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What Drives US Inflation and Unemployment in the Long Run?

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Abstract

There is a growing consensus on the existence of a positive, long-run relation between inflation and unemployment in the US economy. However, the conclusion that the two variables move in the same direction at low frequencies leaves open the question of the identification of the factors - real or, alternatively, monetary - underlying this co-movement. In this paper we try to shed light on this question by adopting a structural VAR agnostic approach. The important finding is that in the postwar US economy an important role, though not a pre-eminent one, has been played by supply shocks in shaping the long-run evolution of unemployment. This result is robust to alternative choices of the money supply index. Thus, the main conclusion arising from our empirical results is that any monothematic explanation of the long-run relation between inflation and unemployment is difficult to reconcile with US postwar data. A second, important result shown by this investigation concerns the presence of a pronounced liquidity effect in the US economy.

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1. Introduction

The relation between inflation and unemployment in the US economy for the postwar period exhibits two stylized facts: (1) in the short run, the two variables mainly move in opposite directions, driven by real and nominal aggregate demand shocks; (2) in the long run, their joint behaviour is quite different, since inflation and unemployment move in the same direction.[1]

However, the literature offers alternative interpretations of the dominant factors explaining the long-run behaviour of unemployment (and inflation). Following the lead of Friedman (1977), Berentsen *et al.* (2011) have argued that the long-run, positive relation between inflation and unemployment may be explained by monetary factors combined with a search-and-bargaining approach.

In this research area, Gomis-Porqueras *et al.* (2013) have recently developed a search-theoretic model of money and unemployment in order to derive optimal fiscal and monetary policies.

Although based on a different theoretical framework, relying in particular on the inability of the central bank to pursue a credible low-inflation target, the same conclusion was essentially reached by Ireland (1999).

A different view has been expressed by Karanassou and Sala (2010). The authors argue that the classical dichotomy model does not hold for the US economy, since they find evidence of a downward-sloping Phillips curve, both at short and long horizons.

Instead, in Ball and Mankiw (2002) and in Ribba (2006), among others, the empirical evidence on the low-frequency co-movements between inflation and unemployment has been interpreted mainly in terms of a real, productivity shock story.

This story was first proposed by Grubb *et al.* (1982). The authors built a model capable of explaining the correlation among the strong deceleration in productivity growth and the contemporaneous increase in both inflation and unemployment which affected the industrialized economies in the 1970s.

In a recent paper, Benigno *et al.* (2015) have indeed proposed a theoretical interpretation of the long-run co-movement of productivity growth and unemployment. According to the authors, the long-run relation has its roots in the volatility in productivity growth which is capable of causing related changes in the unemployment rate.

In related research, Selgin *et al.* (2015) investigate the conduct of monetary policy in the 1990s and in the first part of the 2000*s*, in the face of the productivity growth acceleration. In particular, the authors maintain that the Fed gave a significant, though unvoluntary, contribution to the subprime boom, by keeping the nominal short-term interest rates too low for a prolonged period in response to productivity growth acceleration.

In the present paper we adopt an agnostic approach, in the spirit of Uhlig (2005) and, as far as possible, let the data speak on the relative importance of monetary, aggregate demand and aggregate supply shocks in explaining the behavior of unemployment, both in the short and in the long run.

It is worth noting that if the monetary interpretation were correct, then we should expect to find that persistent effects are exerted on inflation and unemployment by monetary policy

[1] See *e.g.* Ireland (1999), Ribba (2003), Berentsen *et al.* (2011), Haug and King (2014).

shocks and, moreover, that the great part of variability of the two variables at longer horizons is attributable to monetary shocks. Conversely, the Friedmanian interpretation would be consistent with low persistence of supply, productivity shocks and with a lesser role exerted by such shocks in driving the movements of inflation and unemployment at low frequencies.

In this study we find that a relevant role is played by supply shocks, both in terms of persistence and in terms of relative importance in the explanation of the variability of unemployment in the long run. A role, but far from a pre-eminent role, is also played by monetary shocks.

The results are robust to the inclusion in the estimated VAR model of alternative indexes of money supply. For, when we use a divisia monetary index (see, among others, Kelly *et al.* 2011), instead of $M2$, we find that the responses of the variables to the identified shocks do not show significant modifications. Moreover, the relative importance of the structural shocks in composing the variability of unemployment is largely in line with the results obtained by using $M2$ as a monetary aggregate.

Thus, our main conclusion is that a one sole explanation of the long-run co-movement of inflation and unemployment fails to explain the phenomenon properly.

Our empirical approach allows another interesting economic topic to be investigated: does a contractionary monetary policy shock cause an increase in the nominal interest rate in the short run? Our identification strategy consists of imposing sign restrictions only on money growth, leaving free the response of the nominal interest rate at all horizons.

In other words, we do not try to overcome the potential presence in the data of a liquidity puzzle, *i.e.* the short-run decrease of the nominal interest rate following a contractionary monetary policy shock, by imposing an a-priori, positive sign of the response.[2]

We find that a contractionary monetary policy shock causes an increase of the interest rate in the short run, *i.e.* our conclusion is that a significant liquidity effect does characterize the US economy in the postwar period.

The rest of the paper is organized as follows. In section 2 we present the (agnostic) strategy of identification of the structural shocks.

In section 3 the dynamic responses of the variables to the three identified shocks are presented. Moreover, in this context, we also show the results concerning the forecast-error variance analysis for inflation and unemployment.

Section 4 is devoted to a sensitivity analysis: we check the robustness of the results obtained to alternative measures of the money stock included in the estimated VAR.

Section 5 concludes and we also try to draw some implications for monetary policies and for further development of the research in this area.

[2]The liquidity effect has been widely investigated in the last forty years, both on the theoretical and on the empirical side. Interesting papers, among others, in this area of research are Leeper and Gordon (1992), Lastrapes and Selgin (1995) and Christiano *et al.* (1996). In a recent article Kelly *et al.* (2011) have claimed that the liquidity puzzle might arise as a consequence of the inclusion in the estimated VAR of the official monetary aggregates, which they see as improper indicators of money supply.

2. The agnostic approach to structural VAR identification

A small VAR model for the US economy is estimated. It includes four variables: the inflation rate, the rate of unemployment, a broad monetary aggregate and a short-term interest rate. We use monthly data for the sample period $1960:1-2011:12$.

We start with the estimation of the following reduced form of a VAR model:

$$X_t = \mu + A(L)X_{t-1} + e_t \qquad [1]$$

where for a VAR of order p, $A(L) = \sum_{i=1}^{p} A_i L^{i-1}$. In this empirical investigation, in accord with the Akaike information criterion, we take $p = 14$. L is the lag operator, such that: $L^i X_t = X_{t-i}$. μ is a vector of constant terms and e_t is the 4×1 vector of error terms, such that $E(e_t) = 0$ and $E(e_t e_t') = \Sigma_e$.

The 4×1 vector X_t is given by:

$$X_t' = (\ \pi_t \quad u_t \quad \tfrac{\Delta M_t}{M_t} \quad i_t\ )$$

where π_t is the annual rate of inflation based on the Consumer Price Index; u_t is the civilian unemployment rate; $\frac{\Delta M_t}{M_t}$ is the year-on-year rate of change of the broad monetary aggregate, $M2$; i_t is the federal funds rate. All series are taken from FRED at the St. Louis FED Web site.

In the second step, the covariance matrix of the vector of residuals matrix, Σ_e, is randomly drawn from the posterior distribution of the matrix of the VAR coefficients. In the structural VAR approach, the relation between the error terms, e_t, and the exogenous macroeconomic shocks, ϵ_t, is given by: $e_t = F\epsilon_t$. Where the 4×1 vector, ϵ_t, of the structural shocks is such that: $E(\epsilon_t \epsilon_t') = I$, *i.e.* the vector contains orthonormal variables. The sign restrictions method proposed by Uhlig (2005), given $FF' = \Sigma_e$, aims to identify a set of impulse vectors, $f^1..f^n$, such that $f^i = F_i \alpha^i$, where $\|\alpha^i\| = 1$, which is consistent with some standard macroeconomic theory. Thus, each impulse vector, f^i, is a column of F and, moreover, n, the number of identified shocks, is smaller than m, the number of total shocks driving the dynamic system. More precisely, in this empirical study, given $m = 4$, we identify $n = 3$ economic shocks.

The minimal set of restrictions imposed by this approach implies that there exists a space of impulse vectors consistent with the chosen macroeconomic model. However, in order to select a unique set of impulse vectors, it is possible to introduce a penalty function. In particular, in this investigation we use a penalty function which is similar to the one introduced by Mountford and Uhlig (2009).

A further step is required in order to calculate the confidence bands. We follow the Bayesian approach suggested by Sims and Zha (1999)[3]. The assumption is that VAR errors are normal and that both prior and posterior density belong to the Normal-Wishart family.

[3] See also Doan, (2010).

We take 10000 draws from the posterior[4], where each draw is subject to the numerical minimization associated with the penalty function.

In table 1 we report the sign restrictions imposed on the impulse responses. We identify the productivity, supply shocks by imposing a negative response of both inflation and unemployment for 6 months. In other words, we impose that an unexpected increase in productivity produces a reduction in the inflation rate and in the rate of unemployment. Instead, the aggregate demand shock is separated by the supply one, by imposing on inflation and unemployment a short-run (6 months) movement in opposite directions. These last sign restrictions are indeed consistent with the traditional characterization of the short-run dynamic effects associated with expansionary aggregate demand shocks.

As far as the monetary policy shock is concerned, in this paper we do not follow the strategy pursued by Uhlig (2005) and by many other researchers based on imposing sign restrictions even on the responses of inflation and interest rate (see, among others, Rafick and Mallick, 2008). The logic behind Uhlig's strategy is to impose restrictions consistent with the conventional wisdom about the effects exerted in the short run by contractionary monetary policy shocks on inflation (or price) and on the interest rate and then concentrate the attention on the dynamic effects produced by such monetary shock on the rate of unemployment. However, the important implications of Uhlig's identification strategy are that a liquidity effect is a-priori imposed on the response of the interest rate and, moreover, that the potential presence of a price puzzle is a-priori excluded by imposing a negative response of price (or inflation) for some periods.

Thus, in this research we depart from this identification strategy and, instead, we choose to identify the contractionary monetary policy shock by only imposing a negative sign of the rate of growth of $M2$ for two quarters. Clearly, this alternative identification strategy allows the potential presence of a price puzzle and/or of a liquidity effect to be detected in the data.

Indeed, at least in our opinion, imposing a pre-determined response of the interest rate to an exogenous movement in money growth might be highly questionable, given the lack of theoretical consensus on the subject. Hence, this seems to be an almost ideal context in which to let the data speak on the possible presence (of absence) of the liquidity effect, *i.e.* an increase in the nominal interest following a monetary tightening by the central bank, and then discriminate between competing models.

[4]As stressed in the recent literature, in general, inferential techniques based on the Bayesian approach may produce inaccurate reports. Nevertheless, as shown for example by Liu *et al.* (2016), by increasing the number of draws one can improve significantly the accuracy of results. Thus, taking 10000 draws seems to be an appropriate choice in this context. See also Uhlig (2005)

Table 1. Sign Restrictions and Identification of Structural Shocks

	Structural shocks		
VAR Variables	Aggregate Supply	Aggregate Demand	Monetary Policy
Inflation rate	−	+	
Unemployment rate	−	−	
Money growth			−
Interest rate			

This table indicates the sign restrictions imposed on the impulse responses for the three identified shocks. A sign + (−) imposes a positive (negative) response of the variable for 6 months following the shock. As shown in the table, we do not impose any restriction on the responses of the federal funds rate.

3. Dynamic responses

In figure 1 the median responses of variables to the identified shocks are reported, together with the 16th and 84th percentiles. As shown in figure 1, the response of unemployment to a supply shock exhibits high persistence: a positive productivity shock causes a significant reduction of unemployment for around ten years. A decrease, following the supply shock, is also observed in the inflation rate. However, it is worth stressing that although the median response exhibits a persistence profile which is similar to that of unemployment, the effects exerted by the productivity shock on inflation are significant for around 60 months.

Instead, the responses of the two variables to the aggregate demand shock exhibit less persistence: an unexpected increase in aggregate demand provokes an increase in the inflation rate and a decrease in the unemployment rate which lasts for around three years and thereafter is not significant. Let us recall that opposite signs in the responses of inflation and unemployment are imposed for six months.

When we turn to the response of the variables to a contractionary monetary policy shock, we note three main results: (1) inflation and unemployment move in opposite directions in the short-run as a consequence of a monetary restriction and this seems to be in line with the conventional wisdom about the working of the monetary policy; (2) nevertheless, after a period of four-five years following the shock, the rate of unemployment changes the sign of its response, *i.e.* in the medium run inflation and unemployment move in the same direction and thus both the variables decrease; (3) in the short run, the interest rate increases in response to the contraction in the rate of growth of M2 undertaken by the central bank and, moreover, this liquidity effect is significant for around two years. However, after two years following the contractionary monetary shock, the nominal interest rate begins to decrease, *i.e.* in the medium and in the long run the rate of growth of money, the rate of inflation and the nominal interest rate move in the same direction.

The responses of money growth and federal funds rate to a positive demand shock, which causes an increase in inflation and a contraction of unemployment, are consistent with a monetary policy conduct of the central bank aiming to stabilize the economic system: following the shock there is a significant increase in the interest rate and a decrease in money growth, *i.e.* the response of the central bank is a monetary tightening.

Instead, in response to a positive supply shock, which causes a contraction of both inflation and unemployment, there is a temporary monetary accomodation, with a decrease in the federal funds rate and an acceleration of money growth. However, after around one year the federal funds rate begins to rise and this lasts for around two years.

In figures 2 we report the results concerning the Forecast Error Variance Decomposition (FEV) at various horizons for unemployment and inflation.

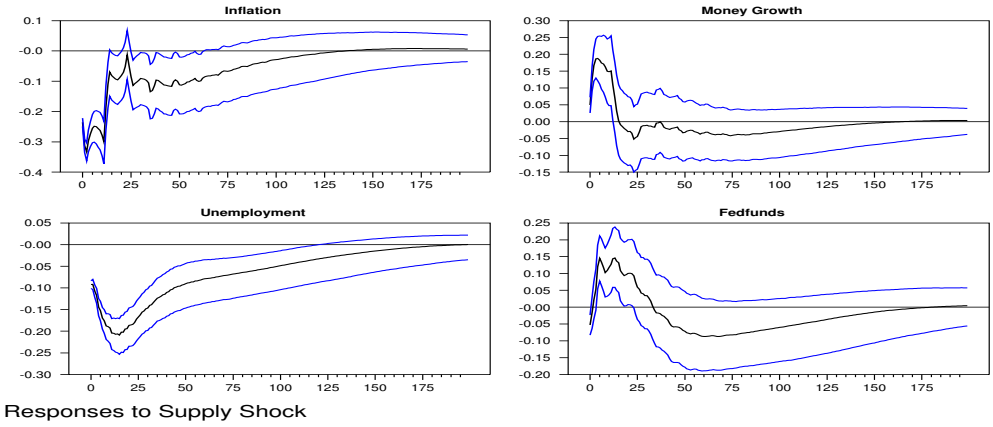
A first, striking result is that supply shocks explain much of the variability of inflation in the very short run. Moreover, there is a pre-eminent role played by the aggregate demand shock from the short to the medium run. Another interesting result concerns the growing role exerted by monetary shocks in driving inflation at longer horizons. Nevertheless, we stress that this result is only partially consistent with a Friedmanian view of inflation since around 75 percent of the variability of inflation at low frequencies is not explained by money growth.

As far as the variance decomposition of unemployment is concerned, demand shocks play a pre-eminent role in the first year following the shock. Instead, the productivity shock explains a stable portion of variability at different frequencies, of around 35 percent. More precisely, by taking into account the estimated confidence bands, it is possible to conclude that the supply shock explains from a minimum of 30 percent to a maximum of 40 percent of the variability of the rate of unemployment, both in the short and in the long run.

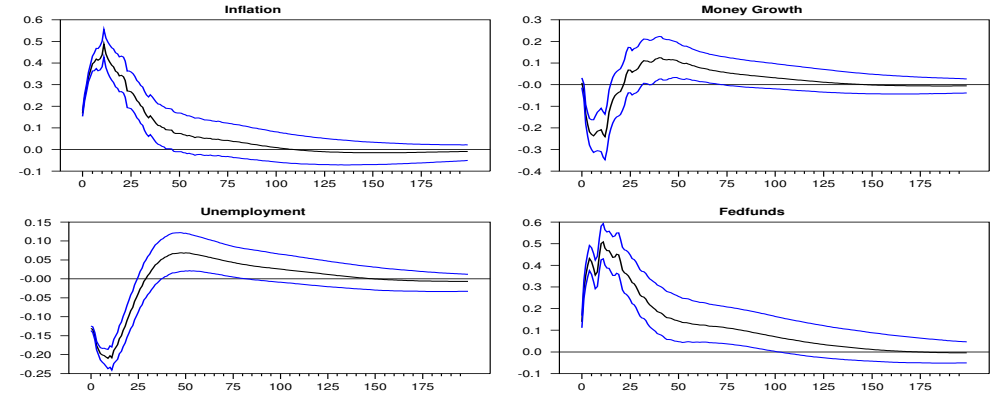
As for the monetary policy shock, it accounts for around 15 percent of the forecast error variance of unemployment at low frequencies.

Hence, as a whole, the results obtained in this empirical investigation reveal that monetary factors are not the main drivers of unemployment in the long run.

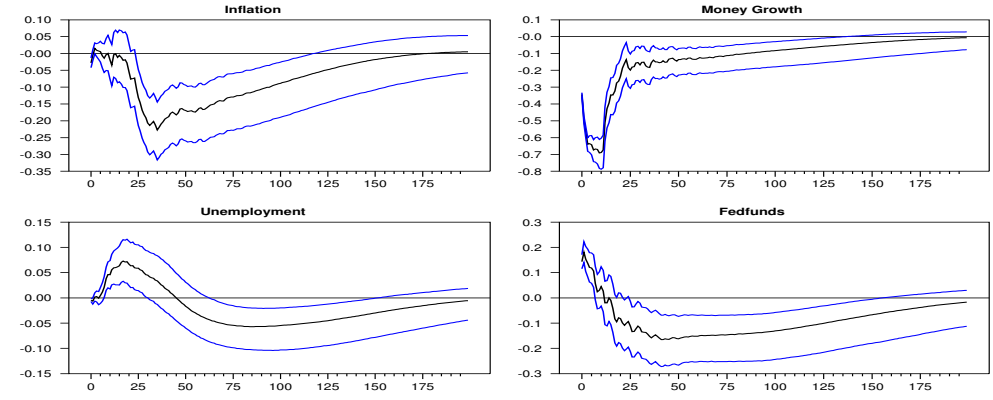
Figure 1: Responses of variables to the identified structural shocks.



Responses to Supply Shock



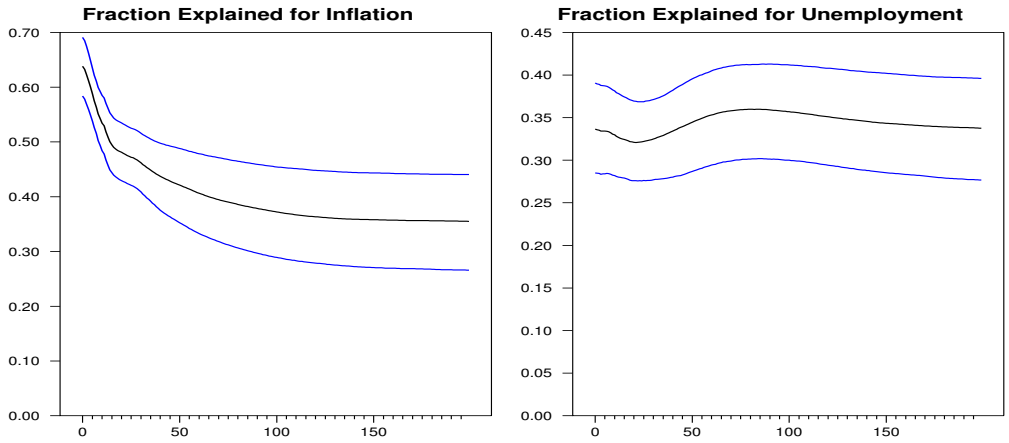
Responses to Demand Shock



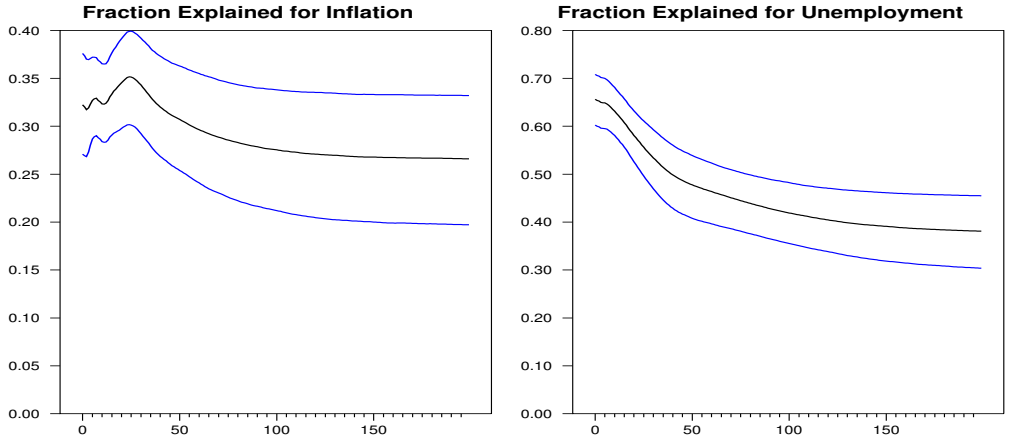
Responses to Monetary Policy Shock

Notes. The estimated VAR includes $M2$ as a measure of the money stock. Median estimate with 68th percent confidence interval.

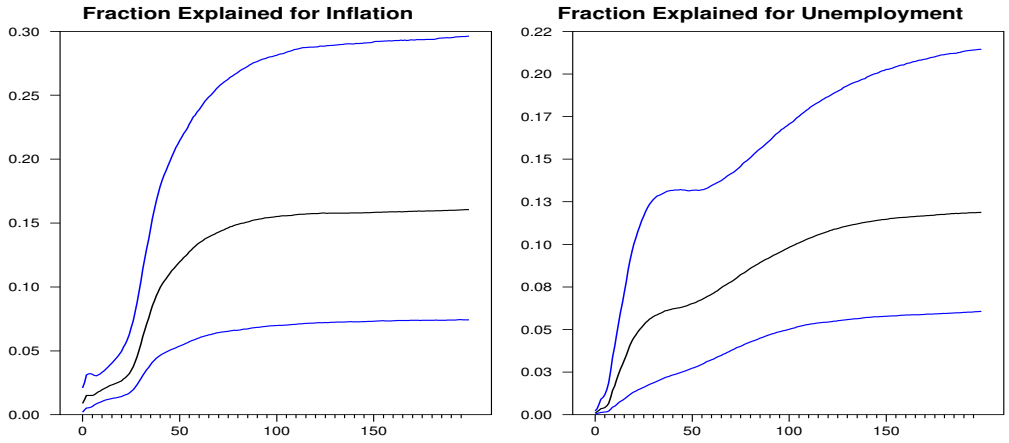
Figure 2: Variance Decomposition of Inflation and Unemployment



Fraction of FEV due to supply shocks.



Fraction of FEV due to demand shocks.



Fraction of FEV due to monetary policy shocks.

4. Using an alternative index of money supply

In this section we re-estimate the VAR model presented in section 2 by including a different index of money supply. We aim to check the sensitivity of the results obtained in previous section to alternative measures of the money stock included in the VAR model.

On this research topic, Kelly *et al.* (2011) have recently criticized the widespread use in empirical analysis of the official monetary aggregates, in particular of those indicators of the money stock based on narrow measure of money. In order to meet this shortcoming, the authors propose to utilize a new measure of stock of money which: (a) takes into account the monetary services exerted by monetary assets; (b) avoids the measurement errors that affect the official monetary aggregates.

Kelly *et al.* (2011) also maintain that the so-called liquidity puzzle, *i.e.* the decrease (instead of the expected increase) of the short-term nominal interest rates in response to a contractionary monetary policy shock, may arise as a consequence of the inclusion in the estimated VAR of wrong measures of the money supply.[5]

It is worth stressing that the empirical analysis undertaken in section 2 is not plagued by the liquidity puzzle. Nevertheless, in this section we want to explore the possibility that the results concerning the dynamic responses of inflation and unemployment to monetary policy shocks might be distorted by virtue of the particular choice for the stock of money. Of course, this sensitivity analysis is also useful in order to investigate the robustness of the evidence concerning the relative importance of the identified structural shocks in explaining the fluctuations of the variables at various horizons.

In figure 5 the dynamic responses of the variables to, respectively, aggregate supply, aggregate demand and monetary policy shock are reported. It is apparent that the results are largely similar to those obtained in the previous section. Indeed, the same conclusion of large similarity holds for the forecast-error variance decomposition and hence, in order to save space, we do not report the related figures.

However, after having documented the coincidence of the main results, it is important to point out that by using the Monetary Services Index (MSI) there emerges a different short-run response of money supply to a positive supply shock, *i.e.* a shock on the supply side producing a joint decrease in inflation and unemployment. The rate of growth of money remains mute, considering the confidence bands, at all horizons. Instead, when we include the more traditional monetary aggregate, $M2$, as in the previous specification of the VAR model, the rate of growth of money increases in response to the supply shock.

Undoubtedly, the dynamic response of money supply to the positive productivity shock, obtained by using the MSI monetary aggregate, appears more reasonable since it implies that the central bank does not change the rate of growth of money in response to the shock. Indeed, in the presence of a contraction in the unemployment rate caused by the positive supply shock, an acceleration in the money growth decided by the central bank (*i.e.* the result obtained in the previous section) would pose risks of overheating of the economy.

Summing up the main results of this section: productivity growth shocks are a relevant source of fluctuations of inflation and unemployment at all horizons, though it is confirmed

[5] We use the Monetary Services Index, MSI-M2, produced by the Federal Reserve Bank of Saint Louis (see Anderson and Jones, 2011). Given the availability of data for the period $1967:1-2011:12$, the estimated VAR model covers a slightly different sample period with respect to the estimated VAR of section 2.

that shocks on the supply side do not represent the only explanation for these fluctuations. Moreover, the presence of a significant liquidity effect characterizes the US economy in the postwar period. Further, including a Monetary Services Index as an indicator of the stock of money produces an increase in the qualitative profiles of the results, though leaving the main conclusions substantially unchanged.

5. Conclusion and some policy implications

In this paper, by using a small structural VAR model for the postwar US economy identified by sign restrictions, we have found that productivity growth shocks are an important, exogenous source of the long-run positive co-movement of inflation and unemployment.
Our results also show that monetary policy shocks are another source of the long-run evolution of the variables. However, these shocks are neither the exclusive nor the pre-eminent source, as is instead maintained by economic interpretations aligned with the Friedmanian tradition.
Thus according to our empirical analysis a first, important conclusion is that choices of the central bank concerning money growth and interest rates are capable of influencing not only nominal variables but also real variables. Moreover, these effects are exerted both in the short and in the long run.
We must add that the relative importance of monetary factors in shaping unemployment and inflation fluctuations at lower frequencies does not seem to rely on a potentially inappropriate choice of the measure of the money stock, since when we include in the estimated VAR model a divisia measure of money supply the main results of our empirical investigation are confirmed.
A second, important result shown by this investigation concerns the presence of a pronounced liquidity effect in the US economy since, by leaving free the response of the short-term nominal interest rate to an expected monetary supply contraction, we detect a statistically-significant increase of the interest rate. This result holds by utilizing, alternatively, two distinct indexes of broad monetary aggregates: $M2$ and the divisia monetary index.
Thus, as far as the liquidity puzzle is concerned, at least according to our results, it seems that its source lies more in uncorrect specification and identification of the VAR model rather than in measurement errors affecting the choice of the stock of money.
Turning to the main point of our investigation, *i.e.* looking for the main drivers of the fluctuations in inflation and unemployment at different frequencies, in our opinion the main conclusion arising from our empirical results is that any monothematic explanation of the long-run relation between inflation and unemployment is difficult to reconcile with US post-war data.
In particular, further research should be devoted to better clarify the channels and the mechanism through which accelerations in productivity growth translate their persistent effects in a decrease in the rate of growth of prices and in a reduction in the rate of unemployment, at medium and low frequencies.
More generally, our empirical results put into question an interpretation of the relationship between unemployment and inflation based on both "natural rate" and "NAIRU" models and thus, at least potentially, call for a rethinking of these theoretical models. "Potentially", since further independent evidence would be welcome to reinforce or, alternatively, to weaken

the results obtained in the present investigation.
We conclude with two notable policy implications of our results: (a) the important role of monetary policy in the stabilization of business cycle fluctuations is confirmed; (b) government policies and regulations aiming to stimulate technological innovation may contribute to reaching (and maintaining) full employment by contemporaneously keeping inflation under control. Indeed, the time-honoured Luddite view seems to be at odds with the data.

References

Anderson, R.G. and Jones B.E. (2011). A Comprehensive Revision of the U.S. Monetary Services (Divisia) Indexes. *Federal Reserve Bank of St. Louis Review*, **93**, 325 – 359.

Ball, L. and Mankiw G.N. (2002) The NAIRU in Theory and Practise. *Journal of Economics Perspectives*, **16**, 115 – 136.

Benigno, P., Ricci, L.A. and Surico P. (2015). Unemployment and Productivity in the Long Run: The Role of Macroeconomic Volatility. *Review of Economics and Statistics*, **97**, 698 – 709.

Berentsen, A. Menzio, G. and Wright R. (2011). Inflation and Unemployment in the Long Run. *American Economic Review*, **101**, 371 – 398.

Christiano, L. Eichenbaum, M. and Evans CL (1996). The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds. *Review of Economics and Statistics*, **78**, 16 – 34.

Doan, T.A. (2010). RATS User's Manual, Version 8, Estima, 1560 Sherman Avenue, Suite 510, Evanston, IL 60201.

Friedman, M. (1977). Inflation and Unemployment. *Journal of Political Economy*, **85**, 451 – 472.

Gomis-Porqueras, P., Julien, B. and C. Wang (2013). Optimal Monetary and Fiscal Policies in a Search-Theoretic Model of Money and Unemployment. *Macroeconomic Dynamics*, **17**, 1330 – 1354.

Grubb, D., Jackman, R. and Layard R. (1982). Causes of Current Stagflation. *Review of Economic Studies*, Special Issue, 707 – 730.

Haug, A.A. and King I. (2014). In the Long Run, US Unemployment Follows Inflation like a Faithful Dog. *Journal of Macroeconomics*, **41**,42 – 52.

Karanassou, M. and Sala H. (2010). The US InflationUnemployment Trade-off Revisited: New Evidence for Policy-Making. *Journal of Policy Modeling*, **32**,758 – 777.

Kelly, L.J., Barnett, W.A. and Keating J.W. (2011). Rethinking the Liquidity Puzzle: Application of a New Measure of the Economic Money Stock. *Journal of Banking and Finance*, **35**, 768 – 774.

Ireland, P.N. (1999). Does the Time-Consistency Problem Explain the Behaviour of Inflation in the United States? *Journal of Monetary Economics*, **44**, 279 – 291.

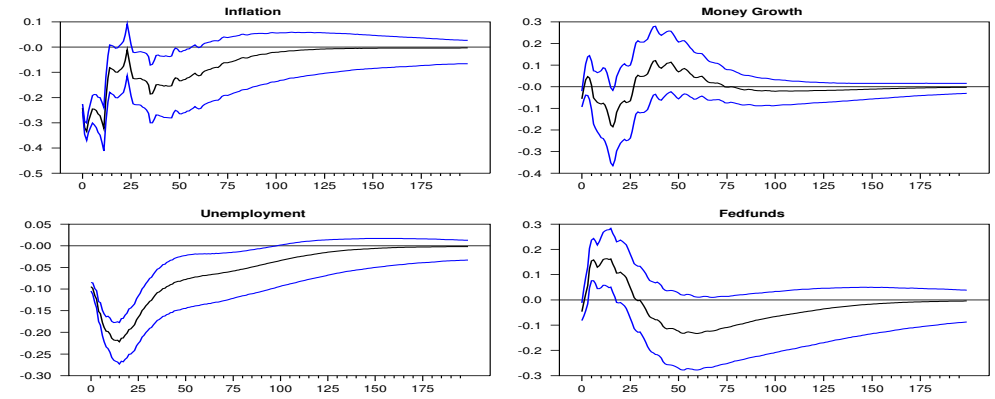
Lastrapes, W.D. and Selgin G. (1995). The liquidity Effect. Identifying Shot-Run Interest Rate Dynamics Using Long-Run Restrictions. *Journal of Macroeconomics*, **17**, 387 – 404.

Leeper, E.M. and Gordon D.B. (1992). Searching for the Liquidity Effect. *Journal of Monetary Economics*, **29**, 341 – 369.

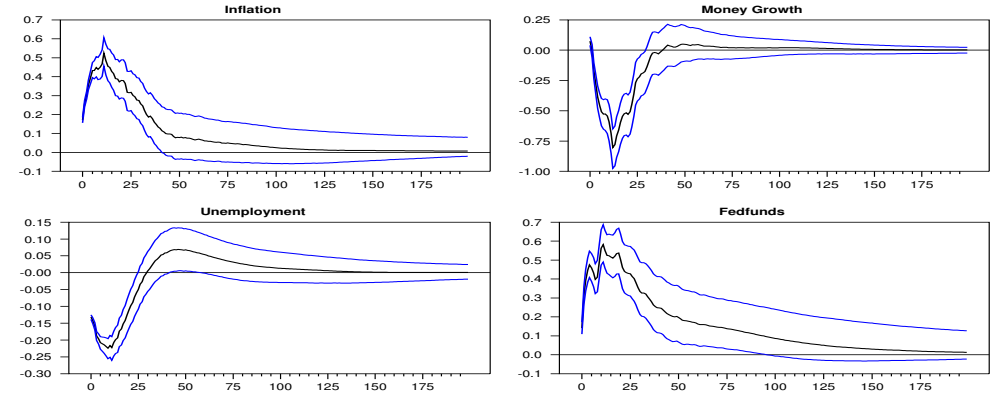
Liu, J.D., Nordman, D.J. and Meeker W.Q. (2016). The Number of MCMC Draws Needed to Compute Bayesian Credible Bounds. *The American Statistician*, **70**, 275 – 284.

Mountford, A. and H. Uhlig (2009). What Are the Effects of Fiscal policy Shocks? *Journal of Applied Econometrics*, **24**, 960 – 992.
Ribba, A. (2003). Short-run and Long-run Interaction between Inflation and Unemloyment in the USA. *Applied Economics Letters*, **10**, 373 – 376.
Ribba, A. (2006). The Joint Dynamics of Inflation, Unemployment and Interest Rate in the Unites States since 1980. *Empirical Economics*, **31**, 497 – 511.
Selgin, G., Beckworth, D. and B. Bahadir (2015). The Productivity Gap: Monetary Policy, the Subprimeboom, and the Post-2001 Productivity Surge. *Journal of Policy Modeling*, **37**, 189 – 207.
Sims, C.A. and Zha, T. (1999) Error Bands for Impulse Responses. *Econometrica*, **67**: 1113 – 1156.
Uhlig, H. (2005). What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure. *Journal of Monetary Economics*, **52**, 381 – 419.

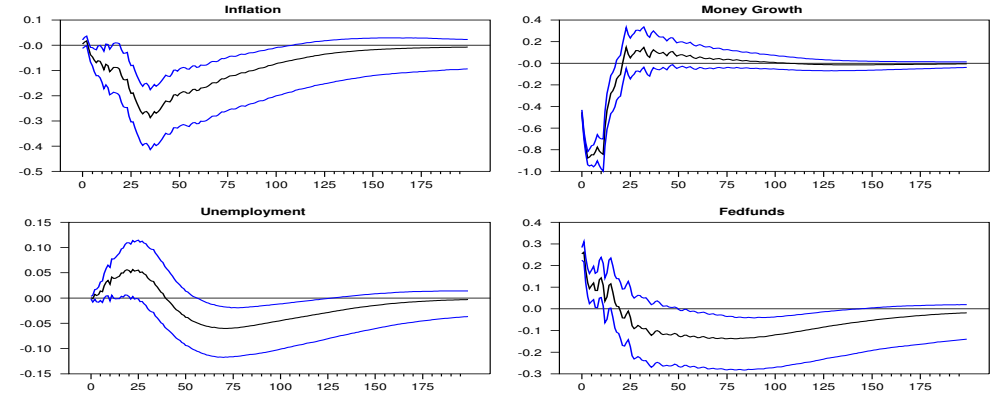
Figure 3: Responses of variables to the identified structural shocks. Alternative indicator of money supply.



Responses to Supply Shock



Responses to Demand Shock



Responses to Monetary Policy Shock

*Notes.*The estimated VAR includes a Monetary Services Index as a measure of the money stock. Median estimate with 68th percent confidence interval.