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On the Long-run Neutrality of Demand Shocks

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Abstract

Long run neutrality restrictions have been widely used to identify structural shocks in VAR models. This paper revisits the seminal paper by Blanchard and Quah (1989), and investigates their identification scheme. We use structural VAR models with smoothly changing covariances for identification of shocks. The resulted impulse responses are economically meaningful. Formal test results reject the long-run neutrality of demand shocks.

Key Words: Smooth transition VAR models, identification via heteroskedasticity, long-run neutrality, aggregate demand, aggregate supply

JEL classification: C32

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1 Introduction

In their seminal paper, Blanchard and Quah (1989) propose to identify demand and supply disturbances based on the assumption that the aggregate demand shocks have no long run effects on output. Long run neutrality restrictions have since been widely used to identify structural shocks in VAR models. Examples include Gali (1999) and Francis and Ramey (2005).

However, the assumption of long-run neutrality of aggregate demand shocks is not beyond doubt. Blanchard and Quah (1989) themselves raise concerns that this assumption might not be correct. Through capital accumulation or learning by doing, the demand disturbances can lead to long-lasting effects on output. Recently, Keating (2013) finds that the aggregate demand shock had long-run effects on output in the pre-World War I economies.

In order to shed more light on this issue, in this paper we relax the long-run neutrality assumption on demand shocks, and instead use information from changes in volatility to identify shocks following a recently developed method by Lütkepohl and Netšunajev (2014).[1] This method is advantageous to capture the volatility shifts in the data due to the Great Moderation. Combing the distinct relative variances with the intuition that the demand shocks push output and unemployment to opposite directions, we achieve identification of the demand and supply shocks via heteroskedasticity. The resulted impulse responses are similar to those by Blanchard and Quah (1989). However, the demand shocks' effects on output do not die out in the long run. A formal test further show that the long-run neutrality restriction is rejected by the data. These results suggest that supply shocks are not the only sources of permanent shifts in output.

[1] Other literature that use changes in volatility for identification include Rigobon (2003), Lanne and Lütkepohl (2008) and Bacchiocchi and Fanelli (2015).

2 Identification Strategies

2.1 Standard Structural Identification

In this subsection, we first show how shocks in a structural VAR model are commonly identified. Consider the baseline VAR of order p (VAR(p)) of the form:

$$y_t = \nu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t, \tag{1}$$

where $y_t = (y_{1t}, \ldots, y_{Kt})'$ is a vector of observable variables, the A_i are $(K \times K)$ coefficient matrices, ν is a $(K \times 1)$ constant term and the u_t are K-dimensional serially uncorrelated reduced form residuals with mean zero and covariance matrix Σ_u. Suppose we denote the structural residuals by ε_t. They can be obtained from the reduced form residuals u_t by a linear transformation:

$$u_t = B\varepsilon_t \quad \text{or} \quad \varepsilon_t = B^{-1}u_t. \tag{2}$$

The matrix B contains the instantaneous effects of the structural shocks on the observed variables.

To proceed with impulse response analysis or forecast error variance decomposition, one has to first identify the shocks based on certain economic assumptions. The standard approach is to impose restrictions on B (or on objects incorporating B) to pin down the economic shocks of interest. These restrictions may be zero restrictions indicating that a specific shock does not have an instantaneous effect on a certain variable, or a restriction on the long-run effects of a structural shock. In the setup by Blanchard and Quah (1989), they are imposed on the matrix of long-run effects of structural shocks that is given by:

$$\Xi_\infty = (I_K - A_1 - \cdots - A_p)^{-1}B,$$

assuming that the inverse exists.

2.2 Identification via Smoothly Changing Covariances

This paper follows the recently developed approach by Lütkepohl and Netšunajev (2014) for identification of shocks. Instead of relying on the long run restric-

tion by Blanchard and Quah (1989), we suppose that u_t is a heteroskedastic error term with smoothly changing covariances:

$$E(u_t u_t') = \Omega_t = (1 - G(\gamma, c, s_t))\Sigma_1 + G(\gamma, c, s_t)\Sigma_2 \tag{3}$$

where Σ_1 and Σ_2 are distinct covariance matrices and $G(\gamma, c, s_t)$ is a transition function. The function depends on a parameter (vector) γ and c as well as a transition variable s_t. We model the transition in variances using a logistic transition function proposed by Maddala (1977) with time being the transition variable, i.e., $s_t = t$, so that we can capture endogenously the volatility changes in the data known as the Great Moderation.

$$G(\gamma, c, t) = (1 + \exp[-\exp(\gamma)(t - c)])^{-1} \tag{4}$$

with $\exp(\gamma) > 0$ for all values of γ.

The transition of the volatility from the covariance matrix Σ_1 to Σ_2 can be used for identification purposes. Consider the decomposition

$$\Sigma_1 = BB' \text{ and } \Sigma_2 = B\Lambda B', \tag{5}$$

where $\Lambda = \text{diag}(\lambda_1, \ldots, \lambda_K)$ is a diagonal matrix with positive diagonal elements. Apart from changes in sign of the columns of B this decomposition is unique for a given ordering of the λ_i if these quantities are all distinct (see Lütkepohl (1996, Section 6.1.2 (10)) or Theorem 7.6.4 in Horn and Johnson (2013)). The diagonal elements of the Λ matrix can thus be interpreted as variances of structural shocks in the final regime relative to the initial regime. We refer to the smooth transition structural VAR model through the acronym ST-SVAR(p) with p defining number of lags.

If the uniqueness conditions for B are satisfied, any restrictions imposed on B or Ξ_∞ in a conventional SVAR framework become over-identifying and can be tested against the data. Various studies use likelihood ratio tests for this purpose. For that reason the model shown here is suitable to test formally the doubts on the long run neutrality of demand shocks expressed by Blanchard and Quah (1989). The fit of the model to the data will be discussed in the next section.

3 Empirical Analysis of Demand and Supply Shocks

To analyze supply and demand shocks, we follow Blanchard and Quah (1989) and consider the following two variables: $y_t = (\Delta GNP_t, U_t)'$. Where ΔGNP_t is the first differences in log GNP, and U_t is the level of unemployment rate. Seasonally adjusted data are downloaded from the Federal Reserve Bank of Saint Louis. The sample period covers from 1970Q1 to 2007 Q4.

3.1 Estimates of the ST-SVAR Model

Table 1: Comparison of models for $y_t = (GNP_t, U_t)'$

Model	$\log L_T$	AIC	SC
VAR(2)	-190.609	407.219	446.357
ST-SVAR(2)	-155.280	346.561	400.752

Notes: L_T *– likelihood function,* $AIC = -2\log L_T + 2\times$*no of free parameters,* $SC = -2\log L_T + \log T\times$*no of free parameters.*

The estimation of the ST-SVAR model is performed with the algorithm developed by Lütkepohl and Netšunajev (2014). We perform a grid search over parameters c and γ, refining the grid in the neighborhood of the optimum. Table 1 compares some summary statistics of the ST-SVAR(2) model with those of the VAR(2) model.[2] Both the Akaike and Schwarz information criteria favor the choice of the ST-SVAR model.

Figure 1 shows the estimated transition function from the ST-SVAR model. The estimated transition takes place in 1983Q1, which fits the timing of the Great Moderation. Figure 2 shows the standardized residuals of the ST-SVAR(2) model. They seem to be much more homogeneous compared with those from the VAR(2) model shown in Figure 3. Bai and Perron (2003) test further shows no breaks in the variance. The ST-SVAR model seems to adequately fit the data.

[2]The lag length is chosen according to the Akaike information criteria.

Figure 1: Estimated transition function of the ST-SVAR model

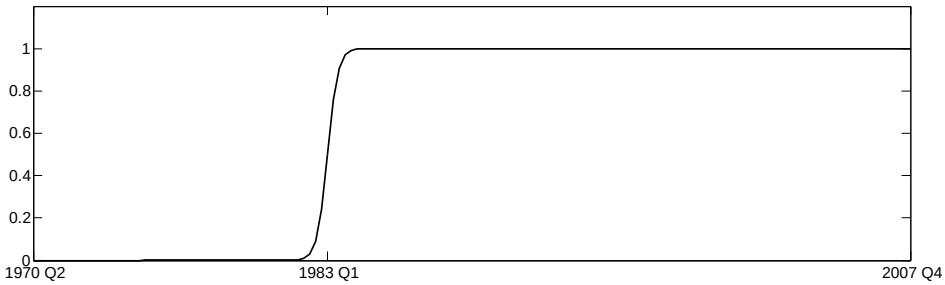


Figure 2: Standardized residuals of the ST-SVAR(2) model

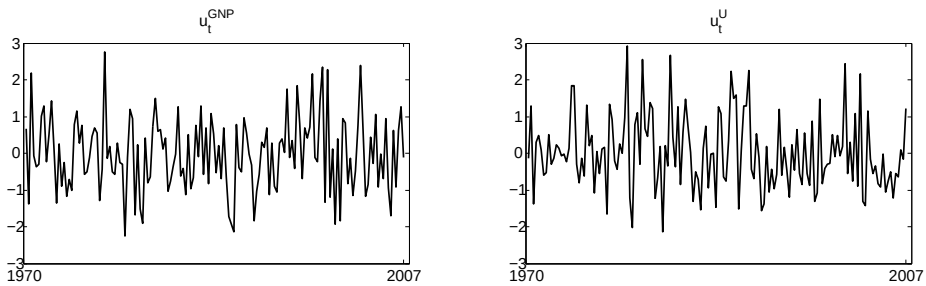
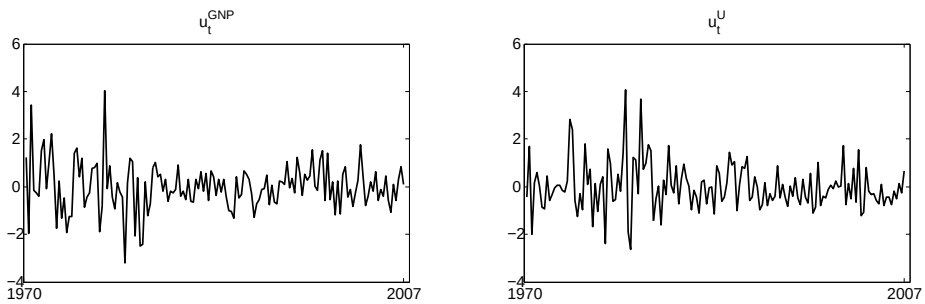


Figure 3: Standardized residuals of the VAR(2) model.



For identification of shocks, we need to check some estimated parameters of the ST-SVAR model. Table 2 presents the estimated relative variances.

They are all below one, indicating that a change to the low volatility state occurs. The estimated variances look quite different, and the standard errors of the estimates are relatively low. The variances are about two standard errors apart from each other. Thus the data is informative on the two shocks, and they can be identified by the means of their changing variances.

Table 2: Estimates of relative variances of the unrestricted ST-SVAR(2) model

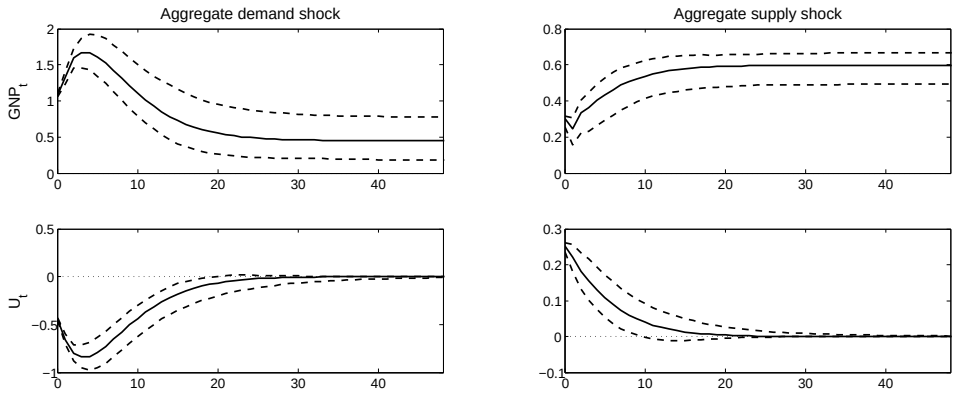
parameter	estimate	std.dev.
λ_1	0.142	0.039
λ_2	0.450	0.152

3.2 Impulse Responses and the Test on the Long-run Restriction

Figure 4 shows the impulse responses of the higher volatility state that are resulted from the identification via changes in volatility. We label the first shock as the aggregate demand shock because its effects on output and unemployment go in the opposite directions, which is a stylized fact. In contrast, the responses of output and unemployment are both positive after an aggregate supply shock. The identified demand shocks have a hump-shaped impact on both output and unemployment. After a positive supply shock, the output increases steadily for around 5 years and then stays at a plateau level. The response of the unemployment is initially positive but declines to zero over time. In general, our impulse responses are in line with those of Blanchard and Quah (1989), except that the impact of the demand shock on output seems not to decay to zero over time.

Since our impulse response analysis shows evidence against the long run restriction proposed by Blanchard and Quah (1989), we further test this restriction statistically. We estimate the ST-SVAR model with the identifying restriction imposed on the matrix of long run effects Ξ_∞, making it lower triangular. We next perform the likelihood ratio test of the restric-

Figure 4: Impulse responses of the higher volatility state



Notes: This graph shows the impulse responses of the higher volatility state obtained from the unrestricted ST-SVAR model. Solid lines - point estimates, dashed lines - 68% confidence bands based on 1000 bootstrap replications.

tion, obtaining the test statistic of 5.389 and the p-value of 0.020. This is strong evidence against the long run neutrality assumption of the demand shocks' effects on output. If the demand shocks are not long-run neutral, permanent and transitory shocks identified à la Blanchard and Quah (1989) are actually mixtures of different structural shocks.

4 Conclusions

This paper revisits the structural VAR model proposed in the seminal paper by Blanchard and Quah (1989). Using a new identification method following Lütkepohl and Netšunajev (2014), we are able to identify shocks without relying on the long run neutrality assumption of demand shocks. Our impulse response are economically interpretable. The estimated long run effects of the demand shocks on output do not die out over time. Formal test results on the long run restriction also provide evidence against it. Our findings suggest that demand shocks may result in permanent changes in output. It is recommendable for policy makers to take this into account for optimal

policy decisions.

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