunch literature is highly related. The difference is primarily that the balance sheet or asset price effect is due to the reduction in value of the assets as the bond prices and asset prices are generally inversely correlated. Thus, the value of the firm is reduced as bond prices rise. In contrast the credit crunch idea is that marginal firms are crowded out as an insufficient availability of loans exist.

minor importance in a credit crunch model of Canada. However, they do find loan regulation to have substantial real effects. In a general equilibrium model of financial intermediation, Yuan and Zimmerman allow banks to screen applicants. This enables banks to choose less risky loans, in the model, when the Central Bank reduces the availability of credit by raising interest rates. However, a calibration exercise shows that this adjustment is relatively minor in its effect on the overall economy. In contrast when the loss/deposit ratio is changed, the response is substantial. Therefore the effect of financial authorities changing the credit availability has a minor effect, whereas the direct regulatory effect is major.

As the credit crunch and bank lending channels imply differential effects across industries or financial institutions, some researchers have tested the asymmetric responses across industries or firms to a monetary shock. Kashyap and Stein (1997), for example, examine the balance sheet data on U.S. banks between 1976-1993. They find that effects of monetary policy appear more pronounced in banks with less liquid balance sheets. This finding lends some credibility to the bank lending theories of transmission. This also points to a need for Central Banks to balance their goals of price stability and financial stability. Focusing only on price stability may have adverse effects on financial stability through the credit channel effects. Exploring the possible transmission effects through the credit channel should therefore be a priority for central banks where price stability has become the major goal.

In a similar study on bank balance sheets in Europe, Favero et al. (1999) find less support for any bank lending transmission. They study the monetary tightening episode of 1992 in France, Germany, Italy and Spain, but do not detect any significant change in the bank lending. The different findings of the above authors points to a need for further work in this area to determine if bank lending transmission is important in countries in general, or if the U.S. is an isolated case.

The view that differences exist across countries have been proposed by Cecchetti (1999) who argues that the legal and financial structure of countries lead to differences in the monetary policy impact. He argues that countries with a banking system consisting of predominantly many small banks, and a poor direct capital access show a greater sensitivity to policy changes than do countries with big healthy banks. This study then points to a bank lending effect existing in some countries with less substitutable assets, in other words less direct access to capital markets.

A different approach is to examine the industry sectoral responses to monetary shocks. Such a disaggregated approach has been taken by Dale and Haldane (1995) who examine the reponse of the UK personal and corporate sectors, and Gertler and Gilchrist (1994) in comparing the effect of monetary shocks to small and large US manufacturing firms. A detailed examination of the industrial response is done by Ganley and Salmon (1997). They estimate a VAR system for 24 industries. They found a wide divergence in the effect of a monetary policy shock to industries. Some of the industries with the highest response are also the ones with some of the lower concentration ratios.[5] This implies that these industries had several small industries that might be credit constrained, and hence a contracting money supply would have a large effect on these industries.

2.3 Asset Channels

Changes in money supply can also lead to direct effects that do not enter through the interest rate mechanism. Asset channels include models that allow other indirect effects of monetary policy in addition to the direct interest rate effects. These models do not focus on the constraint of credit rationing as the models of the credit channel do. Instead, the focus here is on the indirect effects

[5] This is, however, not true in general in the study. The third highest effect, among the manufacturing industries, was in the electric machinery industry with one of the highest concentration ratios.

that money supply changes can have on other variables, and the resulting effect that these other variables have on prices and output.

Meltzer (1995, 1999, 2000) provides examples of such additional channels that money supply changes can work through, in addition to the interest rate channel. Changes to the money supply alter, in Meltzer's view, "actual and anticipated prices on a variety of domestic and foreign assets. Intermediation, the term structure of interest rates, borrowing and lending, and exchange rates respond." (Meltzer, 1995, p.51). Meltzer's argument is that standard models focus exclusively on one interest as the channel of transmission, and such a focus is much too restrictive view of the potential channels. Clearly money supply effects will be much broader, and therefore could reach output in more ways.

(4) M⇣ ⇨ relative prices adjust, exchange rate value⇣, wealth⇣ ⇨ C⇣ and I⇣ ⇨ Y⇣

A variety of assets are affected, not only business investment. Furthermore the aggregate effects hide adjustments in relative prices. Thus bond and stock markets may be more quickly affected than durable goods markets due to the costly adjustment process. In addition, housing markets will be affected. For example, in Sweden the sharp contraction of money supply to keep the Krona linked to the ECU in 1991, led to a sharp decrease in house prices and commercial real estate.[6]

In Meltzer (1999) the argument for other channels is summarized by the discussion surrounding a potential liquidity trap for Japan. An increase in money supply ought to have a very limited effect on output, with interest rates near zero, if interest rates were the only form of transmission. But, if the Japanese central bank increases money supply by 50% by buying U.S. dollars, would there be no effect? Clearly the exchange rate mechanism can be an alternative

[6] The sharp fall in housing prices was also likely exacerbated by the concurrent deregulation of housing and changes to the taxation system in Sweden.

mechanism. Furthermore, according to Meltzer, monetary impulses have real effects even in countries without central banks. Relative prices can respond to an increase in the monetary unit even if organized financial markets, where interest rates are determined, do not exist. Therefore the mechanism may not be through the interest rate, but the direct effect from an increase in real balances.

Koenig (1990) finds some support for the argument that other sources are more important for the transmission mechanism. Koenig finds a strong effect of real balances on changes in consumption spending, but finds a minor effect of interest rates on consumption. These findings are explained, in Koenig's model, by households timing their consumption so that it is increased in times when households have large holdings of liquid assets. Thus the marginal utility of consumption increases as real balances increase.

Another example of an indirect mechanism that affects real output is an expectations channel.[7] Here agents view the future movements in money as tighter or looser, and adjust their valuation of assets in response to these future expectations.

(5) $M^e\downarrow \Rightarrow P_{equity}\downarrow, \Rightarrow$ wealth$\downarrow \Rightarrow C\downarrow$ and $I\downarrow \Rightarrow Y\downarrow$

Thus an expectation that the central bank will tighten money supply leads to a fall in the prices of stocks today, and thus a reduction in wealth holdings by consumers and businesses. Consumers will reduce their purchases, and businesses will reduce their capital goods purchases. Therefore, according to the model, output will fall and wealth is reduced. The difference in this asset channel is that money supply doesn't even have to change. A threat of a change may be sufficient.

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[7] Not much explicit reference to this channel exists, but many discussions imply an expectations channel of monetary transmission. One recent discussion of the expectations channel can be found in a discussion paper by the monetary policy committee of the Bank of England (1999).

2.4 Exchange rate channel

The final mechanism is the exchange rate mechanism. Here the effect of the tighter money translates to a stronger domestic currency. There are two processes that could lead to a stronger currency. Tighter money might lead to an increased real interest rate causing capital flows to increase the value of the domestic currency. The higher value of the domestic currency causes import prices to fall and export prices to rise, resulting in a net trade balance deterioration. The increased competition from imports, and fall in exports cause a slowdown in output.

(6) $M\downarrow \Rightarrow i\uparrow \Rightarrow E\uparrow \Rightarrow P^{FC}_{X}\uparrow, P_{M}\downarrow \Rightarrow X\downarrow \;, \; M\uparrow \Rightarrow Y\downarrow$

Where E represents the foreign currency value of the domestic currency, and P^{FC}_{X} and P_M represent the foreign currency price of exports and the import price, respectively. The alternative exchange rate transmission can be seen as:

(7) $M\downarrow \Rightarrow \pi^{e}\downarrow \Rightarrow E\uparrow \Rightarrow P^{FC}_{X}\uparrow, P_{M}\downarrow \Rightarrow X\downarrow \;, \; M\uparrow \Rightarrow Y\downarrow$

In comparison to the prior transmission mechanisms, this framework does not emphasize interest rates as the key transmission variable that causes exchange rates to fluctuate. Instead the movement is directly from the decrease in the inflationary expectations. However, the final effect on output is the same. The effect of this channel is primarily on the exportable industry, especially in markets with high price elasticities, and indirectly on the input supplying industries of those exportable industries. Therefore one should be able to detect a differential effect on industries that are sensitive to foreign competition versus those that are subject only to local competition. As output is likely to be slow to adjust due to contracting and lags in procurement,

it may be hard to detect these differences in practice. However, asset prices of the affected companies ought to reflect these differential impacts at an early stage. Thus one could envision an immediate reaction in stock prices, to an inflationary environment in open economies in the industries that produce tradeables, followed by a more favorable competitive climate for the tradeable industries. This output effect could be detected as a differential response to a monetary injection by the local industry as compared to the tradeable industry, or if these effects are too confused in the lag structure, one might be able to detect them from the stock price movements.

The empirical tests of this channel is linked to the Monetary Approach to the Exchange Rate (MAER) literature. In this literature exchange rates respond primarily to money supply and demand shocks. If support exist for such a theory then the above exchange rate channel might be important. Unfortunately most empirical evidence is fairly weak as far as the money to exchange rate effect. Meese and Rogoff (1983) showed that in a forecasting equation based on the MAER even the inclusion of the true future values of the independent variables did not lead to any improvement in forecasts. This implies that the MAER does not provide any additional information to the trader, and a pure random walk appears to be the best alternative. Due to the stochastic nature of the variables, included in the MAER, this approach has been frequently tested in recent years. Few have provided any strong support for any relationship. Chinn and Meese (1995) did find some usefulness of the MAER in long-run forecast in an update of the early Meese and Rogoff paper using cointegration analysis. Extending the methodological framework, Flaherty et al. (1999) use a threshold cointegration model to find some support for the MAER. However, in both of these latter two papers the support is only marginal and over a long period. Therefore positive monetary shocks will on *average* lead to exchange rates depreciating, but this effect may be swamped in the short-run by other movements.

3. Empirical Regularities

Most of the test procedure on individual theories have had mixed results. Part of the concern, for many of those studies, is the reduced form estimation methodology used. Results from reduced form models were often misleading because of the missing feedback from other equations. Because of such concerns the econometric methodology turned to VAR and VECM type models, and attempted to minimize the number of theoretical restrictions to allow for a wide variety of potential transmission effects. However, identification was necessary also in these types of models, so that the response to an exogenous monetary shock could be estimated. In this section we will discuss two general types of identification. The focus on estimating responses to monetary shocks has recently been questioned. Instead, some authors argue, that expected monetary policy may also have transmission effects. This issue is also discussed in this section. Finally, some cross-country studies will be examined to investigate whether the results hold only for the US or generalize to other countries in the world.

3.1 Identification through time series methodology

Identification of the monetary policy shock has been done in two general ways, namely: time-series methodologies and the "narrative" approach. The time series technique is considered a more objective way in that it is based on pre-specified statistical regularities. The narrative approach, discussed later, depends on the interpretation of the economist as someone has to interpret the central bank action to determine whether a shock has occurred. In this case the definition itself can be subjective because the rules have to be determined during the hypothesis testing. Therefore the rules of identification may be modified to reach a desired outcome in the data. Clearly, this can also happen in the time-series approach, if economists are imposing subjective restrictions on the data interaction that would lead to pre-determined outcomes.

Two general ways of using time series methodologies have been developed. The first is a Choleski decomposition in a VAR system, and the second is the use of a structural VAR

approach. Both require some form of modeling strategy on behalf of the economist, and thus neither is purely "atheoretical."

To test a model one needs to have a benchmark to use for comparison of the model behavior. As discussed in Christiano, et al. (1998) the methodology involves three steps: first, identifying the monetary policy shock, then observing the real world data response to such a shock, and finally comparing this result with an artificial model's behavior. Note that this appears general, but it does involve one subtle restriction. The whole experiment will only deal with exogenous shocks and therefore not allow systematic policy changes to affect the economy. We discuss this possibility further below. Essentially the idea is that the central bank follows some function such as:

$$(8) \qquad x_t = f(\Sigma\Psi_{t-1}) + v_t \quad ,$$

where, x_t is the monetary policy variable of the central bank (e.g. interest rate or aggregate money measure), $\Sigma\Psi_{t-1}$ is the response function of monetary policy or the feedback rule of the central bank, and the v_t is the money shock. If one can appropriately identify the response function of monetary policy, then one could isolate the v_t.[8] If such a shock could be identified what is the interpretation of such a shock? Three possible interpretations are:

1. Exogenous shocks to the preferences of the central bank.
2. Shocks to agents' expectations of monetary policy that the central bank adopts. See Chari, Christiano and Eichenbaum (1997).
3. Responses to mismeasurements in preliminary data announcements as in Bernanke and Mihov (1995).

[8] Actually that is not a sufficient criterion for isolating an exogenous monetary policy. Correlated measurement errors could lead to estimated v(t) that are not orthogonal to the policy feedback rule. See Christiano, et al. (1998) for a discussion of this.

It may be questioned whether such exogenous shocks have much importance for the day-to-day activity of the central bank. All of the above interpretations have limited occurrence or importance for a central bank. In other words if the central bank is responding mostly to inflationary targets, and adjusts its monetary policy according to this reaction function then it would be a fairly rare occurrence that it alters its response function. Therefore most of the activity by the central bank may be left out of the test procedure.

To estimate the exogenous shock one can think of four ways of identifying v_t. First one could identify the information set of the central bank and estimate a residual to a linear (or potentially nonlinear) regression of the monetary policy variable on the feedback rule. A variation on this could be done by having different ways of identifying the shock through restrictions on the covariance matrix in the VAR. Second, one could observe data that signals the exogenous shock. Romer and Romer (1989) and Bagliano et al. (1999) follow this approach. The third approach relies on all changes in a policy instrument being innovations. This approach was pursued in Cooley and Hansen (1997), and Christiano and Eichenbaum (1995) by using the movement in money aggregate as an indicator of monetary policy.[9] The final strategy is to constrain the effect of monetary policy. For example, Faust and Leeper (1997) and Pagan and Robertson (1995) argue that the long run effect of monetary policy should be superneutral, and they use this condition to identify policy.

The most common type of identification methodology is to use a Choleski decomposition. Such an identification rests on the contemporaneous responsiveness of monetary policy to economic variables. For example, by ordering the monetary policy variable last in the order, one assumes that the monetary authority observes the movements in the other variables immediately, but the response of other variables is restricted to be lagged a period. After the contemporaneous period is over the response is again unrestricted. This type of decomposition

[9] Also Rudebusch (1996) assumes all movements in the federal funds rate to indicate monetary policy movements.

can be extended to a block-Choleski type of decomposition as in Christiano et al. (1998). Thus the disturbance term becomes orthogonal to the information set, and thus to the monetary authority's reaction function. For example, in Christiano et al., the benchmark model has current and four lagged values of output, prices and a commodity price as well as four lagged values of the Federal Funds rate, non-borrowed reserves, total reserves and M1. The monetary policy instrument is either the Federal Funds rate or the non-borrowed reserves depending on which model is reported. In this set-up the current values of GDP and two price indices are seen by the policy maker, but are not affected by the policy contemporaneously. This order implies that the policy maker assumes that policy shocks only affect real variables with at least a one period lag. This ordering identifies an exogenous monetary policy measure under the set of restrictions of the ordering. This type of identification scheme leads to estimates of output effects that initially fall and display humped-backed responses over time, for several different policy measures. Furthermore, aggregate price effects are minor in this type of model.

The impulses that are estimated are very noisy. Thus it is not too surprising that a small effect of money on output is found. For example, Christiano, et al. (1998) shows two models, one with non-borrowed reserves as the indicator of monetary policy, and the other with the Federal Funds rate as the policy indicator. The unexplained innovation to the policy, in each model, is compared against the recessions in the U.S. during the 1965:3-1995:2 period. According to Christiano et al. "… policy was relatively tight before each recession, and become easier around the time of the trough" (1998, p. 19). In his figures, most of the recessions appear to be preceded by values above zero, but one can also see many other instances of positive values without any recession. In three of the five recessions, the trough is followed by a loosening of monetary policy. However, in the 1980 and 1991 recessions one cannot observe such a loosening. Furthermore, substantial loosening also occurred in other periods that do not follow troughs, such as 1973 and mid-80's. Thus the statement that policy eased following a trough is only partially

supported by the research. One noticeable fact from this type of research is the large variability of the monetary policy shock. If each spike constitutes a policy change, then the Federal Reserve appears to continuously change its monetary policy. Such noisy estimates of monetary policy innovations would be unlikely to correlate well with changes in output. Therefore it is important to establish whether the estimated changes are indeed capturing the policy innovations, before one can make any conclusion about the effect of such innovations.

Structural VAR models are another way to identify the monetary shock to the system. For example Leeper, Sims and Zha (1996) discuss how one can identify the monetary policy shocks by placing enough "economic" restrictions on the VAR model. The definition of "economic" is important here. "Economic" restrictions are defined as a set of structural restrictions that are set to be broadly consistent with economic theory and provide sensible outcomes. Of course, given the fact that the econometric model does not come directly from a macroeconomic model causes some concern. It is therefore important that the restrictions are well specified and that they are clearly consistent with commonly accepted models. Otherwise it may be tempting for the econometrician to pick constraints that induces responses that are desired.[10] Some restrictions will be more innocuous than others. For example, long run money super-neutrality, and the condition that prices move slower than interest rates are commonly accepted restrictions. Both restrictions can be generated from theoretical models.

3.2 Identification through the narrative approach

The difficult part of the Choleski decomposition, or the structural methodology for identifying monetary policy shocks is that those approaches require the researcher to take a stand on the Central Bank's monetary policy reaction function. An alternative approach that promises to

[10] This is the sense that the econometrician can introduce subjectivity into the analysis. Constraints need to be clearly shown, so that the reader is aware of possible influences by these constraints.

isolate the monetary policy shock without needing to explicitly identify such a reaction function is the narrative approach[11]. Romer and Romer (1989) were first to use such an identification scheme to create a monetary shock variable that could be used in testing framework. Instead of using a time-series methodology to identify the exogenous monetary policy shock, they identified the shock based on their interpretation of Federal Reserve documents. Reading these documents enabled them to create a dummy variable that identified the contraction of monetary policy. A policy change was defined as each time that the Federal Reserve "specifically intended to use the tools it had available to attempt to create a recession to cure inflation" (Romer and Romer, 1989, p. 134). Thus the Romer and Romer variable was one-sided in that it only identified shifts designed to reduce inflation. This measure indicated a strong effect of money on real output in papers such as Romer and Romer (1990, 1994a, 1994b) and Kashyap et al. (1993).

Recently, however, some have questioned if the narrative approach leads to a truly exogenous measure of monetary policy. Leeper (1997) shows that in fact the dummy variable appears to be predictable using variables at the Federal Reserve's disposal at time t-1. This casts some doubt on the assumption that the policy variable is exogenous, and the findings of strong persistent output effects from the narrative monetary policy.

An interesting recent extension of Romer and Romer's work is a paper by Bagliano et al. (1999). This paper attempts to extend the narrative approach to an open economy, in this case Germany. An open economy extension seems trivial, but it involves a complication in that the identification of monetary policy in interest movements becomes more difficult due to the simultaneity problem of the exchange rate and interest rate. Thus the Choleski type ordering done in other papers becomes suspect when one has to order the interest rate and exchange rate equations so that either exchange rates are unaffected by contemporaneous interest rate

[11] Of course this approach requires that the researcher is able to identify accurately when the Central Bank actually intends to change policy, and when it is just responding to market conditions. Thus implicitly the researcher must have some particular reaction function in mind for the Central Bank to disentangle the shock from a policy response.

movements, or interest rates are unaffected by contemporaneous exchange rate movements. Neither case would be realistic.

Bagliano et al. resolve this issue by identifying monetary policy as the "unexpected change in the very short term interest rate occurring at 'special' dates" (Bagliano et al., 1999, p.10). These dates are picked analogously to the Romer and Romer methodology. The Bundesbank Council meets every two weeks, and by reading the publicly available minutes the authors can identify the dates when a relevant monetary policy shift took place. Bagliano et al. then proceed to estimate the unexpected component of the change in the interest rate, in contrast to the dummy variable approach used by Romer and Romer.[12]

Romer and Romer's approach has a serious limitation in the way it is constructed. By identifying each contractionary policy by the Federal Reserve as a zero-one dummy variable, the result becomes a substantial endogenous component as shown by Leeper (1997). Intuitively that is to be expected. The Fed obviously does not act in a vacuum, and market participants have full-time "Fed-watchers" that attempt to react before the announcement takes place. When the FOMC meeting takes place the sentiment of the meeting may be described as a "trying to shift aggregate demand inwards" using Romer and Romer's terminology. If so then one would record a 1 for this date onwards. But part of that tightening, or perhaps the whole tightening might already be expected, therefore the effect might have already been realized.

Skinner and Zettelmeyer (1996) and Rudebusch (1996) attempt to extend the Romer and Romer dummy variable approach. Skinner and Zettelmeyer (1996) replace the use of a dummy variable with a change in the three-month interest rate. However, this approach may also be criticized for not creating an exogenous measure. Rudebusch (1996) creates an unexpected change in interest rates from the 30-day Fed funds future contracts. Clearly this measure will

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[12] Boschen and Mills (1991) extend the Romer and Romer (1989) monetary policy index by refining the dummy variable to be of a scale from –2 to 2 with unit increments. Thus a +2 would indicate a loose monetary policy relative to a score of 0 or +1.

include all unanticipated changes in the Federal Funds rate, not only the policy changes, so Rudebusch has to find the policy effect by finding an orthogonal measure to news about employment. Two drawbacks with this approach are that the future market has only existed since 1988, and this estimate measures all unexpected movement in interest rates not only such that are associated with the Federal Reserve announcements.[13]

Bagliano et al. extend the dating procedure of Romer and Romer by estimating the unexpected component using a methodology by Svensson (1994) and Söderlind and Svensson (1997). This methodology compares the fitted yield curve of the forward market preceding the change in the monetary stance with the spot yield curve after the change took place. Assuming no other announcement effects caused the change in the yield curve one can then estimate the unexpected monetary policy effect by the difference in the two yield curves. Bagliano et al. do not attempt to distinguish between dates, but instead estimate the change for every time the Bundesbank Council met. To be more Romeresque one would need to evaluate the minutes and decide on contractionary or expansionary decisions.

Bagliano et al. proceed to introduce the measured monetary policy variable as an exogenous variable in the VAR system, but leaving both the interest rate and exchange rate variables in the VAR, with a Choleski ordering with interest rates last. The intuition is to capture monetary policy effects on the exchange rates, while preserving the potential effect of exchange rates on interest rates. The results indicate that interest rates and exchange rates have a very limited simultaneity, and that for Germany this simultaneity need not be dealt with. The results show a very minor effect of the exogenous monetary policy measure on output, and on the other variables in the VAR. This indicates that either monetary policy shocks are unable to affect the major variables in Germany, or the money measure is not as accurate as one would want.

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[13] In Christiano et al. (1998) they use the Rudebusch (1996) measure, instead of the Federal Funds rate in a VAR model and find very similar responses to output and prices.

Another interesting approach to measuring policy shocks has been done by Jansson and Vredin (2000). Here, policy shocks are defined as the difference between the interest rate movements expected in a benchmark forecasting equation by the staff at the Riksbank, and the actual rate. The advantage with this approach is that the exact information set that was available at the time of the forecast can be used, instead of trying to create the timing of when the data became available.[14] This is a particularly interesting measure to answer the question of whether the policy that was used could have been improved upon.

3.3 Systematic and nonsystematic policy

In the above identification literature, the idea is to find a monetary injection that is exogenous, and measure its effect on output. However, a very small part of central bank policy may be captured by such a monetary shock. Instead, some authors argue, the more relevant effect comes from the systematic part of monetary policy. McCallum (1999), for example, points out that it is quite conceivable that policy behavior is completely dominated by the systematic portion. Clarida, Gali and Gertler (1997) estimate that the Bundesbank, Bank of Japan and the Federal Reserves's reaction function shows the fraction of the interest-instrument variability that is unexplained to be 1.9, 3.0 and 1.6%, respectively.[15] The reaction function is not particularly complex. For example, for Bank of Japan and the Bundesbank the reaction function includes: the consumer price index to measure inflation, industrial production, and a lagged inter-bank lending rate. The reaction function for the US is:

[14] See Orphanides (2000) for a description of how substantial the difference in policy response can be between using announced preliminary data and final data.

[15] The fractions are not reported in the paper by Clarida et al. (1997), instead the values have been provided directly by Clarida to McCallum (1999) and are reported there. Similar small numbers of unexplained instrument variability is found in Rotemberg and Woodford (1997) and McCallum and Nelson (1997).

$$(9) \qquad r_t = (1-\rho_1 - \rho_2)(\alpha + \beta \pi_{t+n} + \gamma \Psi_t) + \rho_1 r_{t-1} + \rho_2 r_{t-2} + \varepsilon_t \quad ,$$

where π, Ψ, r are the inflation rate, output gap away from the target, and the interest rate, respectively. McCallum argues that with such a small fraction of movements left in the residual variance relative to the inter-bank interest rate variance then this would imply that most of the policy responses are systematic adjustments.[16] Note that this assumes that the variance of the interest rate is, in general, due to the Central Bank activities. This might be questionable if one examines the tremendous daily volatility in these rates without any Central Bank action. Furthermore, the percentage attributable to the shock of monetary policy would be low in the case of an interest rate smoothing policy on the part of the Central Bank. If the interest rate is monitored, and the goal is to stabilize the variability of the interest rate, then by definition variability would be low. In such a case the interest rate measure would be an inappropriate measure of monetary policy shocks.

The point McCallum is trying to make is that, for example, if the Federal Reserve decides to raise interest rates 50 basis points in response to a perceived increase in future inflation, then this should be counted as a systematic policy. Therefore, McCallum argues, the emphasis of the estimation literature has been focused in the wrong direction. It is not surprising, to McCallum, that the major finding in the literature is that monetary shocks have minor effects on output due to the minor size of the shocks. Instead McCallum estimates a small-scale structural model where one can observe a link between the policy choice of the central bank and the variability of output from the natural rate. Thus the response function by the central bank leads to the response of output. McCallum shows that if we resort to a structural model, rather than a VAR, we find substantial effects of monetary policy feedback adjustments. For example, a stronger feedback to inflation rate discrepancies from the desired inflation leads to an increasing variability of output

[16] The inter-bank interest rate used for Germany is the "Day-to-Day" rate, the Federal Funds rate for the US, and the Call-Money rate for Japan.

away from the full employment level. Clearly the shortcoming of such a methodological approach is the need to rely on a structural model as the accurate representation of the economy.[17]

Another question that comes to mind is if the interpretation of McCallum is consistent with the definition of systematic policy. In a sense this kind of changing feedback is exactly what a shock would be. In other words if the Federal Reserve decides to increase the discount rate by 50 basis points because it is more sensitive to the inflation divergence than earlier, then a shift in policy has taken place and we would record this as a shock.

Some VAR models find prolonged, persistent and sometimes large effects of money shocks on output. Most of the literature on VARs has dealt with how to identify the monetary shock appropriately, but Cochrane (1998) points out that the VAR literature does not discuss the fact that a VAR system estimated the policy shocks only in the case where a shock is followed by the customary further policy actions. In other words the effect of a shock may be minor, but the subsequent policy changes in response to the shock and its effect on output might amplify the initial shock. Thus the economy has an initial shock that is propagated by subsequent policy behavior that prolongs and augments the shock. For this to be the case there has to be some effect of anticipated policy shocks. Cochrane (1998) shows that this may indeed be likely.

Cochrane (1998) shows that a standard response to a monetary policy shock seems to last a long time. A shock to M2 leads to a prolonged hump-shaped response, with a long-run return to zero.[18] However, at the same time a prolonged effect of the initial shock takes place on the future M2. If anticipated money shocks do matter then it may be the case that the initial money shock has a small and short-lived effect, but the monetary shock is normally associated with an

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[17] Of course one could argue that this criticism is true for economic models in general, and therefore it is not a relevant criticism of this type of research.

[18] This long-run response is sometimes a result of the model, or is assumed as an identifying assumption. Although tests of long-run neutrality have led to mixed results, it is still a maintained assumption in most of the literature. See Bernanke and Mihov (1998) for a discussion of the long-run neutrality tests.

endogenous response leading to higher future money supply growth that is translated into further growth in the output.

How could anticipated policies matter? For example in Romer and Romer (1994a) systematic policy matters. Similarly in McCallum (1999) anticipated policies matter. Furthermore these views can also be seen in models such as: overlapping contract models (Taylor, 1979), sticky price models (Blanchard, 1990), or recently in cash-in-advance models with adjustment costs (Christiano and Eichenbaum 1992, 1995).

Take, for example, a simple model as in Cochrane (1998).[19]

$$(10) \qquad Y_t = a^*(L)[\lambda m_t + (1-\lambda)(m_t - E_t m_t)] + b^*(L)\,\delta_\tau .$$

Asterisks on a*(L) denote structural lag polynomials, and λ is a prespecified parameter that varies between 0 and 1. The last part of the equation, $b^*(L)\,\delta_\tau$, captures the non-monetary output disturbances. As $\lambda \blacklozenge 0$ this model specifies that only unanticipated money matters. As $\lambda \blacklozenge 1$ there is no difference between anticipated and unanticipated money. Thus setting $\lambda = 0$ turns the model into a straightforward shock type model.

$$(11) \qquad Y_t = a^*(L)[m_t - E_t m_t] + b^*(L)\,\delta_\tau .$$

Whereas setting $\lambda = 1$ turns it into a model where no distinction is made between anticipated and unanticipated money, so that

$$(12) \qquad Y_t = a^*(L)\, m_t + b^*(L)\,\delta_\tau .$$

[19] Cochrane also shows a more elaborate version of this type of model that is a sticky price version, showing that such a model has the same features as this model.

Cochrane examines a VAR after all orthogonalization assumptions have been imposed. In his experiment one can observe the different responses to a monetary shock for different values of λ. In the first period all models have the same effect, but then they depart dramatically. The simple unanticipated model results in a standard hump-shaped response that is prolonged. However, if one allows anticipated money to have an effect, the immediate response is much smaller and returns to zero quickly. Note that a very small anticipated effect has a substantial effect on the shape of the response. Thus, even if λ is set to only 0.2, a sharply different effect occurs from identifying the model using only unanticipated effects. This experiment highlights the question of what happens when the central bank shocks money and then follows a different pattern from normal.

An analogous approach, to Cochrane (1998), has been taken by Sims (1999) who performs an interesting experiment on the policy function. Instead of replacing the reaction path of money with a different one as in Cochrane, Sims switches the policy reaction function and the monetary shocks between two time periods perceived as dramatically different. Sims shows that when monetary policy is switched between time periods a very minor effect on output is noticed. This, Sims argues, indicates that monetary policy may be ineffective.

Sims sets up a VAR with the standard variables plus some additional money stock variables: industrial production, consumer price index, currency in circulation, currency plus demand deposits, Federal Reserve discount rate, and a commodity price index. To identify the policy shocks Sims uses behavioral reasoning to add sufficient restrictions. He compares the results for the U.S. for the 1948-97, and the 1919-1939 periods. Examining the response to a policy shock Sims finds a similar hump-shaped response of output for both the 1948-97 and 1919-1939 periods. So similarly to earlier models Sims finds money to have a prolonged effect

on output. However, the total effect of money explains very little of the forecast variance of industrial production, indicating a relatively minor total effect.

Although the case for monetary policy seems weak here, it may not have such a small effect. The only response that this type of test will have is the possibility that unexplained shocks to the money equation will influence output. But systematic policy could have been the source of the sharp difference in the two periods. Most economists would argue that the response by the Federal Reserve was incorrect in the Great Depression, implying that the systematic policy was incorrect. Sims tests this directly by switching the policy response functions between the two periods. The policy equation estimated in the inter-war period is replaced with the post-war equation. The results indicate that this replacement has a relatively minor effect on inter-war output. Thus the policy function appears to explain very little of the slowdown in the inter-war period. The reverse experiment, replacing the estimated post-war function with the inter-war policy function also has a minor impact on the post-war growth of industrial output.

Some might argue that this experiment is flawed in that it doesn't satisfy the Lucas critique. The Lucas critique states that in cases where structural models do not identify "deep" parameters, then unprecedented values of variables should not be introduced into estimated equations. The reason is that the system has not been conditioned to such data, and the estimated relationship could be different if such data had been used. Here, Sims introduced a monetary policy equation that was conditioned on very different data, and thus the experiment fails the Lucas critique. However, the expected outcome is then that something very strange happens. For example one would expect that if we condition a demand function on prices of $1-$2, and then we introduce a price of $50 then we might see negative purchases. But the findings by Sims are the opposite. We see very small changes indicating that either these policy functions are not so different, or that the effect of monetary policy on output is minimal.

Another interesting study on systematic policy has been done by Orphanides (2000). He shows that a Taylor (1998) rule is ineffective in stabilizing the U.S. economy due to the large

errors in real-time and final data. The Taylor rule sets the policy instrument, in this case the interest rate, according to how much some policy objectives deviate from the desired levels. Thus:

$$(13) \qquad R_t - R^*_t = \gamma(\pi_\tau - \pi^*) + \delta(y_t - y^*_t) \qquad ,$$

where R, π, y, are the real interest rate, inflation and output, and * denotes the desired target. Using a small VAR model of the above three variables Orphanides identifies the model by assuming that output is not influenced contemporaneously by inflation or the Funds rate, and the Federal Funds rate influences inflation contemporaneously. Thus the Choleski ordering is output, inflation, and Federal Funds rate. Using this system Orphanides shows that by replacing the estimated policy in the system by a Taylor rule would lead to a dramatic improvement in output and inflation. The Taylor rule would lead to a dramatically lower inflation during the 70s, although the oil-price shock is felt even in this case. Furthermore, the deep recession of the early 80s would be avoided. So replacing the historical policy with a different policy appears to have a major effect in this model. However, Orphanides goes on to argue that this policy effect would be unattainable in practice due to a sharp contrast in real-time and final data. This error causes enough of an effect to make the policy inoperable in practice, and given the real-time errors, inflation would have been substantially above the actual value in the 80s.[20]

3.4 Country studies of monetary policy effects

Most of the studies have focused on the US, but recently the literature has been permeated with studies from all around the world. Most country studies use a version of a structural VAR model,

[20] The lack of an inflation slowdown would also have led to a lessening of the 1982 recession. Therefore the output time series, using the Taylor rule, appears smoother then the actual. See Orphanides (2000).

but with the addition of an exchange rate variable. The countries in question are most often small open economies. These are sensitive to exchange rate movements. Due to the simultaneous nature of the movements between interest rates and exchange rates, a simple Choleski ordering is insufficient to identify monetary shocks. Therefore most authors have resorted to structural VAR models. For example, Brischetto and Voss (1999) examine the monetary transmission in Australia using a structural VAR model. The structural restrictions are a mixture of: implications from theoretical modeling, timing of response, and priors due to the small size of the Australian economy compared to the world economy. This latter restriction is quite powerful and allows one to either restrict the contemporaneous feedback, or completely zero out the feedback at all lags as in Cushman and Zha's (1997) study of the Canadian economy. Completely constraining the feedback is useful in that it not only helps identifying the monetary innovation, but it also improves precision in that fewer unknowns need to be estimated. In the Brischetto and Voss paper the degrees of freedom problem becomes a serious concern. Although they estimate a relatively small seven-variable VAR with six lags, they only have data from 1980:q1-1998:q4. They find that monetary shocks have a small temporary effect on output. Cushman and Zha (1997) also find small temporary output effects for the Canadian economy. In their study the traditional VAR system with exchange rates is augmented by imports and exports. In their study the feedback effects are zeroed out for all lags from Canadian to U.S. variables to save degrees of freedom. Thus the U.S. is considered the world whereas Canada is a small open economy that does not affect world variables.

Smets (1997) estimates a small four-variable VAR for France, Germany and Italy. The identification scheme follows Bernanke and Mihov (1995), but their approach is extended by allowing a reaction function of monetary policy to exchange rates adjustments. The policy shock becomes:

(14) $\varepsilon_t = (1-\alpha)\upsilon_t + \alpha v_t$,

where ε_t , υ_t , v_t are the policy shocks, shock to interest rates, and shock to exchange rates, respectively. The α parameter captures the degree to which the central bank responds to interest rate versus exchange rate shocks. If $\alpha = 0$ then the central bank is interest targeting, whereas setting the parameter equal to one leads to exchange rate targeting. Clearly a similar setup can be used for other trade-offs such as inflation targeting versus exchange rate targeting. The α parameter is an unknown and therefore Smets first estimates the above equation using a GMM methodology, and then uses the estimates in the VAR calculation. France and Italy end up with logical estimates, whereas Germany's estimates are above unity.[21] In accordance with other results Smets' finds small output effects of a monetary injection. Similarly, in a benchmark analysis of the Swedish economy Jacobson et al. (1999) finds small temporary oscillating output effects of domestic nominal shocks. This study develops cointegration restrictions to identify the shocks that affect the variables in the VECM. The analysis shows that one can develop a benchmark model that allows the economist to answer several questions within the same broad framework. In contrast to most others Gaiotti (1999) finds a more substantial response of output to a monetary shock, in an updated case of Italy, using a VAR model. This implies that either the Italian case is different from the rest, or some assumed theoretical restriction is violated the Italian case.

3.5 Some empirical puzzles

The empirical literature has some common concerns. These concerns are mentioned in several papers, but are usually assumed away due to the difficulty of dealing with them. A few of these

[21] The German result creates some concern about whether the model is correctly specified.

are discussed in this section namely: missing variables, nonlinear estimation, and variable-coefficient models.

The missing variables that Metzler (1999) alludes to in the discussion of asset channels could, for example, be the additional variables that Bernanke (1983) argues caused the Great Depression in the US. The monetary effects of the Great Depression came primarily through other variables such as bankruptcies and bank failures, instead of affecting output through the standard interest rate channel. If that was the case then the relevant question becomes what type of non-monetary variables are relevant for the post-war period? The effect of monetary policy on the financial system of a country is clearly relevant here. One could think of a stable monetary policy leading to facilitated access to venture capital that leads to improvements in entrepreneurial activity. Thus the direct effect of monetary policy on industrial output is small, but the indirect effect may be large.

Another interesting recent puzzle is the effect of the fluctuations in the term structure. In the US the short-term interest rates have fluctuated rapidly whereas the long-term rates have been fairly static. The short-term interest rates primarily influence the price movements, while the long-term rates are more important for investment decisions. Therefore models that have a single interest rate may calculate an incorrect impact of monetary impulses. Thus one potential criticism of most VAR studies is that due to the small size of the system of variable they may not be including the variables of importance.

Monetary shocks may have variable effects on output indicating a nonlinear relationship. For example, a stable credible monetary policy may lead to a financial climate that is conducive to investment in entrepreneurial activity. When does the monetary policy become unstable? One could envision some limits that monetary policy may reach where either high inflationary or highly contractionary behavior lead people to lose faith in the monetary policy of the central bank. Take the first case of a high inflationary environment. We know that many countries have lived with a relatively high inflation rates at times without much impact on growth rates. The

question then becomes why do some countries suddenly go from a high growth period to a low growth environment? Assuming that one controls for real sources of growth, there may be some shifts in growth due to monetary policy, but this could be highly nonlinear. In other words the central bank may have a monetary policy that makes the investment climate conducive to entrepreneurial activity. However, a too loose monetary policy may make the investors leery about potential high future inflation, and therefore cause investors to pull out of the investment market and thus make it harder for entrepreneurial activity to take place. Similarly too tight conditions may make investors fear that a slowdown in the economy would make this a less attractive environment for investment. For example, April 14, 2000 a core CPI announcement of 0.4% instead of 0.2% caused the NASDAQ to fall by 9.7%. Clearly 0.4% is not an unusual announcement and should not have caused much change, but investors saw this as a signal that the Fed would tighten severely in the next open market meetings. Instead of an expected 0.25% increase, markets expected at least a 0.50% increase. At the same time the Fed had up until that point in time increased the discount rate gradually without any noticeable effect.[22] In other words, most of the time the effect of the monetary change had been minor, but at some point before they even have a chance to announce the effect we see a sharp response by the market.

This type of nonlinear response can be seen as a type of threshold process.[23] For a certain range of activity by the central bank very little or no effect occurs on the economy, but when certain ranges are reached one can see a major impact of even relatively small policy movements. Thus in the interior range one would expect other factors, such as real shocks, to have a major

[22] During the week both the NYSE and NASDAQ had fallen substantially causing an estimated $1.7 trillion dollar loss in wealth for this week alone. Although this is only a paper loss, one might expect some of the wealth loss to translate into a smaller purchasing or smaller ability to collateralize project borrowing. If companies are trying to finance new investments with bank financing they would need collateral which often is required in terms of stock portfolio valuation. A reduced value of the stock portfolio would then lead to a forced contraction of new projects, and a reduced ability to generate new venture capital through newly issued stock.

[23] Alternatively one might see this as a signal for a change in Central Bank Activity.

impact on the economy, whereas the monetary policy has an impact on the economy when it reaches the boundaries.

The type of econometric methodology used in the estimation could be another problem. If we estimate linear fixed coefficient models for a period such as 1948-97 we are implicitly assuming that this period has a fixed response for the entire period. If policy functions are changing during the time-period then the error term will be increased. The erratic error term is essentially the unexplained monetary innovation or the shock to the policy function. Thus the monetary innovation may also be changing estimates of the policy function. Ohanian (2000), for example, argues that M1 velocity has changed sharply. From 1950-1980 M1 velocity has climbed sharply only to fall sharply between 1980 and the beginning of the 90's. This implies that monetary responses by the central banks may be very different during a period of 1948-97.

If we examine a simple equation of the type used by Cochrane (1998), such as

$$(15) \qquad m_t = c_{mm,t}m_{t-1} + c_{my,t}y_{t-1} + e_{m,t}$$

where $c_{my,t}$ and $c_{mm,t}$ are the feedback rules that here are allowed to vary across time. In the estimation the $e_{m,t}$ would increase as one erroneously fixed $c_{my,t} = c_{my}$ and $c_{mm,t} = c_{mm}$. Because the $e_{m,t}$ is the measure of monetary policy shocks, one would overstate the variance of monetary policy. Thus much of the monetary policy shock is then a changing monetary policy response to the new M1 velocity. This type of problem could be examined using some sort of varying coefficient model. A similar problem would be the result of real shocks that change the reaction function to economic conditions. For example, in Gordon (1999) he argues that technological improvements have substantially altered the inflationary path. The real wage growth and the growth in the price level have diverged recently, in the US. Such behavior would be consistent with a high productivity growth. Gordon estimates that the additional productivity growth due to improvements in information technology has contributed to an annual reduction of U.S. inflation

of 0.5%. If a broader definition of information technology is adopted the impact increases to almost 1% in an annual reduction of inflation. Therefore the revolution in information technology has led to a positive supply shock similar to the supply shocks that occurred in response to oil price changes.

4. Conclusion

The reviewed literature indicates that we have so far learned very little about the empirical transmissions effects of money. Although the literature is voluminous, little agreement exists on the exact variables that cause the transmission mechanism. We would expect a powerful effect of monetary policy, and the empirical literature ought to be able to bring some guidance as to what variables are responsible for such an effect.

However, the empirical literature cannot even find the expected monetary policy effect. Instead, most research appears to find small, but persistent effects. Therefore the focus of the literature so far has been in trying to explain why the expected effects cannot be empirically identified. Much of this work has centered on identifying the monetary policy variable. Both narrative and statistical methods have been used to identify shocks to monetary policy. The narrative approaches have ranged from readings of the minutes of the Federal Reserve creating a simple dummy variable, to using forward markets to indicate the expected change at the date of the identified policy change. Statistical methods have also had a wide range of approaches focusing on the type of contemporaneous restrictions of the policy effects on other economic variables.

Thus, the empirical literature has not been able to move past the first step of identifying a total effect of monetary policy in line with expectations. Once such a total effect is found, then the literature can move to the next step of identifying the exact method of transmission. As can be seen in work by, for example, Cochrane (1998) the first step might not be accomplished independently of theory. Taking a stand on what type of theoretical effects systematic policy has,

needs to be taken into account for the economist to have an accurate understanding of the empirical effects. Therefore more work that explicitly takes a stand on the theoretical effects of systematic monetary policy needs to be done. Similarly, the question of what really constitutes monetary policy needs to be clarified. In other words, does the central bank only affect the economy when it changes its policy (i.e. shocks the policy function)? Hopefully these thoughts will lead to useful directions for future research into the transmission effects of monetary policy.

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