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Productivity Growth Shocks and Unemployment in the Postwar US Economy

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Abstract. In recent years growing attention has been paid to the dynamic interaction between productivity growth and unemployment in the US economy. In this paper we aim to investigate the effects of productivity growth shocks on unemployment, both in the short run and in the medium - long run. We adopt a structural VAR approach and find that, in the last decades, productivity shocks have exerted persistent effects on unemployment. Moreover, these shocks have played an important role in explaining the fluctuations in the unemployment rate at different frequencies. This conclusion seems to be robust to alternative identification strategies of the structural shocks.

JEL Classification: C32, E24

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1. Introduction

In this paper we want to investigate the dynamic relation at different horizons between productivity growth and unemployment in the postwar US economy.

It is well known that in the 1970s adverse supply shocks were associated with a persistent increase in unemployment. Symmetrically, in the second half of the 1990s, the speed-up in productivity growth accompanied the decrease in the unemployment rate.

Grubb *et al.* (1982) were among the first to offer an explanation of the observed correlation in almost all the industrialized countries among the productivity growth deceleration of the 1970s and the joint increase of inflation and unemployment.

However Blanchard (1989), by using a structural VAR model identified in coherence with a Keynesian view of economic fluctuations, reached a different conclusion. Considering the period 1965 – 1986, he found that in the US economy, following a productivity shock there was an increase in unemployment for some quarters.

As far as more recent decades are concerned, Ball and Moffitt (2002) presented evidence in favour of a significant role played by the acceleration in productivity growth of the 1990s in shaping the joint evolution of inflation and unemployment towards a decrease in that decade. Instead, in Ribba (2003) an empirical investigation was undertaken in order to separate transitory, aggregate demand shocks, moving inflation and unemployment in opposite directions in the short run, and permanent supply shocks, causing movement in the same direction for inflation and unemployment in the long run¹.

Ball and Mankiw (2002) and Ribba (2006) present empirical evidence on the low-frequency co-movements between inflation and unemployment, by structurally interpreting these co-movements in terms of a causal relation running from productivity growth to unemployment.

In a very recent paper, Benigno *et al.* (2015) have suggested the existence of a long-run relation between the volatility in productivity growth and long-run unemployment.

An alternative, theoretical interpretation of the dominant factors driving unemployment (and inflation) in the long run has recently been offered by Berentsen *et al.* (2011). The authors argue that a positive long-run relation between inflation and unemployment may be explained by monetary factors combined with a search-and-bargaining approach. Notice that the pre-eminent role attributed to monetary factors is in line with the Friedmanian interpretation of the stagflation which characterized the 1970s. (cf. Friedman 1977).

Building on Berentsen *et al.*, Gomis-Porqueras, Julien and Wang (2013) develop a search-theoretic models of money and unemployment in order to derive optimal fiscal and monetary policies. In particular, they show that in a framework with search-and-bargaining frictions some market inefficiencies can be overcome with proper fiscal policies.

A monetary explanation of the long-run evolution of the rate of unemployment has also been offered by Ireland (1999). In Ireland's interpretation, the joint positive long-run relation between unemployment and inflation is explained by the inability of the central bank to pursue a credible low-inflation target.

¹However a different long-run story might have characterized the European economy in the 1980s and in the first part of the 1990s. For example in Ribba (2007) evidence is provided for Italy of a long-run increase in the unemployment rate driven, among other factors, even by contractionary monetary policy shocks.

Although Beyer and Farmer (2007) have criticized Ireland's explanation of the low-frequency movements of unemployment, even their interpretation rests on a dominant role played by shocks on the side of the aggregate demand. More precisely, they identify the roots of the simultaneous increase of inflation and unemployment in 1970s in a downward drift which affected the real interest rate.

On the empirical side, Haug and King (2014) have claimed in a recent investigation that their results concerning the US economy seem to be consistent with a monetary interpretation of the long-run behaviour of unemployment.

Thus, in the present chapter, we aim to investigate the response of unemployment to productivity growth shocks. Moreover, we want to measure the contribution of productivity growth shocks in composing the variability of unemployment at various horizons. We accomplish this task by estimating and identifying a bivariate structural VAR model, using a sample data covering the period 1960 : 1 – 2014 : 4. Indeed, as stressed by Hutton (2007), empirical research investigating the long-run effects of productivity growth on macroeconomic variables should, ideally, utilize samples covering longer periods than just a few decades.

Our main findings can be summarized as follows: (1) productivity growth and unemployment rate exhibit a negative correlation, both at business cycle frequencies and in the medium run; (2) a positive productivity growth shock moves the unemployment rate towards a significant reduction which lasts for many quarters; (3) the productivity growth shocks explain an important part of the variability of unemployment at various horizons; (4) A relevant role in driving unemployment fluctuations is also played by aggregate demand shocks, nevertheless structural disturbances on the demand side cause short-run movements of productivity growth and unemployment rate in the same direction.

Indeed these results seem to be robust to alternative identification strategies of the structural shocks. For, we first identify the productivity growth shock by imposing a recursive structure to the bivariate VAR model including productivity and unemployment, and after, in order to check for the robustness of the conclusion reached, we adopt a more agnostic approach in the spirit of Uhlig (cf. Uhlig 2005) and identify the productivity shock by imposing sign restrictions on the responses of unemployment.

It is worth stressing that although by adopting a sign restrictions approach we detect an increase in the persistence of the effects of productivity growth shocks on unemployment, as a whole the two identification strategies lead to quite similar results.

Let us also note that in the presence of a pre-eminent or, in the limit, exclusive role of monetary factors, one should not expect to detect in the data any significant role played by productivity growth shocks on unemployment fluctuations, at least at lower frequencies. Thus, given the empirical results obtained in the present research, our conclusion appears to be in contrast with researches pointing to a pure monetary explanation of the medium to long-run co-movement of inflation and unemployment.

Further, we want to point out that our empirical results might also be interpreted as a call for theoretical modelling to incorporate the influence of productivity growth on unemployment at different frequencies.

The rest of the chapter is organized as follows. In section 2 we present some facts concerning the correlations at different leads and lags between productivity growth and

unemployment. Section 3 presents the strategy of identification of the VAR model together with the dynamic responses of the two variables to the identified shocks. In this context, we complement the impulse-response function analysis with the decomposition of variance at different horizons, in order to measure the relative importance of the structural shocks.

In section 4 we undertake a sensitivity analysis in order to check the robustness of the results obtained in section 3 and thus we identify the productivity growth shock imposing sign restrictions on the response of unemployment.

Section 5 concludes and some implications of the results obtained are also drawn.

2. Some Simple Facts on the Joint Evolution of Productivity Growth and Unemployment in the Postwar US Economy

In figure 1 productivity growth and unemployment rate in the US economy, for the sample period 1960 : 1 – 2014 : 4, are reported.

We consider the annual rate of growth of labor productivity and the civilian unemployment rate. Both the series are taken from FRED at the St. Louis FED Web site.

Obviously, it is not possible to infer any causal relationship characterizing the variables by simply inspecting their joint evolution. An attempt to identify the causal relations between the two variables will be undertaken in the subsequent sections, by utilizing the structural VAR methodology. Nevertheless, some simple facts clearly emerge from the descriptive analysis conducted in the present section.

The first stylized fact concerns the strong, negative relation between the two variables in the first part of the 1970s, when a sudden and deep decline in productivity growth is associated with an increase in the unemployment rate. The same negative relation is also apparent in the second half of the 1990s, when an acceleration in the rate of growth of productivity is associated to a tendency of strong decrease in the unemployment rate.

However, an importance difference characterizing the 1990s with respect to the 1970s consists in the smoother process which exhibits both the increase in productivity growth and the decrease of the unemployment rate in the more recent decade.

Another interesting fact which emerges from this simple graphical inspection concerns the positive relation between the two variables characterizing other historical periods. In particular, this positive co-movement is apparent in the first part of the eighties and in the more recent period, 2008 – 2014, in which the US economy was affected by the so-called Great Recession. This evidence seems to suggest that in the presence of shocks arising on the side of aggregate demand, productivity growth and unemployment move in the same direction.

Once again, we stress that it is difficult to draw sound conclusion on the causality directions in the observed movements of the variables without the identification of a structural model. As a consequence, we will try to check this conjecture on the dynamic effects exerted by aggregate demand shocks on productivity growth and unemployment in the next section, by utilizing a more structural approach.

In table 1 we present the cross correlations of productivity growth and unemployment at various leads and lags. The results show clear evidence of a negative relation between the two variables, both in the short and in the medium run.

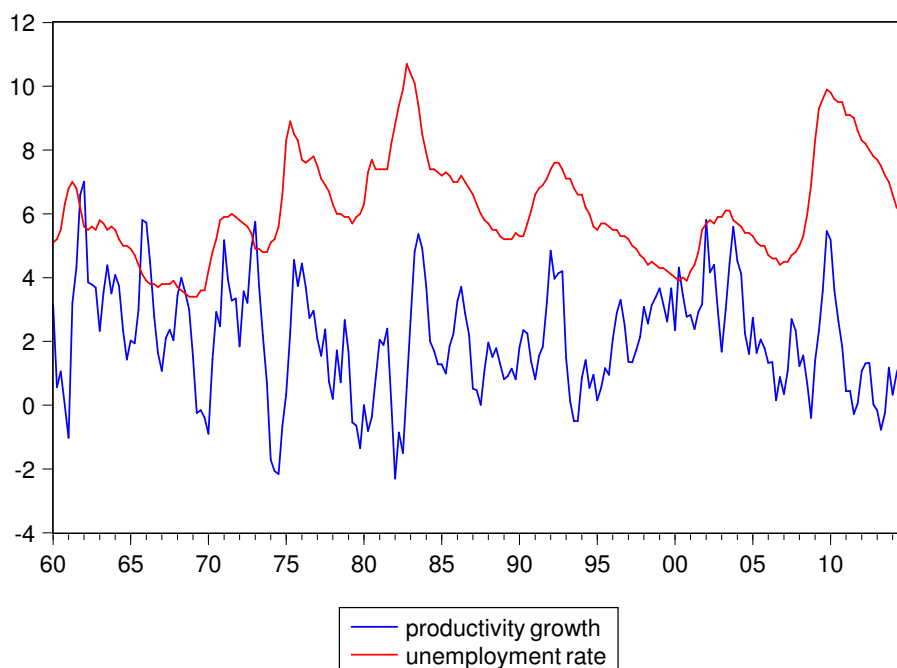


Figure 1: Productivity growth and unemployment rate in the US economy 1960:1 - 2014:4

Table 1. Measuring the co-movements of productivity growth and unemployment in the US economy.

Lag						Lead					
0	4	8	12	24	36	0	4	8	12	24	36
-0.071	-0.02	-0.32	-0.26	-0.092	.003	-0.071	-0.29	-0.32	-0.31	-0.14	.10

Note: Cross correlations of productivity growth and unemployment rate at various leads and lags are reported for the sample period 1960 : 1 – 2014 : 4.

As shown in table 1, there is evidence of positive cross correlations only at lead and lag of 36. Instead, all the other correlations, from lead and lag 0 to 24, have negative signs.

The maximum values are obtained, respectively, at lag 12 (-.26) and at lead 8 (-.32).

3. The estimated structural VAR model

A bivariate VAR model for the US economy is estimated, covering the sample period 1960 : 1 – 2014 : 4. It includes the labor productivity growth and the rate of unemployment. We start with the estimation of the reduced form VAR model:

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

where for a VAR of order p , $A(L) = \sum_{i=1}^p A_i L^{i-1}$. We take, in accord with the Schwartz criterion, $p = 5$. 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 2×1 vector of error terms, such that $E(e_t) = 0$ and $E(e_t e_t') = \Sigma_e$.

In order to fix notation, the 2×1 vector X_t is given by:

$$X_t' = (g_t \quad u_t)$$

where g_t is the annual rate of growth of labor productivity and u_t is the civilian unemployment rate.

Given an assumption of stationary variables included in X_t , we can write the following reduced-form moving average representation of the VAR model:

$$X_t = \gamma + C(L)e_t \quad [2]$$

where $C(0) = I$.

We recover the structural shocks by imposing a (contemporaneous) recursive structure to the estimated VAR model. The structural moving-average representation is given by:

$$X_t = \gamma + B(L)\eta_t \quad [3]$$

Where $B(L) = C(L)B$ and $\eta_t = B^{-1}e_t$. B is the Cholesky factor of Σ_e , *i.e.* is the unique lower triangular matrix such that $BB' = \Sigma_e$. η_t is the 2×1 vector of orthonormal shocks.

Thus we are imposing the following restriction: an unexpected increase in the unemployment rate does not influence the productivity growth within the period (one quarter in our sample data). Moreover, by interpreting the structural shock obtained by the VAR unemployment equation as an aggregate demand shock, it follows that the zero, contemporaneous restriction implies imposing that an aggregate demand shock does not cause modification in the rate of growth of labor productivity in the current quarter.

In figure 2 the impulse-response functions are reported.

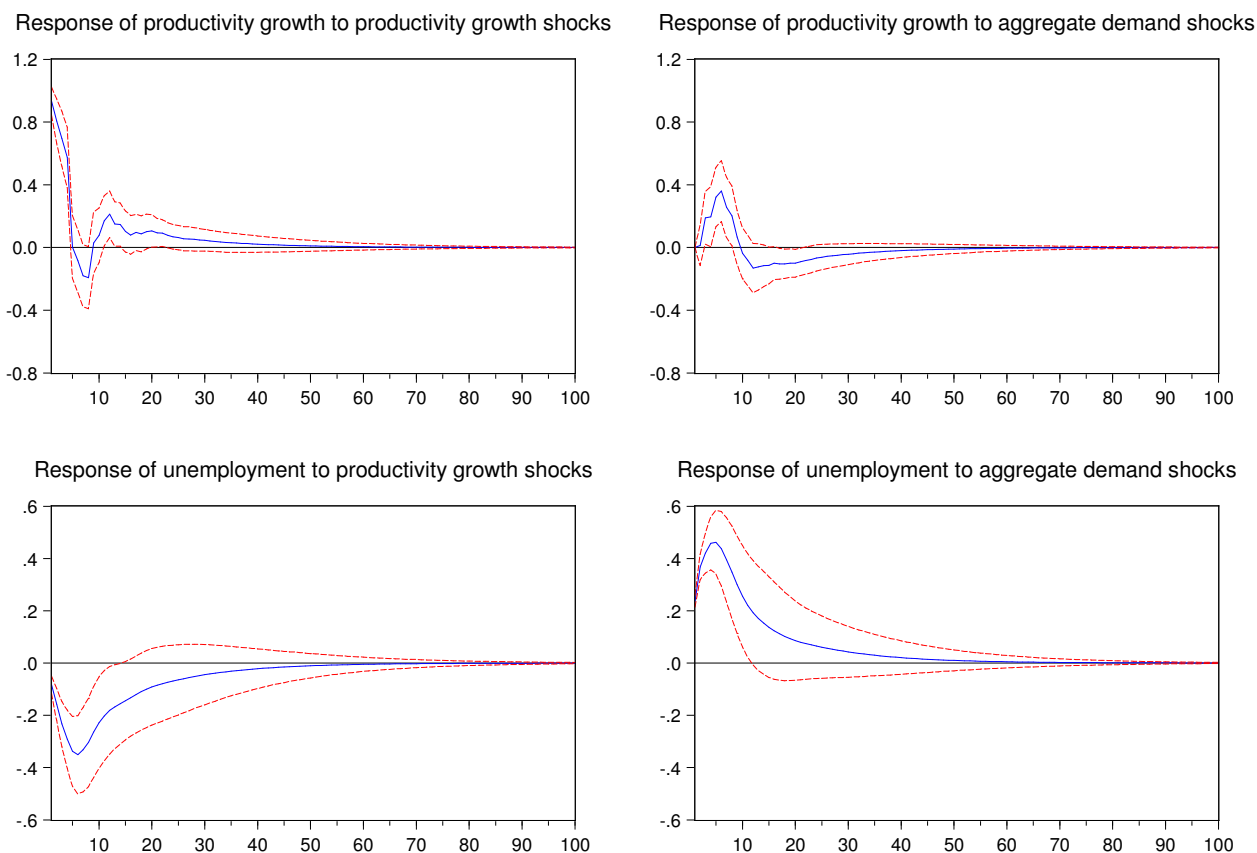


Figure 2: Responses of variables to the identified shocks

As shown in figure 2, there is a significant, negative effect on unemployment of a positive productivity growth shock. No less importantly, this negative effect is also quite persistent, since it requires around forty quarters to vanish. To be more precise, the median response of unemployment to the productivity shock exhibits this persistent effect. However, taking into account the confidence bands, the response becomes statistically non-significant after around fifteen quarters.

A different conclusion was instead reached by Blanchard (1989) in an investigation concerning the US economy for the period 1965 : 1 – 1986 : 4. The author found, by identifying a structural VAR model in the spirit of the Keynesian view of economic fluctuations, that a positive productivity shock causes a temporary increase in unemployment.

As far as the aggregate demand shock is concerned, an unexpected reduction in aggregate demand, *i.e.* an unexpected increase in unemployment, causes a temporary increase, which lasts for around ten quarters, in productivity growth. Hence, we detect a good deal of persistence even in the shocks on the aggregate demand side.

It is important to point out that this structural analysis seems to reinforce the conclusion reached in the previous section, based on a descriptive analysis, of a positive relation induced by aggregate demand movements between productivity and unemployment.

Thus, on the basis of this analysis, the conclusion is that fluctuations in the rate of unemployment are significantly driven by movements in the productivity growth, both in the short and in the medium run. Another important conclusion is that also shock on the demand side play a relevant role in explaining the fluctuations in the rate of unemployment. Of course, the relevance of aggregate demand shocks is far from surprising and a subsequent step will be to measure the relative importance of these two structural shocks at different horizons.

Once analyzed the impulse-response functions, a potentially interesting and complementary analysis concerns the decomposition of the forecast error variance.

The structural representation [3] allows the error in forecasting X_t for each horizon s to be built:

$$X_{t+s} - E_t X_{t+s} = B_0 \eta_{t+s} + B_1 \eta_{t+s-1} + B_2 \eta_{t+s-2} + \dots + B_{s-1} \eta_{t+1} \quad [4]$$

From [4] and given the orthonormality of the structural disturbances, the variance of the forecasting error is:

$$Var(X_{t+s} - E_t X_{t+s}) = B_0 B_0' + B_1 B_1' + B_2 B_2' + \dots + B_{s-1} B_{s-1}' \quad [5]$$

By using equation [5] it is thus possible to decompose the total variance of the forecast error, for each variable, due to the variance of each structural shock. Clearly we would like to use [5] in order to measure the relative important importance of productivity growth shocks in composing the variability of unemployment at various horizons.

The main results are reported in table 1.

Table 1. Fraction of the forecast error variance of the rate of unemployment attributable to productivity growth shocks at different horizons.

Horizon						
1	4	8	12	24	36	60
11.0	22.8	32.7	35.0	36.9	37.2	37.3

Note: The total variance of the forecast error for unemployment is computed and then decomposed in the part attributable to each structural shock (cf. formula [5]). The table presents the fraction of variability at various horizons which is due to the productivity growth shock.

At horizons comprised from one quarter to one year the productivity growth shock explains around one fifth of the total variability of unemployment. However, there is an

increase in the subsequent periods and at horizons from 24 to 60 quarters the variance explained is around 37 percent. Hence a relevant, though not dominant, role is played by productivity growth shocks in explaining the variability of unemployment at different frequencies.

4. A more agnostic approach to identification of productivity growth shocks

In this section we provide an alternative strategy of identification of the productivity growth shock, based on sign restrictions.

Let us start with the estimation of the reduced form:

$$X_t = \mu + A(L)X_{t-1} + e_t \quad [6]$$

where, as stated in section 3, for a VAR of order p , $A(L) = \sum_{i=1}^p A_i L^{i-1}$, with $p = 5$ in this context. e_t is the 2×1 vector of error terms, such that $E(e_t) = 0$ and $E(e_t e_t') = \Sigma_e$.

We obtain the identification of the productivity growth shock in the following way: given the relation between the error terms, e_t , and the exogenous macroeconomic shocks, ϵ_t , $e_t = F\epsilon_t$, 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; since $E(\epsilon_t \epsilon_t') = I$, *i.e.* the vector contains orthonormal variables, and given $FF' = \Sigma_e$, we identify a set of impulse vectors, $f^1 \dots f^n$, such that $f^i = F_i \alpha^i$, where $\|\alpha^i\| = 1$, which is consistent with some plausible macroeconomic hypothesis.

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 $m = 2$, we identify $n = 1$ one single economic shock.

In particular, we impose the following sign restriction: the response of unemployment to a positive productivity growth shock is negative for 4 quarters.

It is important to note that this identification strategy allows a set of impulse vectors consistent with the imposed sign restrictions to be selected. Hence, in order to select a unique set of impulse vectors we apply a penalty function (cf. Mountford and Uhlig 2009).

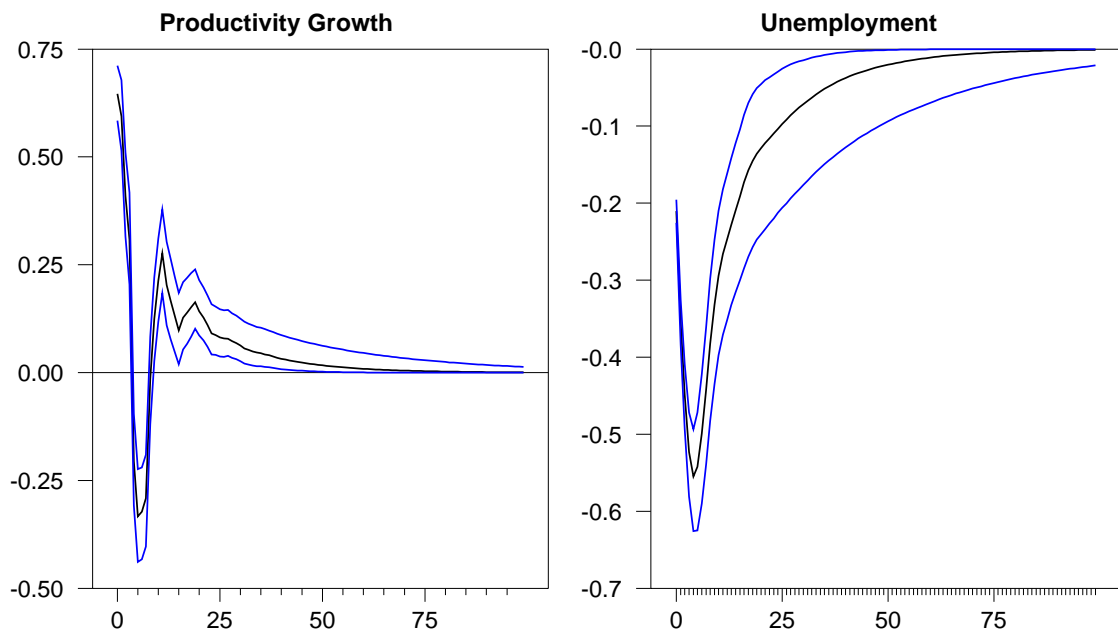
We calculate the confidence bands by using the Bayesian approach proposed by Sims and Zha (1999)². The assumption is that VAR errors are normal and that both prior and posterior density belong to the Normal-Wishart family. We take 10000 draws from the posterior, where each draw is subject to the numerical minimization associated to the penalty function.

Thus we recover the structural disturbance by imposing that an unexpected increase in productivity causes a reduction in the rate of unemployment for some quarters.

In figure 3 the response of the rate of unemployment to the productivity growth shock is reported. More precisely, we report the median responses of the variables to the identified shock, together with the 16th and 84th percentiles.

Instead figure 4 presents the results concerning the variance decomposition analysis.

²See also Doan, (2010).



Responses to Productivity Growth Shock

Figure 3: Responses of variables to a productivity growth shock identified by sign restrictions

There are some interesting features of this analysis which deserve attention.

The most important is represented by the confirmation of the qualitative profile of the dynamics effects exert by productivity growth shocks on unemployment, in line with the results obtained in the previous section, by imposing a recursive structure to the VAR model.

The second, quite interesting feature of the response of the unemployment rate to a productivity growth shock, concerns the increase in the persistence detected by adopting a sign restrictions approach, since the effects exerted on the rate of unemployment become statistically non-significant only after 35 quarters.

Further, this conclusion is reinforced if we concentrate attention on the median response of unemployment, which shows a decrease in the unemployment rate following a productivity shock which lasts for 65 periods.

Thus there is also some evidence of long-run effects of productivity growth on unemployment.

Summing up: the sensitivity analysis conducted in this section points to the confirmation of the relevant role played by productivity growth in shaping the evolution of the unemployment rate in the US economy in the last 50 years.

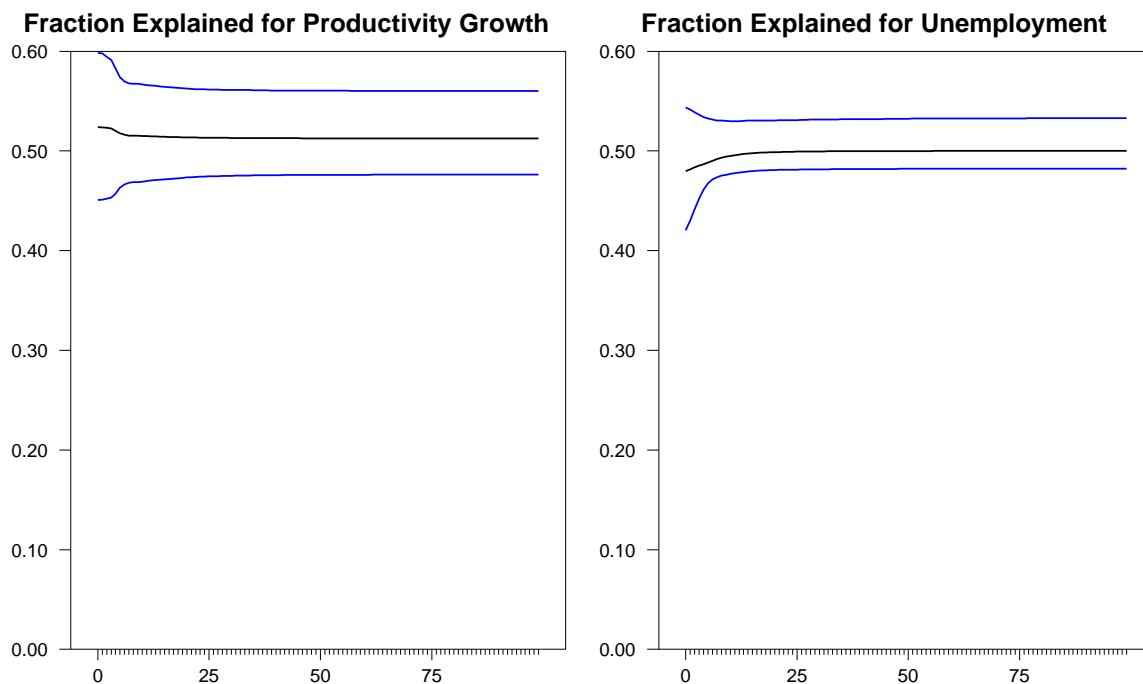


Figure 4: Fraction of the forecast error variance of the variables attributable to productivity growth shocks at different horizons.

The variance decomposition analysis, based on the sign restrictions approach and reported in figure 4, shows that the productivity growth shock explains a relevant part of the variability in the rate of unemployment, both at business cycle frequencies and at lower frequencies.

Indeed, it is important to note that by adopting a more agnostic approach to the identification of the structural shocks, the relative importance of productivity in composing the variability of unemployment at different horizons increases, in comparison to the recursive identification strategy previously adopted. For, the productivity growth shock, according to this analysis, explains around 50 percent of the forecast-error variance of unemployment at almost all frequencies.

Moreover, we point out that, as shown in figure 4, the estimated confidence bands do not add particular uncertainty in the interpretation of the main results, given their relatively moderate amplitude.

However, it is worth stressing that our results, at least in this bivariate context, imply that both shocks, on the supply side and on the demand side, play a relevant role in driving unemployment rate fluctuations.

Summing up: from a qualitative point of view, the results of this section confirm that the productivity growth shocks have played a significant role in shaping the evolution of the rate of unemployment in the postwar period and that there is a large convergence of results provided by the two alternative identification strategies.

5. Conclusion

In this empirical investigation we have tried to shed some light on the dynamic relation between productivity growth and unemployment in the postwar US economy. We have used a bivariate structural VAR model and our main finding is that productivity growth shocks have represented an important, exogenous source of fluctuations of the unemployment rate, both in the short and in the medium run in the last fifty years. More precisely, a positive productivity growth shock causes a persistent decrease of unemployment and this contraction in the rate of unemployment remains significant for many quarters.

This result revealed itself to be robust to alternative identification strategies of the structural shocks, since the results obtained by imposing a recursive structure with productivity growth ordered first are similar to those obtained by imposing sign restrictions on the responses of the unemployment rate.

Although the variance decomposition analysis has shown that a relevant role in shaping the evolution of unemployment has been played by productivity shock, unexpected movements on the aggregate demand side are also an important source of fluctuations of unemployment. In particular, by adopting a sign restrictions approach to the identification of the productivity growth shock, we find that there is a very persistent effect of this disturbance on unemployment and, moreover, that around fifty percent of the variability of unemployment at various horizons is explained by productivity growth shocks.

As far as long-run effects of productivity growth shocks are concerned, by adopting a sign restrictions identification strategy clear evidence emerges of a long-run effect exerted on the rate of unemployment, since 65 quarters are required before the dynamic effects of the structural shock vanish.

It is important to stress that our results point to an important distinction between the dynamic effects exerted on the two variables by shocks originated on the aggregate supply side and, alternatively, on the aggregate demand side. For, we find that in the first case productivity growth and unemployment move in opposite directions whereas, in the second, they move in the same direction.

Thus, as a whole, on the basis of the evidence presented in this chapter, we are led to conclude that one-single explanation of the fluctuations of unemployment at different frequencies in the postwar US economy, relying on monetary or alternatively real factors, does not fit the data well.

Instead, according to our empirical investigation, it seems that theoretical frameworks need to incorporate an explanation of the channels through which unexpected changes in productivity growth translate their persistent effects in a decrease in the rate of unemployment, at medium and low frequencies.

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