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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 main conclusion is that in the postwar US economy an important role has been played by supply shocks in shaping the long-run evolution of unemployment. Thus, it seems that this evidence is at odds with purely monetary explanation of the co-movement between inflation and unemployment.

JEL Classification: E32, E62, C32;

Keywords: Long-run Unemployment; Inflation; Structural VARs;

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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 recently argued that the long-run, positive relation between inflation and unemployment may be explained, both on a theoretical and on a empirical ground, by monetary factors. Although based on a different theoretical framework, the same conclusion was essentially reached by Ireland (1999).

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.

Thus, 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 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 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 minor role exerted by such shocks in driving the movements of inflation and unemployment at low frequencies.

Instead, 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. Nevertheless, the monetary shocks do not exhibit high persistence.

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.

Another interesting result provided by our investigation is that a contractionary monetary policy shock causes an increase of the interest rate in the short run, *i.e.* we find that a significant liquidity effect characterizes the US economy in the postwar period.

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:

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

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

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:

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

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)[2]. The assumption is that VAR errors are normal and that both prior and posterior density belong to the Normal-Wishart family. We take 10000 draws from the posterior, where each draw is subject to the numerical minimization associated to 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.

[2]See also Doan, (2010).

As far as the monetary policy shock is concerned, in this paper we do not follow the strategy pursued by Uhlig (2005) and by other researchers based on imposing sign restrictions even on the responses of inflation and interest rate. The logic behind Uhlig's strategy is to impose restrictions consistent with the conventional wisdom about the dynamic 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 effects produced by such monetary shock on the rate of unemployment. However, the important implication of Uhlig's strategy is 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.

Insert Table 1 about here

3. Dynamic responses

In figures $1-3$ 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, figure 2 reveals that 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 (cf. figure 3), 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.

Insert Figure 1 about here

Insert Figure 2 about here

Insert Figure 3 about here

In table 2 and 3 we report the results concerning the decomposition of variance 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 Friemanian 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 becomes the main factor behind the variability of unemployment at horizons comprised between 24 and 120 months. Further, after 200 months the productivity shock still explains around half of the total variability of unemployment.

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.

Insert Table 2 about here

Insert Table 3 about here

4. Conclusion

In this paper, by using a small structural VAR model for the postwar US economy identified by sign restrictions, we have found that the pre-eminent exogenous source driving the long-run evolution of unemployment is represented by productivity shocks.

Our results also show that monetary policy shocks are another source of the positive, long-run co-movement between inflation and unemployment; however, neither the exclusive

nor the pre-eminent one as instead maintained by economic interpretations aligned to the Friedmanian tradition.

More generally, the main conclusion arising from this investigation is that any monothematic explanation of the long-run relation between inflation and unemployment is difficult to reconcile with US postwar data.

Thus, it seems that theoretical frameworks need to incorporate an explanation of the channels 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.

Another important result shown by this investigation concerns the presence of a pronounced liquidity effect in the USA economy, since we detect an increase of the short-term interest rate in response to a contractionary monetary policy shock.

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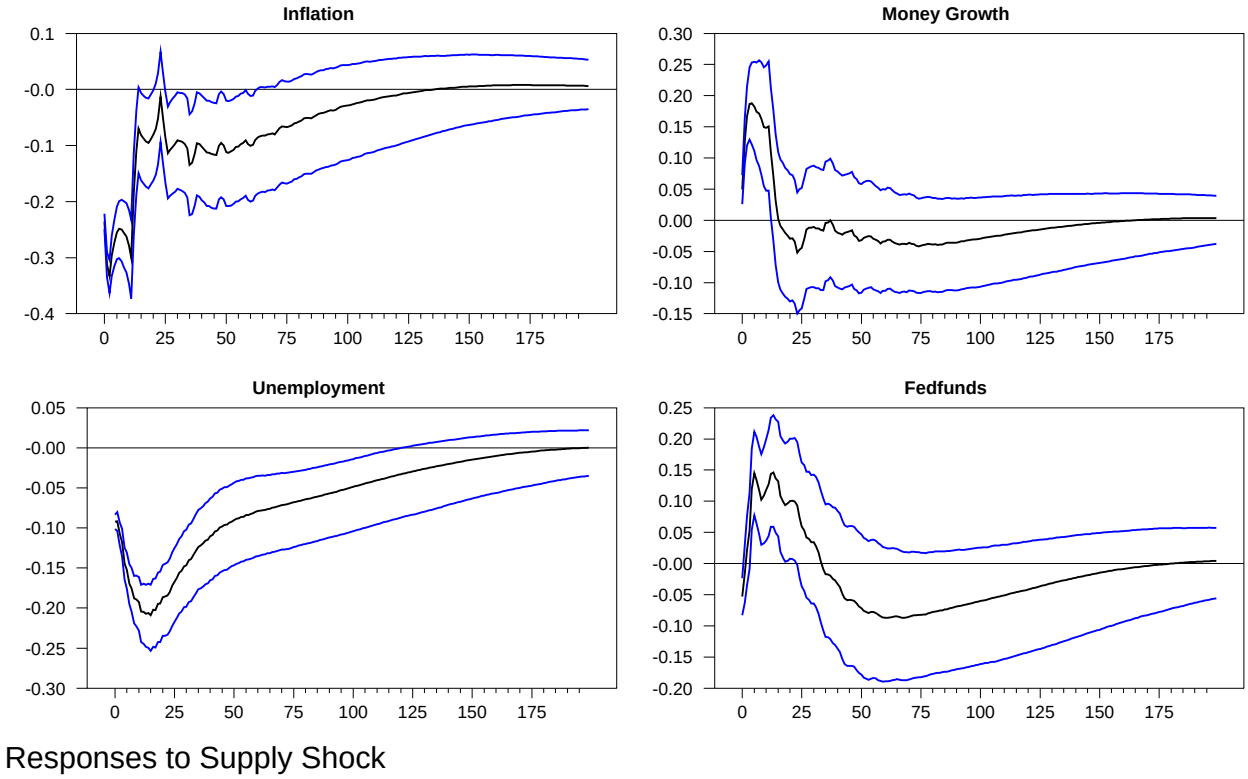

Figure 1: Responses of variables to a supply shock

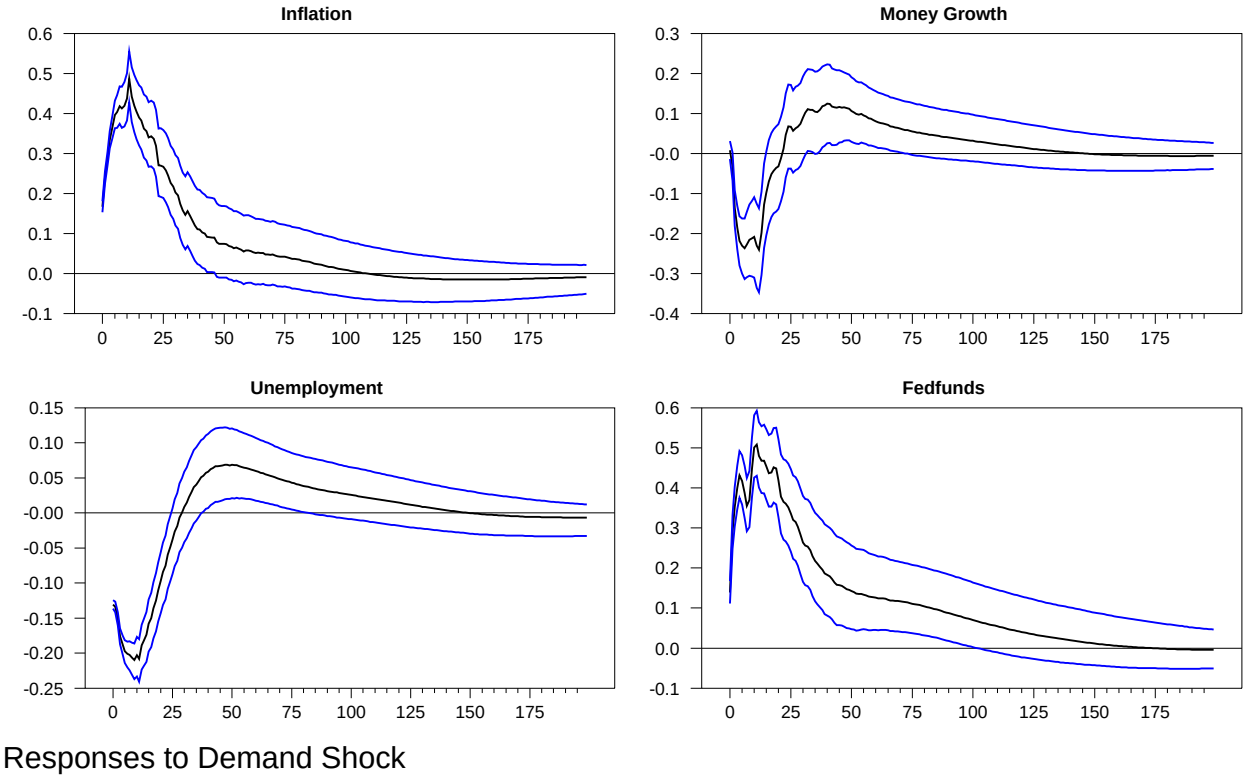

Figure 2: Responses of variables to a demand shock

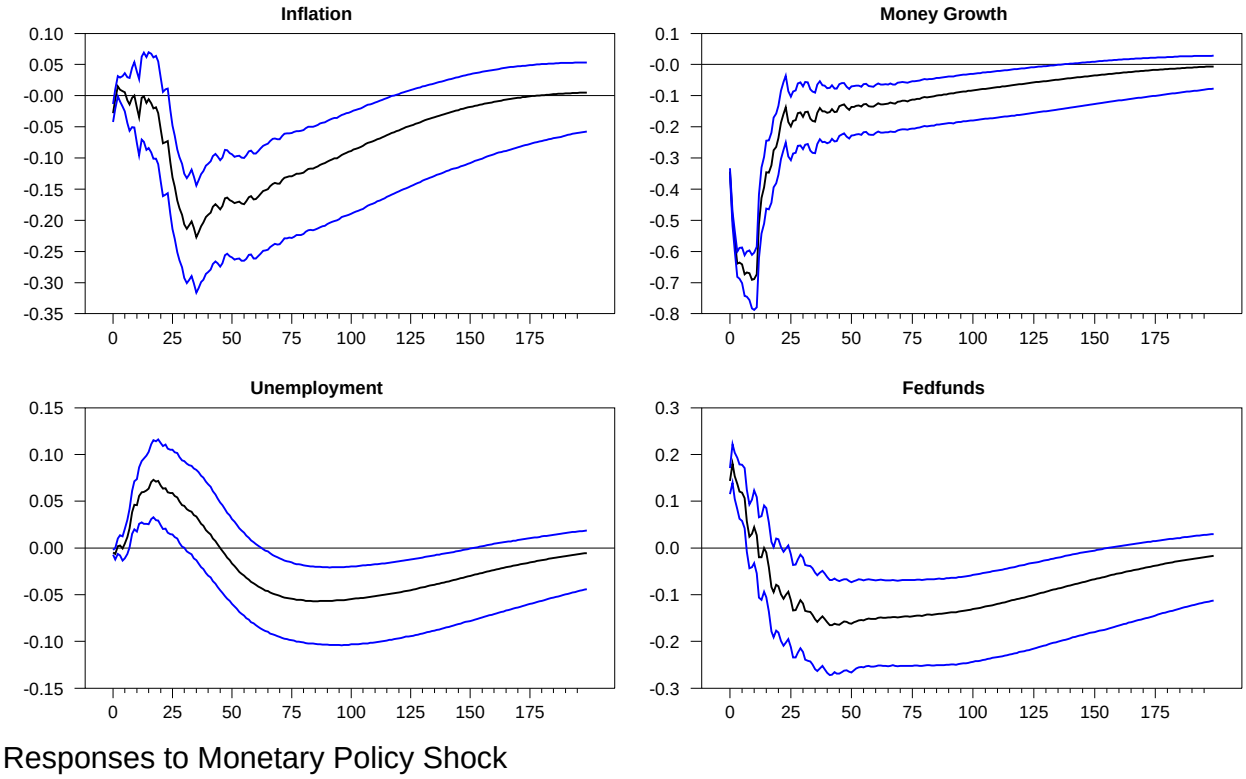

Figure 3: Responses of variables to a contractionary monetary policy shock

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.

Table 2. Fraction of the forecast error variance of unemployment due to supply, demand and monetary policy shocks.

Horizon	Aggregate Supply	Aggregate Demand	Monetary Policy
1	33.3	66.1	0.1
12	40.9	57.3	1.4
24	51.4	42.9	4.3
60	55.8	35.7	6.9
120	51.5	32.6	13.1
200	49.5	31.2	15.8

Note: The table presents the fraction of variability at various horizons which is due to the three shocks identified by sign restrictions.

Table 3. Fraction of the forecast error variance of inflation due to supply, demand and monetary policy shocks.

Horizon	Aggregate Supply	Aggregate Demand	Monetary Policy
1	65.6	33.2	0.9
12	35.1	64.2	0.5
24	23.6	73.8	1.7
60	21.4	56.9	18.3
120	21.7	49.2	24.4
200	22.4	47.6	25.2

Note: See Table1.

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