Review over Empirical Evidence on Real Effects of Monetary Policy

Sun, Rongrong

School of Economics, University of Nottingham Ningbo China

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Rongrong Sun[1]

Abstract: This paper reviews and discusses the empirical literature on the impact of monetary policy on output. We focus on the evolution of methods that these studies have applied and demonstrate the established fact that monetary policy has significant impact on output. Throughout the review, we particularly highlight two problems in estimating the effects of monetary policy: the problem of how to measure monetary policy and the identification problem.

Key words: monetary policy, non-neutrality, systematic monetary policy reactions, vector autoregression

JEL-Classification: E42, E52, E58

[1] School of Economics, University of Nottingham Ningbo China, rongrong.sun@nottingham.edu.cn. All remaining errors are my own.

1. Introduction

The recent financial crisis and recession have revived debates about the role of monetary policy. An understanding of how monetary policy works is crucial for successful policy-making in terms of whether monetary policy has the potential to stimulate and/or stabilize the economy. For decades, these debates have inspired a lot of thoughts. There seems to be a wide agreement that monetary policy influences inflation, but not all economists agree that monetary policy affects real economic activities. Essentially, there are three main schools of views.

The first school is Keynesian economics, arguing that monetary policy does not only affect inflation but also systematically affects investment, production, employment and real incomes (at least in the short run).[2] The non-neutrality of monetary policy arises from market frictions, imperfect information, nominal rigidities or asynchronized price- and wage-setting behaviour, or even different norms[3] of decision-makers. Some Keynesians (though not all) argue that economic developments are path dependent[4] and thus, the demand shocks through monetary policy can lead to long-lasting effects on economic activities (see, e.g., Akerlof 2007, Ball 2009, Mankiw 2001). Despite this divergence in terms of short-run or long-run non-neutrality, all Keynesian economists believe that the short-run real effects matter. They argue that demand disturbances are the main source of economic fluctuations and activist demand management via monetary policy is strongly supported (see, e.g., de Long and Summers 1988, Romer and Romer 1989).

The second school is the monetarist argument that monetary policy affects the economy in the short run, but with uncertain lags and uncertain magnitudes. In the long run, it affects nominal variables only and inflation is a purely monetary phenomenon. Monetary policy is nevertheless important because inflation is costly and monetary policy determines the inflation rate, as argued by Milton Friedman (1968). Thus, the overriding objective of monetary policy should be price stability. This is the main contribution that monetary policy can provide. Monetary policy should be long-run oriented. Erratic monetary policy should be avoided. A rule of a fixed monetary growth rate is proposed by Milton Friedman (1968) – for example, 3 to 5 percent per year.

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[2] The new development of the Keynesian school is known as New Keynesian economics, which emphasizes the provision of microeconomic foundations for traditional Keynesian macroeconomic models. As the main predictions about monetary policy of these two kin schools are essentially the same, we will not particularly distinguish between them in this thesis.

[3] Akerlof (2007) defines norms as how decision-makers think they and others should or should not behave.

[4] The theoretical foundations include inter alia the hysteresis theory and the endogenous growth theory (Aghion and Howitt 1998, Blanchard and Summers 1986).

The third school is new classical economics, arguing for rational expectations and full-employment equilibrium. New classical economists believe that only unexpected monetary policy shocks have an impact on economic activities, while systematic monetary policy actions are expected by economic agents and thus have no effect on the economy (see, e.g., Lucas 1972, 1973, 1996, Sargent 1976). However, since policies cannot systematically fool all the people, monetary policy eventually plays a minor role in influencing economic developments. In the world of perfect markets, or the world with information imperfections but with rational expectations, monetary policy is neutral. Changes in the money stock induce proportional changes in prices only. Demand management with monetary policy is not desirable as these policy disturbances may amplify economic fluctuations. Rather, supply-side policies (for example, fiscal reforms to mitigate tax distortions) should be given more attention (see Lucas 2003).

The Keynesian school differs from the other two in fundamentals. For Keynesians, the perfect market hypothesis does not hold: there are markets distortions, nominal rigidities and sluggish demand. Therefore, activist demand policy (for example, monetary policy) should be pursued to stimulate demand and impair distortions. The Phillips curve (i.e., the existence of tradeoff between inflation and unemployment) is one of the most important prediction of Keynesian theories for policy-makers. In contrast, new classical and monetarist economists believe in the power of the "invisible hand". Economic fluctuations are mainly driven by the supply side. Unemployment is largely structural (for example, due to a mismatch between job vacancies and the unemployed in skills, location, etc.). Activist demand policy is not wanted as it neither has an impact on the supply side nor on structural unemployment. Rather, monetary policy should more or less follow a fixed rule such that its unnecessary disturbances to the economy can be minimized. Once again, such debates are reflected in the current arguments among economists of different schools on how economies get out of the Great Recession and how high unemployment in the US can be reduced.

We can test the views of different schools by checking their rationales. According to the Keynesian view, changes in nominal aggregate demand affect real output because of nominal wage and price rigidities, which might arise due to costs of price adjustment. It predicts that a higher trend inflation leads to more frequent price adjustment and hence a steeper short-run Phillips curve (i.e., the tradeoff between inflation and unemployment is smaller). The new classical explanation for the Phillips curve is the Lucas imperfect information model (1972, 1973). The short-run tradeoff between inflation and real output is observable only when firms misinterpret a change in the price level as a movement in relative prices and thereby adjust their production. The producers' expectations depend on the relative volatility of an individual price to the aggregate price level. The more volatile is nominal aggregate demand, the less often a misperception occurs at the firm level. It predicts that the curve relating real output to unanticipated inflation should be steeper for countries with highly variable nominal aggregate demand.

Lucas (1973) tests his imperfect information hypothesis with data from 18 countries and finds supportive evidence: increased nominal aggregate variability is associated with a diminishing output-inflation tradeoff. Ball, Mankiw, and Romer (1988) provide empirical evidence based on a 43-country sample and confirm Lucas observation. However, their interpretation of this finding is different from that of Lucas: the uncertainty, arising from high nominal aggregate variability, increases nominal flexibility and thus reduces the real effects of nominal disturbances. They provide further evidence for the nominal rigidity hypothesis: they find that the cross-country differences in the output-inflation tradeoff are well explained by trend inflation even when nominal aggregate variability is controlled for. Their findings are consistent with the Keynesian theory that nominal rigidity is an important determinant of the output-inflation tradeoff.[5]

The key prediction of the Keynesian school is that monetary policy is not neutral. Indeed, various empirical evidence developed over the past five decades conforms this prediction. It is a well-established fact that in advanced economies[6], monetary policy is found to have a significant impact on output (at least in the short run). Earlier surveys, such as Blanchard (1990), Benjamin Friedman (1990) and Orphanides and Solow (1990), focus on the grounds of monetary non-neutrality, while Boivin, Kiley, and Mishkin (2010) and Christiano, Eichenbaum, and Evans (1999) mainly discuss recent studies that apply VAR (vector autoregression), or FAVAR (factor-augmented VAR) and DSGE (dynamic stochastic general equilibrium)[7] approaches. This paper reviews empirical evidence in the literature about the real impact of monetary policy, but it differs from the previous surveys by following the evolution of empirical methods that these studies have applied. Throughout the review, we discuss limits and advances of each method. In particular, we highlight two problems in estimating the effects of monetary policy: the problem of how to measure monetary policy and the identification problem.

[5] Sun (2014a) extends the sample till 2007 and provides updated evidence in support of the Keynesian theory.

[6] A large body of studies address monetary non-neutrality issue in advanced economies. Thus, this paper mainly focuses on the evidence established for advanced economies.

[7] DSGE models have become a standard approach to theoretically examine effects of monetary policy.

This paper proceeds as follows. Section 2 reviews studies focusing on the money-income relationship in a simple regression, followed by the estimates based on a simultaneous-equation system. Section 3 discusses the policy measurement problem. Section 4 presents some more empirical evidence, with monetary policy measured with the short-term interest rate. Section 5 addresses some puzzles in the VAR literature and presents an alternative approach. Section 6 concludes.

2. Money and Income: From Milton Friedman to the VAR Studies in the 1980s

The empirical study of the money-income relationship can be traced back to Friedman and Schwartz (1963b). In that study, they examined timing patterns of changes in the money growth rate in the US, and compared those to the reported peaks and troughs of the business cycles. They found that changes in the money growth rate led fluctuations in the business cycle, though those leads were varying over time. Thus, their conclusion was the short-run non-neutrality of monetary policy. Another empirical contribution in this line is made by Andersen and Jordan (1968) of the Federal Reserve Bank of St. Louis. They regressed changes in GNP on contemporary and three lagged values of changes in money stocks, and found that changes in money stock have significant impacts on output. Afterwards, this money-output regression became known as the St. Louis equation and has been widely applied by economists in the estimation of the effects of monetary policy.

Yet, the result based on this single equation provides information about the correlation between variables, but nothing about the direction of causation. Causation can run in both directions. The observed interaction of money and output could reflect the policy reaction to the state of the economy, or the effects of monetary policy on output, or very likely, the mixture of both. Hence, we need to identify the causal direction.

In 1980, Christopher Sims (1980b) proposed a new econometric methodology, vector autoregression (VAR), to solve this identification problem. VAR is a kind of extension of the St. Louis equation through including several simultaneous equations in a system. We can thus run regressions of the variables of interest on their own lagged terms, and the lagged and *contemporaneous* terms of the other variables in the system. The reaction of monetary policy to the state of the economy is (implicitly) modelled in the equation for the policy indicator (for example, the money stock). Then, in an identified VAR model, the unexplained part of changes in the money stock (the error term or the so-called structural innovations in the VAR literature) is interpreted as exogenous policy shocks. The estimates of the impact of these structural innovations on output give the effects of monetary policy on the real economy.

Thus, in a standard VAR model, at least two equations are included: one is designed to identify the effects of monetary policy on output – represented by the equation with output regressed against a policy indicator; and other captures the reaction of policy to the state of the economy – represented by the equation with changes in the money stock depending on the output. With the regression results, it is possible to generate an impulse response analysis that traces out dynamic impacts of policy changes on the variables of interest.

However, special efforts have to be made to identify the policy shocks. In a VAR model, the true relationship between macroeconomic variables includes the contemporary interaction of those variables, as specified in structural equations. That is, a vector of the current terms of these variables, X_t, appears on both sides of the equations. To run multi-regressions simultaneously, we need to transform equations to a reduced form: with X_t appearing only on the left-hand side of equations. However, the reduced-form error terms are different from structural errors and hard to interpret with economic meanings. Therefore, it is necessary to restore structural equations and derive structural errors that we can interpret, for example, as policy shocks. *Identifying* structural equations from the estimated reduced-form equations is a key issue and requires some additional structural restrictions on the system. Quite often used identification restrictions include recursive ordering, orthogonalization of contemporaneous errors, or the introduction of some neutrality constraints, either in terms of the short run or the long run.[8] This kind of VAR is known as structural VAR (SVAR), as structural assumptions are made to identify policy shocks.

The VAR methodology was soon widely applied by monetary economists. In Bernanke's words, "identified VAR methods are currently the best available means of measuring effects of monetary policy changes on the economy" (Bernanke 1996: 73). Over the past three decades, large amounts of literature using VAR have emerged. The application of VAR methodology first appeared in the studies continuing to explore the money-income relationship in the 1980s. The conclusions concerning the predictability of money on income made by those studies are not robust and not consistent over time, in contrast to Friedman and Schwartz' (1963b) claims that there exists a steady relationship between money and income. Table 1 shows four selected studies, which shed some light on the debates in monetary economics during that period.

[8] For more, see Kennedy (2003) and Lütkepohl (2005).

Table 1: Selected studies on the money-income relationship, using VAR

Study	Sample Period	Variables	Conclusions
Sims (1980a)	1920-41; 1948-78	Rs, M1, P, IP	With the interest rate added into the model, M1 loses predictive power. The interest rate turns out to explain more of the variation in output, accounting for about 30 percent in the Postwar period.
Eichenbaum and Singleton (1986)	1949 -1983	$\Delta(M1)$, $\Delta(IP)$, π, Rr	The monetary growth rate does not help predict output growth.
Stock and Watson (1989)	1959 – 1985	IP, M1, P, Rs	M1 does not Granger-cause IP growth, but the deviation of money growth from a linear time trend does.
Spencer (1989)	1948-1978	M1, IP, P, Rs	The VAR estimates are not robust, but sensitive to the relative ordering of the variables, the detrending methods, the lags selection, and the data frequency.

Notes: M1 stands for the monetary aggregate M1; P for consumer price index; IP for industrial induction; π for CPI-inflation; IR for residential investment; Rs for three-month Treasury bill rate; Rr for real interest rate. All variables are in logarithm, with the exception of various interest rates and the inflation rate. $\Delta(x)$ indicates that variable x is in first difference.

Source: Authors' summary based on the studies listed.

These studies use a monetary aggregate, M1[9], to measure monetary policy and examine the effects of changes in M1 on industrial production for the US economy. Despite this similarity, they come to different conclusions. Sims (1980a) examines the forecast error variance decomposition of the VAR model at the time horizon of four years after a policy shock. In the first specification of the VAR model with M1, IP and price level, Sims shows that although money helps predict real income for both the interwar and the postwar period in the US, the predictability of money for the latter period is only half of that for the former period. When the short-term nominal interest rate is added to the VAR system, money ceases to predict real income. Based on this finding, Sims concludes that monetary policy does not explain post-war business cycles.

Eichenbaum and Singleton (1986) build their VAR model using postwar US data. They find that money growth does not help predict output growth and interpret this as the evidence for neutrality of monetary policy. Stock and Watson (1989) argue that this finding is sensitive to the detrending[10] methods applied to the data. They apply a different detrending method – introducing a linear time trend to money growth – and find that money growth itself does not explain the variations of output, but the deviation of money growth from its time trend is useful for forecasting real growth in industrial production. Spencer (1989)

[9] For the US data, M1 is the sum of currency held by public and demand deposits.

[10] Detrending refers to the process of transforming non-stationary time series into stationary ones. Different methods can be used, e.g., take first differences, which is widely used; introduce a time trend, either linear or time-varying; or, use some filtering techniques, such as the Hodrick-Prescott filter and the Kalman filter.

extends this argument. He confirms Stock and Watson's finding. Moreover, he demonstrates that the VAR estimation results are not robust to the model specification: they vary with changes in the relative ordering of the policy and the macroeconomic variable, the lag length and the data frequency.[11]

The development of the literature on monetary policy in the 1980s showed that it was possible to use the VAR to trace out what happened in the "black box" after changes in monetary policy. Yet, the estimate results based on VAR models are somehow mixed. Despite the sensitiveness to the model specification, in general they indicate less effectiveness (or even neutrality) of monetary policy in the postwar US.

3. Is the Money Stock a Good Measure of Monetary Policy?

The interpretation of those VAR estimates in the 1980s reflects the strong influence of monetarism on the economics profession at that time: the money stock was believed to be the good single indicator of monetary policy and the absence of the money-income relationship simply implied the neutrality of monetary policy. However, McCallum (1983) argues that the breaking-down of a money-income relationship says nothing about the neutrality of monetary policy. Rather, he pointed out that this result was due to the use of improper measures of monetary policy with monetary aggregates.

Bernanke and Blinder (1992) and Bernanke and Mihov (1997, 1998b) argue that the measurement of monetary policy is regime dependent – the indicator for monetary policy should be carefully studied in the framework of central banks' operating procedures. In the United States, the Fed's operating procedure experienced large changes after the War. During most of the postwar period, the Fed is better described as a federal-funds-rate targeter. That is, the Fed sets an implementing target for the federal funds rate, and then through open market operations keeps the target rate prevailing in the reserves market. In doing so, the Fed accommodates the fluctuations in money demand induced by income changes, which makes the money supply endogenous. A change in the money stock hence reflects factors other than policy changes. The endogeneity of the money supply no longer makes the money stock a good policy indictor.

Changes in the operating procedures, which have also been seen in many other advanced economies, thus require economists to find another indicator to measure monetary policy. Studies turn to the short-term

[11] Further evidence can be found in de Grauwe and Costa Storti (2004), where they conduct a meta-analysis with a sample of 43 studies using VAR. They find that the use of different identification assumptions helps explain a large variation in the estimated effects of monetary policies on output in those studies.

nominal interest rate and examine its potential for a policy indicator. Bernanke and Blinder (1992: 901) demonstrate that the federal funds rate is "extremely informative" and "sensitively records shocks to the supply of bank reserves". Thus, they propose the federal funds rate as the policy indicator for the Fed. Applying their approach to Germany, Bernanke and Mihov (1997)[12] argue that, analogous to the US case, policy instrument rates – the Lombard rate and the call rate[13] – performed as the optimal indicator of German monetary policy. Following these findings, it has been a standard practice to measure monetary policy of those central banks in advanced economies with the short-term interest rate. Studies thus focus on the linkage from changes in the short-term interest rate to real GDP and put less or no emphasis on monetary aggregates, what McCallum's (2001) describes as "monetary policy analysis in models without money".

4. Real Effects of Monetary Policy Revisited

Numerous studies have surged in the 1990s, modeling the interaction between changes in the short-term interest rate and economic developments with the VAR approach. The conclusions made in those studies are quite consistent across countries: shocks to monetary policy induce strong real effects, while price effects are sluggish and small (see, e.g., Bernanke, Gertler, and Waston 1997, Christiano, Eichenbaum, and Evans 1999, de Grauwe and Storti 2008).[14] The maximum impact on output is found about two years after a monetary policy shock.

Figures 1-3 represent the findings from four selected studies.[15] As shown in Figure 1, the impulse responses of real output to a contractionary policy shock, estimated by Leeper, Sims and Zha (1996) and Bernanke and Mihov (1997), are quite similar for two countries – the US and Germany. After about six to eight months, real output drops substantially and stays at the lower level over the reported time horizon (four years). Compared to real output, the unemployment rate, as reported by Bernanke and Blinder (1992) and displayed in Figure 2, needs a longer period of time to respond to a policy shock. Then, following a minor drop, it rises quickly and constantly, and peaks after about two years. Figure 3 shows the impulse

[12] The measurement problem turns to be even more severe in case of emerging economies, where the central banks use multiple policy instruments, including unconventional ones. Sun (2014b) extends the Bernanke and Mihov's approach to China and finds that indeed, Chinese monetary policy cannot be sufficiently measured by a short-term interest rate or a monetary aggregate alone. Rather, it is better measured by jointly considering the PBC's multiple policy instruments.
[13] That is the money market rate in Germany, analogous to the federal funds rate in the US.
[14] In particular, de Grauwe and Costa Storti (2008) draw their conclusion from a meta-analysis with a sample of 86 published studies using VAR to estimate the effects of monetary policies on output.
[15] To make the graph easier to read, we represent the point estimates without confidence intervals.

response of real GDP to an expansionary monetary policy shock, reported by Bernanke and Mihov (1998a). Symmetric to the impulse response of output to a contractionary policy shock, real GDP rises quickly and constantly after an initial small decline, and reaches the peak in about two years. Afterwards, it decreases slowly and stays at a higher level.

Figure 1: Responses of output to a rise of the interest rate, US and Germany

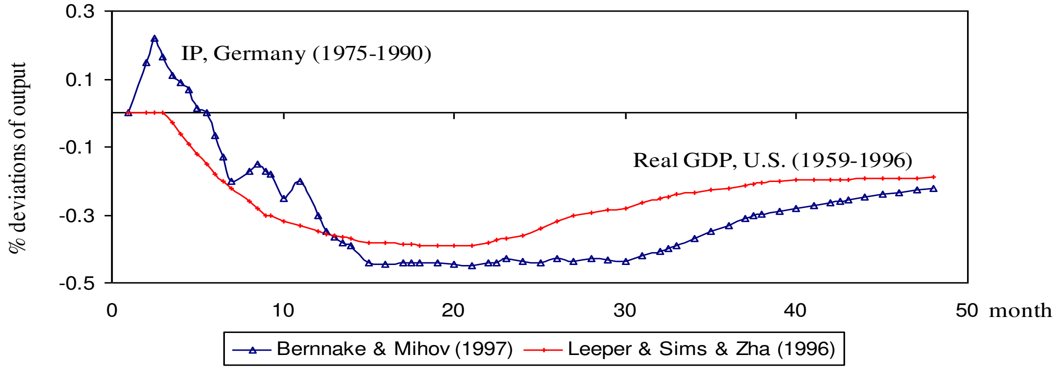


Figure 2: Response of the unemployment rate to a rise of the federal funds rate, US

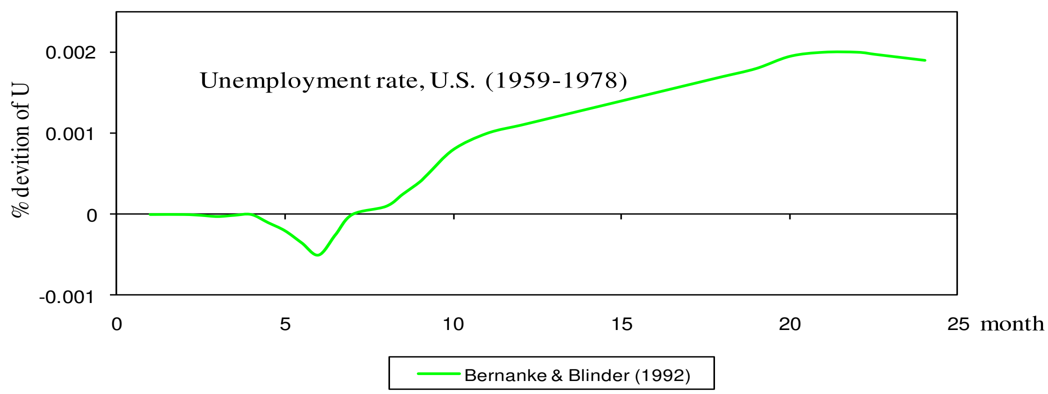
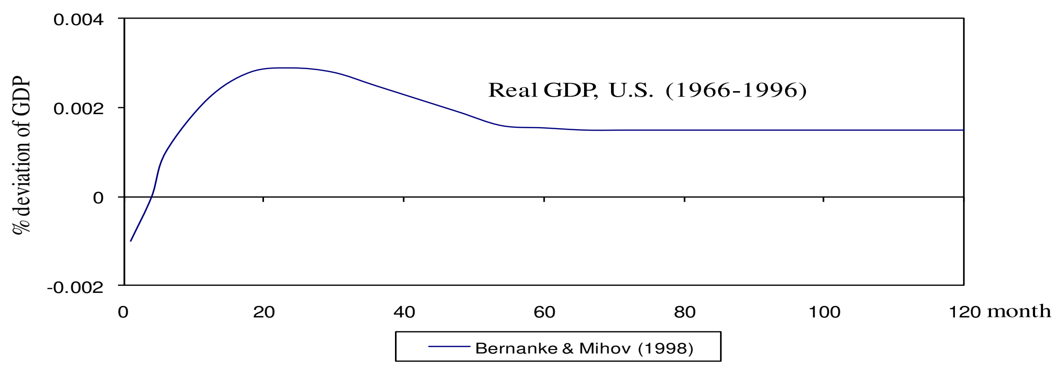


Figure 3: Response of real GDP to a decrease of the federal funds rate, US



Notes: Figure 1 shows responses of output to a contractionary policy shock at the horizon of 48 months in two countries – the US and Germany. The policy shock is measured as a one-standard-deviation increase of the federal funds rate (in the US) or the call rate (in Germany). Figure 2 shows the response of unemployment rate to a one-standard-deviation increase of the federal funds rate in the US at the horizon of 24 months. Figure 3 shows the response of real GDP to a one-standard-deviation drop of the federal funds rate at the ten-year horizon.

Source: Data based on studies from Bernanke and Blinder (1992), Leeper, Sims and Zha (1996), Bernanke and Mihov (1997, 1998a).

5. Some Puzzles in the VAR Studies and an Alternative Approach

To identify the effects of monetary policy from policy reaction to the economy, we need to disentangle exogenous policy movements from systematic policy reactions. The VAR approach attempts to model the central bank's reaction function so as to proxy for exogenous monetary shocks with the structural innovations, which are "changes in a policy variable that are deliberately induced by the central bank actions that could not have been anticipated on the basis of earlier available information" (Hamilton 1997: 80). However, an incorrectly specified VAR model would fail in identifying exogenous monetary policy shocks (Rudebusch 1998) and lead to puzzling results, which contradict the theoretical predictions. A well-known example is that some VAR models estimate that prices rise with a monetary tightening. This is known as the price puzzle (see, e.g., Christiano, Eichenbaum, and Evans 1999, Sims 1992).

This puzzle arises because the expected inflation is not included that the central bank has had in mind when setting the policy (see, e.g., Bernanke, Boivin, and Eliasz 2005, Sims 1992). The forward-looking central banker decides on a policy shift to tightening, given an increase in the inflation expectations. When the policy action is not strong enough to sufficiently reduce inflation, the co-movement of a policy tightening and a rise in prices is observed. The solution to this problem is to include a variable that captures the central bank's inflation expectation – the common practice in the literature is to follow Sims (1992) and include a commodity price index – or include many information variables to possibly closely present the information set that the central banker has had at the decision-making, as modeled in a FAVAR model.[16]

However, even in the most sophisticated model (like FAVAR), it is impossible to proxy for all information that policy-makers have had, particularly their numerical forecasts of future economic developments. In general, if any omitted variable is a determinant of both output and the policy reaction function, omitting it means that it appears in the error terms of both equations for output and the policy reaction function. Then, using the (structural) error term of the latter equation to measure exogenous monetary policy shocks will lead to biased estimates of the effects of monetary policy on output given the correlation of shocks with the error term in the output equation.

[16] Boivin, Kiley, and Mishkin (2010) present rich evidence on effects of monetary policy, estimated with the FAVAR method.

An alternative approach, the narrative approach, can be used to solve the identification problem. This approach was pioneered by Friedman and Schwartz in their *Monetary History of the United States* (Friedman and Schwartz 1963a) and has been applied by Romer and Romer in a series of studies (Romer and Romer 1989, 2004).[17] It "involves using the historical record, such as the descriptions of the process and reasoning that led to decisions by the monetary authority and accounts of the sources of monetary disturbances" (Romer and Romer 1989: 122). This information discloses the central bank's intentions for each policy movement. Some of these intentions are neither linked directly to output nor indirectly to those factors that are likely to affect output growth. In this way, we can single out those policy movements that are exogenous to the current and future economic developments in the real side. A regression using these exogenous policy shocks will yield an unbiased estimate of the impact of monetary policy on output. Indeed, compared to what obtained using conventional indicators, Romer and Romer (2004) estimate quicker and stronger effects of monetary policy on output using their narrative-based exogenous monetary shocks.[18]

6. Conclusion

Thanks to numerous contributions, today we have a deeper understanding of monetary policy compared to half a century ago. It can be summed up into several findings. First, in advanced economies, the policy interest rate, rather than the money stock, reflects changes in monetary policy well. More specifically, the measurement of monetary policy is regime dependent and a policy indicator should be carefully studied in the framework of central banks' operating procedures. Second, the proper measurement of monetary policy is essential for accurate estimates of the policy effect. The neutrality conclusions drawn from the studies in the 1980s that purely focus on the money-income relationship are biased due to the imprecise measurement of monetary policy. Third, monetary policy affects real economic activities and the maximum impact is found about two years after a policy shock. This finding is consistent with the evidence obtained for several industrial countries. Fourth, the accuracy of VAR estimates of the effects of monetary policy crucially depends on the validity of identified exogenous policy shocks. A misspecified VAR model could lead to an omitted-variable bias in its estimates and some puzzling results. Alternatively, one can use the narrative approach to disentangle exogenous policy shocks from systematic policy

[17] The narrative approach has also been applied in studies on the effects of fiscal policy (see, e.g., Alesina, Favero, and Giavazzi 2012, Ramey 2011, Ramey and Shapiro 1998, Romer and Romer 2010).

[18] Sun (2013) applies the narrative approach to China, where she identifies three exogenous monetary contraction over 2000-2011 period. Consistent with the established evidence for advanced economies, she finds that monetary policy in China has strong and long-lasting effects on output.

reactions based on the information inferred from the central bank's historical documents. A regression using exogenous policy shocks yields unbiased estimates of the effects of monetary policy on output.

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