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ON THE ROLE OF FINANCIAL STRESS IN THE TRANSMISSION OF MONETARY POLICY

This paper examines the asymmetric impact of monetary policy shocks on real output growth considering the role of financial stress. We carry out our examination using monthly Turkey data over 1998:M1 and 2012:M12 and apply a threshold vector autoregression model. Our investigation presents evidence that the impact of monetary policy shocks on output growth is stronger during high financial stress periods. However, it is found that there is no sign asymmetry in the real effects of monetary policy shocks.

JEL: F44; E44; E52

1. Introduction

Several researchers have analyzed the macroeconomic effects of conventional monetary policy shocks using VAR models (see amongst others, Bernanke and Blinder (1992), Bernanke and Mihov (1998) and Christiano et al. (1999) for the U.S. or Peersman and Smets (2002) for the euro area.) Although some researchers suggest that monetary policy has an ambiguous or no significant impact on real output, several researchers provide evidence that over the business cycle monetary policy has asymmetric effects on the real economic activity. Specifically, researchers have considered three types of asymmetries including those that arise from i) the state of the economy over the business cycles, ii) the size of the monetary policy shocks and iii) the direction (sign) of the monetary policy shocks. In contrast to the studies which do not allow for such asymmetries, these models suggest that the effect of monetary policy differs based on either of these three criteria. For instance Cover (1992), De Long et al. (1988), Karras (1996), Thoma (1994) find that output growth responds relatively more to a contractionary monetary policy than to an expansionary monetary policy. Ravn and Sola (2004) search the asymmetric impact of monetary policy related to the size of monetary policy shocks. Many other studies have investigated the asymmetric impact of monetary policy shocks on the economy over business cycles (see, among others, Weise (1999); Garcia and Schaller (2002); Höppner et al. (2008)).

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One potential explanation for the asymmetric effects of monetary policy changing over business cycles lies in the convexity of the aggregate supply curve. The aggregate supply function is relatively convex in economic stagnation periods and thereby any changes in aggregate demand driven by monetary policy shocks are likely to have a stronger effect on output and a weaker effect on prices. This is shown as one of the reasons why monetary policy shocks have a larger effect on output in the recession periods.

A second vein of this literature puts emphasis upon the credit channel to explain the asymmetry in the real effects of monetary policy shocks (see, for instance Bernanke and Gertler (1989), Bernanke et al. (1996)). According to this literature, the effects of monetary policy shocks on output are likely to be higher during recessions for any change in interest rates will not only affect the cost of capital but also the external finance premiums that firms face due to the frictions in the credit markets. Besides, high financial stress constrains the credit intermediation capacity of the financial markets. In a period of high financial stress, there is increased uncertainty about asset values and lenders are not willing to accept these assets as collateral; and thereby credit intermediation declines. When firms have difficulties in accessing to credit they have to cut back employment or investment expenditures leading a severe drop in output growth. Thus, any contractionary monetary policy which raises interest rates is likely to lead to a greater drop in output growth in a period of high financial stress.

Alternatively, some researchers propose that cost channel is the primary mechanism of monetary transmission (see, Barth and Ramey (2000), Christiano and Eichenbaum (1992), Christiano et al. (1997)). A cost channel of monetary transmission mechanism can explain some important empirical puzzles. First puzzle is the stronger response of output to monetary policy changes in the periods of economic downturns. During the periods of bottleneck, inventories and account receivables of firms rise while their cash flows decrease. The fall in internal funds as the stock of working capital rises forces firms to seek external financing. A monetary contraction policy which leads an increase in interest rates directly raises the opportunity cost of internal funds. However, when firms are forced to find external funds in the downturns marginal cost of borrowing increase substantially. This is a natural consequence of rising credit market frictions in these periods. Then, a monetary policy shock could lead to a large change in output and a small change in prices for the increase in interest rates and credit conditions affect firms' productive capacity by investing in net working capital.

Cost channel can also explain the price puzzle, noted first by Sims (1992). Price puzzle, observed in standard vector auto-regression (VAR) models, suggests that price level increases in response to a contractionary monetary policy in the short run. The cost channel mechanism argues that the rise in the price level is the result of a cost-push inflation due to the increase in interest rates. When monetary contraction affects an industry mainly by raising its working capital costs, it lowers output in that industry raising the prices.

In this study, we assess the link between financial stress and economic activity and search whether there is any role for financial stress in the transmission of monetary policy changes. For this purpose, we adopt a threshold VAR model. We carry out our investigation using monthly Turkey data over the period between 1998:M1 and 2012:M12. For Turkey this is the first attempt to empirically investigate the asymmetries in the impact of monetary policy shocks depending on the financial conditions. In this framework, the financial stress level is chosen as the threshold variable and the level of threshold is estimated endogenously within the VAR model. By this way, we are able to search whether the impact of monetary policy shocks on the economy differs below and above this threshold. Put differently, we assess whether the impact of the monetary policy shocks changes over low and high stress regimes.

Using generalised impulse response functions (GIRF) generated from the estimated nonlinear model, we find evidence of asymmetry in the effects of monetary policy depending on the financial stress conditions in line with the credit and the cost channel. The results provide evidence that contractionary monetary policy changes deteriorate economic growth more during the periods of high financial stress. However, it is found that there is not any sign asymmetry in the effects of monetary policy changes on economic activity. That is, the impact of contractionary and expansionary monetary policy changes on output growth are same in magnitude. A slight price puzzle is observed in the high financial stress regime in accordance with the cost channel. In the same regime the level of financial stress seems to react considerably stronger to a contractionary monetary policy. In what follows, we first describe the data and provide information on the TVAR methodology in Section 2. Section 3 discusses the empirical results and Section 4 concludes the paper.

2. Data and Econometric Methodology

This section describes the data used in the empirical analysis and provides details on the threshold vector autoregression (TVAR) methodology. Section 2.1 describes the data and Section 2.2 explains the econometric methodology.

2.1. Data

In this study it is aimed to empirically investigate whether the level of financial stress has any role of amplifying the negative effects of a contractionary monetary policy change. We carry out our empirical investigation based on the monthly Turkey data. We take the series of the variables except financial stress index from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Financial stress is measured using the Financial Stress Index for Turkey constructed by Ozturkler and Goksel (2013). The financial stress series is available for the period between 1998:M1 and 2012:M12 and it has a mean of zero. Thus, when the index exceeds zero, financial conditions are more stressed than average.

We measure output growth (y_t) in period t, by the first difference of the logarithm of the real GDP index (2005=100), IFS line 99b. We calculate the inflation rate (π_t) as the first difference of the logarithm of the consumer price index, IFS line 64. We use the first difference of interbank money market rate (r_t), IFS line 60b as a measure of stance of monetary policy.

2.2. Econometric Methodology

Linear Vector Autoregression (VAR) models are useful for examining multivariate links between economic variables. However, these models are unable to capture nonlinearities embedded in time series such as regime switching or asymmetric responses to shocks, introduced by the recent theoretical and emprical macroeconomic research. Moreover, an increasing amount of empirical evidence suggests that the linear conditional expectations implied by standard VAR models are not always in line with the observed facts (Atanasova, 2003). For example, numerous empirical studies show that there are asymmetries in the effects of monetary policy on real economy.

This paper employs a nonlinear VAR methodology to examine whether financial stress amplifies the impact of monetary policy shocks on output growth. Different from linear VAR models, nonlinear VAR models allow for analyzing nonlinear dynamics and asymmetric effects of shocks. We estimate a threshold vector autoregression (TVAR), in which the system's dynamics change across high financial stress and low financial stress regimes. In this study, we aim to analyze the role of financial stress in determining the impact of monetary policy changes on output growth.

TVAR model allows the financial stress level to switch across high and low stress regimes as a result of shocks to the other variables and financial stress. Thus stress regimes are endogenously determined within the model. We estimate the following "structural" threshold vector autoregression model[2] in equation (1):

$$Y_t = A_1^{(1)} Y_t + A_2^{(1)}(L) Y_{t-1} + \left(A_1^{(2)} Y_t + A_2^{(2)}(L) Y_{t-1} \right) I(c_t > \gamma) + U_t \tag{1}$$

where Y_t is the vector of endogenous variables including output growth, inflation, change in interbank money market rate and financial stress level. $A_2^{(1)}$ and $A_2^{(2)}$ are lag polynomial matrices and U_t is the vector of structural disturbances with mean zero and covariance matrix Σ.[3] c_t is the threshold variable that shows which regime the economy is in. $I(c_t > \gamma)$ is an indicator function which equals 1 when $c_t > \gamma$ and 0 otherwise.[4]

Not only the lag polynomials but also the contemporaneous relations between variables are allowed to change across regimes. $A_1^{(1)}$ and $A_1^{(2)}$ denotes the structural contemporaneous relation in the two regimes, respectively. It is assumed that $A_1^{(1)}$ and $A_1^{(2)}$ have a recursive

[2] The empirical approach undertaken here is similar to those performed by Balke (2000) and Atanasova (2003).

[3] The lag length of the TVAR model is chosen as 3 based on the Schwarz information criterion.

[4] $A_1^{(1)}$ and $A_2^{(1)}(L)$ denote the parameters of the VAR in the regime defined by $I_t[\cdot] = 0$ while $A_1^{(1)} + A_1^{(2)}$ and $A_2^{(1)}(L) + A_2^{(2)}(L)$ represent the parameters in the regime identified by $I_t[\cdot] = 1$.

structure with the causal ordering of output growth, inflation, change in interbank money market rate and a measure of financial stress level. This recursive structure is chosen in the light of the VAR literature which uses a similar form of recursive ordering (see, amongst others, Leeper et al. (1996), Bernanke et al. (1997) Christiano et al. (1999)).

The model is estimated using a least squares estimation. In particular, the least squares estimators $\left(\hat{A}, \hat{\Sigma}, \hat{\gamma}\right)$ minimise the sum of the squared errors S_n. γ is assumed to be restricted to a bound set $\left[\underline{\gamma}, \overline{\gamma}\right] = \Gamma$ where Γ is an interval covering the sample range of the threshold variable. S_n is linear in A, Σ conditional on γ. Thus the estimation process gives the conditional estimators $\hat{A}$ and $\hat{\Sigma}$. $\hat{\gamma}$ is the value which minimizes the value of S_n (γ). γ can be identified as follows:

$$\hat{\gamma} = \arg\min_{\gamma \in \Gamma_n} \mathrm{S}_n\left(\gamma\right) \tag{2}$$

Γ is approximated by a grid search on $\Gamma_n = \Gamma \cap \{q_1, q_2, ..., q_n\}$ and thereby equation (2) requires less than n function evaluations. Given the sample size the bottom and the top 20% quantiles of the threshold variable are trimmed to make certain that the model is well identified for all possible values of γ in Γ.

Since no a priori assumption of nonlinearity is made one needs to examine the presence of threshold effects empirically. Hence, we test the null hypothesis of a linear VAR model against an alternative of a threshold VAR before committing this approach. One problem in this examination is that the threshold γ is not identified under the null hypothesis of no threshold effects. Following Atanasova (2003) we use the following F_n statistic in equation (3) to test the presence of threshold effects:

$$F_n = \sup_{\gamma \in \Gamma_n} F_n(\gamma) \tag{3}$$

Since the distributions of the test statistics are non-standard, the p-values for the test statistics are usually derived using the bootstrap procedure proposed by Hansen (1996). Following Hansen (1996), we test the null hypothesis allowing heteroscedasticity in the error term. Under the null hypothesis of no threshold effects, J(= 1000) realizations of the Wald statistic for each grid point are generated and the distribution for the functional of the set of the statistics over the grid space is constructed.

3. Empirical Results

This section presents the results of the paper. Section 3.1 presents the threshold test for TVAR and the estimated threshold values. Section 3.2 presents and discusses the results of nonlinear impulse response analysis.

3.1. Threshold Tests and Estimated Threshold Values

Table 1 presents the bootstrapped p-value of the sup F test of a threshold VAR model against the linear VAR model and the estimated coefficient of the threshold variable. As Table 1 reports there is evidence of threshold effects. The chi-square p value is also presented for comparison and it is clear that it would over reject the null hypothesis of no threshold effects.

Table 1

Tests for Threshold VAR Model

Threshold variable	Estimated γ	sup F	Bootstrapped p	Chi-square p
Financial stress index	146.000	83.383	0.005	0.000

Note: Sample period is 1998:M1–2012:M12. Bootstrapped p-values based on Hansen (1996)'s method of inference with 1000 replications.

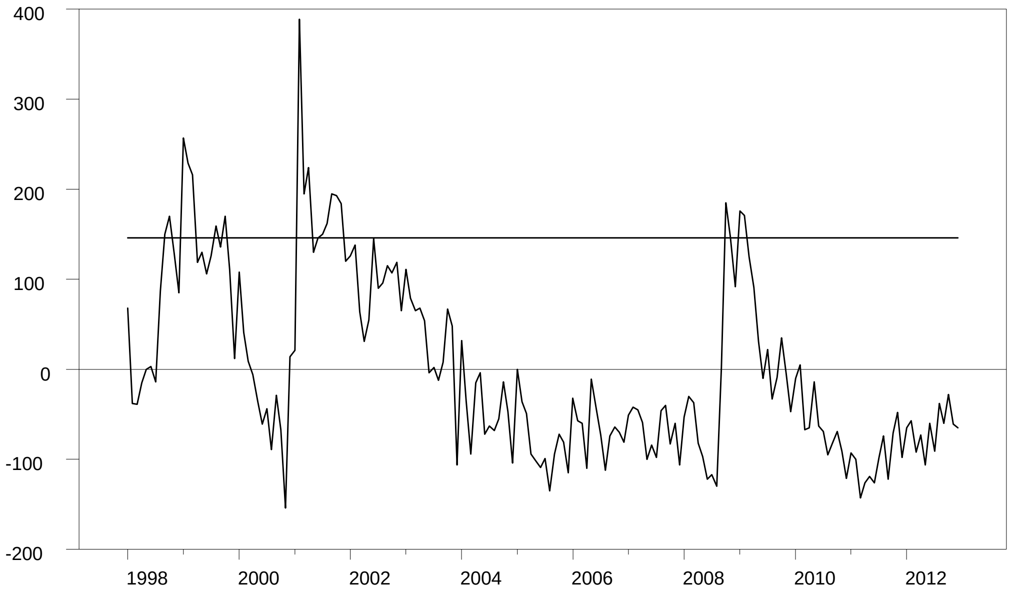
We also plot the financial stress index series and its estimated threshold value for the sample period under investigation in Figure 1. The dashed line in the Figure is the estimated threshold. The timing of the high financial stress periods in which the financial stress index is above the threshold is consistent with the downturns and the spikes in financial stress in Turkish economy. The first period of high financial stress is around between 1998 and 1999. In 1998 the financial crisis in Russia infected the neighboring economy Turkey. Foreign investors left Turkey leading to a large amount of capital outflows. After one year, in 1999, both the political conditions and the earthquake in Marmara region worsen this economic outlook and economic growth fell substantially. The second episode of high financial stress coincides with the time of the 2000/2001 economic and financial crisis in Turkey. There is an extensive literature analyzing the causes of the 2000/2001 crisis. Researchers have focused on different arguments to uncover the causes of the crisis such as wrong political moves, inadequate financial liberalization or IMF driven policies.[5] However the outcome of the crisis was a huge wave of capital outflows which collapsed the economic program. Overnight interest rates rose to several thousand percent as the policymakers attempted to keep the managed exchange rate regime (Dufour and Orhangazi (2009)). Yet, the Turkish lira devaluated inevitably.

After the crisis the economic outlook was not so rosy. In fact, inflation level started to increase, the goverment debt GDP ratio almost doubled and interest rates were extremely high (Akyüz and Boratav (2003)). Not surprisingly, there is a distinct spike in the stress index in Figure 1 during this episode. The last period of high financial stress matches with the recent recession and financial crisis of 2008/2009. However, in accordance with the growth performance of Turkey between 2004 and 2008 the index is below average between those years. It can be concluded that the timing of the distressed regime is generally consistent with economic downturns and negative financial events in the Turkish economy over the past 15 years.

[5] See, Akyüz and Boratav (2003); Alper (2001); Yeldan and Boratav (2002) and Eichengreen (2002).

Figure 1

Financial Stress Index and the Estimated Threshold Value



3.2. Nonlinear Impulse Responses

The analysis of the asymmetry in the effects of monetary policy shocks allows us to search whether positive and negative shocks have different effects and whether monetary policy shocks have different effects over different regimes, i.e. over high stress regime and low stress regime. In this framework, impulse response functions are competent tools to analyze these asymmetries. Similarly to Balke (2000) and Atanasova (2003) we apply the methodology of Koop et al. (1996) to calculate the nonlinear impulse response functions.[6] The nonlinear impulse response of a variable Y at horizon k is defined as the change in the conditional expectation of Y_{t+k} due to an exogenous shock at time t, u_t, given the economy is in a particular regime:

$$E\left[Y_{t+k} \mid \Omega_{t-1}, u_t\right] - E\left[Y_{t+k} \mid \Omega_{t-1}\right]$$

where Ω_{t-1} is the information set available at time $t-1$. Different from the linear models in which the impulse response functions are asymmetric and history independent, the impulse response functions for a nonlinear model is conditional on the entire past history of the variables and on the sign and size of the shocks. The nature of the shock u_t (its size and sign) and the initial conditions Ω_{t-1} are required to be specified to calculate the nonlinear impulse responses. The conditional expectations must be computed by simulating the

[6] See Atanasova (2003) for the details of the procedure used to estimate the impulse response functions.

model. To do this, first, vectors of shocks u_{t+j} for periods 0 to k are randomly drawn from the residuals of the estimated TVAR model and for given initial values of the variables fed through the estimated model to produce a simulated data series. The results from this first step are a forecast of the variables conditional on initial values and a particular sequence of shocks denoted as the baseline forecast. Second, the same procedure is repeated with the shock to the monetary policy variable in period zero is fixed at one standard deviation of the shock in linear model. The shocks are fed through the model to obtain a forecast of the variables. The impulse response function for a particular sequence of shocks and set of initial values is the difference between this forecast and the baseline forecast. Impulse response functions are obtained in this way for one hundred draws from the residuals and they are averaged to produce impulse response functions conditional only on initial values.

Figure 2 and 3 shows the impulse response functions for the response of output growth, inflation and financial stress to monetary policy changes. More specifically, in Figure 2 we plot the estimated response of output growth, inflation and financial stress to a one standard deviation shock (positive and negative) to the monetary variable. The negative shocks are multiplied by -1 so they can be compared to the responses of the positive shock responses. To compare the results from the TVAR model with those from the linear model the impulse response functions from the linear model are also presented. We observe from the graphs in Figure 2 that there are not asymmetric effects of positive and negative monetary policy shocks on output growth, inflation and financial stress. Thus our results do not provide supporting evidence for the asymmetry that arise due to the direction (sign) of the monetary policy shocks.[7]

In Figure 3 we plot the estimated response of output growth, inflation and financial stress to a one-standard deviation negative shock to the monetary variable. The impulse responses exhibit substantial differences over regimes. In particular, the magnitude of the impulse responses differs strongly high financial stress regime. Figure 3 shows that the monetary contraction has asymmetric effects on the underlying economic variables depending on the state of the economy. Specifically, it is clear from the Figure that the contractionary monetary policy changes exert a greater impact on the output growth when there is high financial stress in the economy. This finding supports the existence of credit channel proposed by Bernanke and Gertler (1989). It is in line with the theory as the credit market imperfections and related high financial stress give rise to a mechanism by which the effects of monetary policy shocks amplify.

There is a slight price puzzle in the high financial stress regime as inflation increases initially before decreasing in response to a contractionary monetary policy. The price puzzle is in accordance with the cost channel since there is an increase in the cost of financing in the periods of high stress. However, overall there is a prominent decrease in inflation rate in the high stress regime compared to the low stress regime. This is not surprising as the economy experiences a larger decline in output growth in the high stress regime according to the estimation results. The financial stress rises first and then decreases

[7] Weise (1999) finds a similar result for the US economy using the quarterly data between 1960:Q2 and 1995:Q2. That is, the positive and negative monetary policy shocks have symmetric effects on output growth in the US economy in the related period.

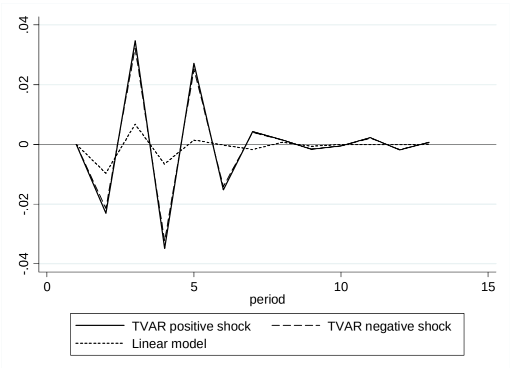
before rising again more. Overall, the rise in financial stress in response to a contractionary monetary policy is considerably stronger in the high financial stress regime.

These results provide convincing support for the hypothesis that monetary policy affects output growth asymmetrically depending on the financial stress level. To sum, our results suggest that the adverse effects of monetary policy shocks on output growth are stronger in high financial stress regime. These findings are interesting for policy makers because in contrast to the studies which argue that monetary policy shocks are neutral, in this study we show that output fall dramatically in response to a monetary contraction in a distressed regime. That is, there is clear evidence of the importance of the financial stress level in the transmission of monetary policy shocks. The researchers may fail to find any significant impact of monetary policy as they do not take into account the embedded nonlinearities in the series.

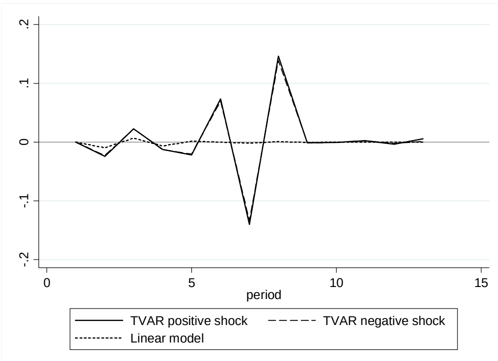
Figure 2

Effect of positive and negative (one-standard deviation) monetary policy changes

Cumulative response of output growth

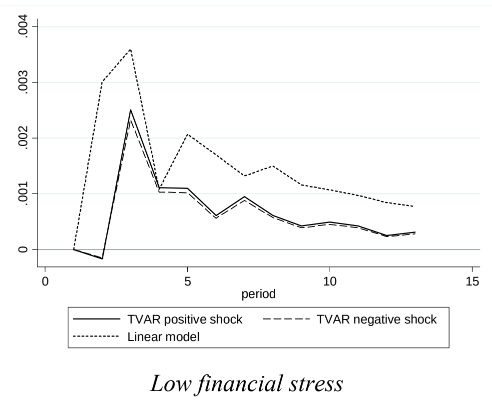


Low financial stress

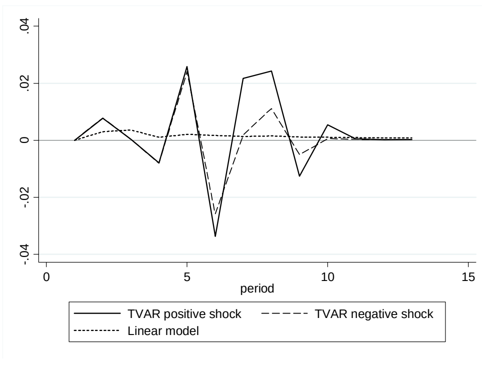


High financial stress

Cumulative response of price

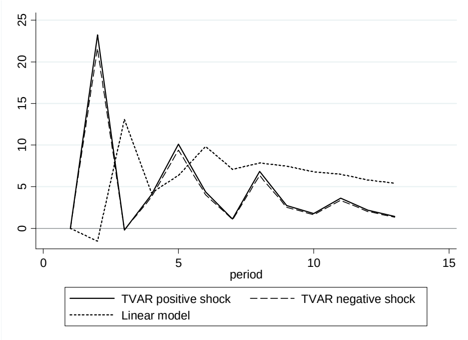


Low financial stress

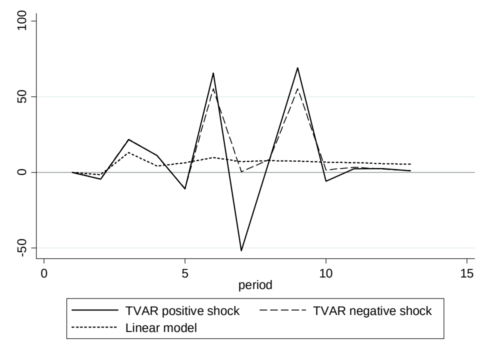


High financial stress

Cumulative response of financial stress



Low financial stress

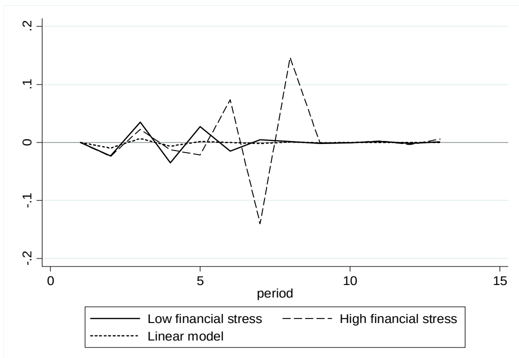


High financial stress

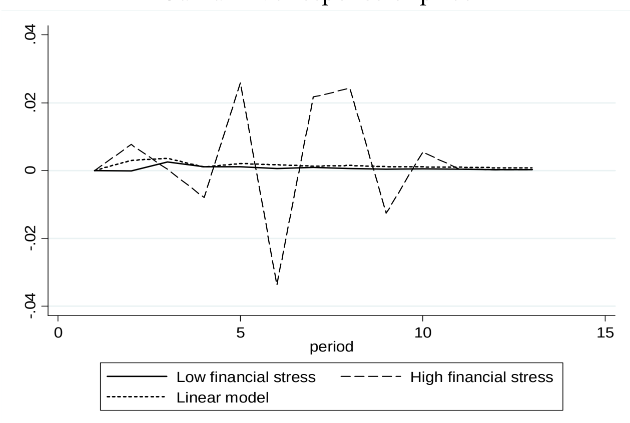
Figure 3

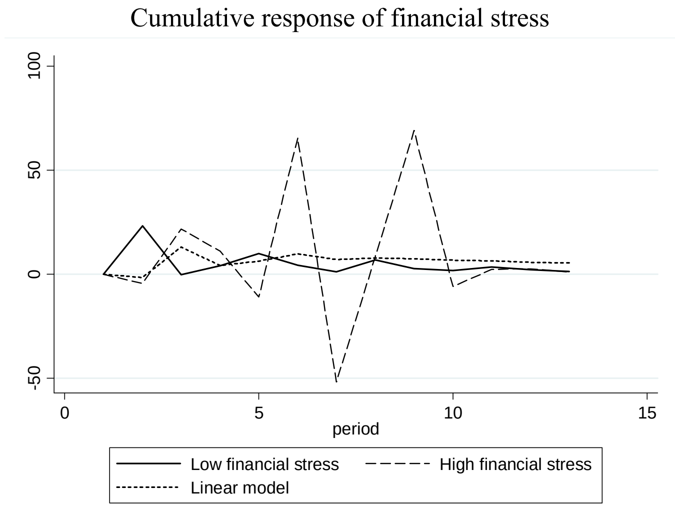
Effect of Contractionary Monetary Change by Initial State

Cumulative response of output growth



Cumulative response of price





Conclusion

In this study we empirically examine the impact of monetary policy on output growth over the business cycle while we consider the role of financial markets. Specifically we search whether monetary policy shocks have an asymmetric impact on the real output growth depending on the financial stress in the economy. We carry out our investigation using monthly Turkey data between 1998:M1 and 2012:M12.

To capture the asymmetric effects of monetary policy shocks on output growth, we apply a threshold vector auto-regression model. In this approach, the financial stress level is chosen as the threshold variable and the level of the threshold is estimated endogenously within the VAR model. To summarize the empirical findings, we find that there is an asymmetry in the effects of monetary policy changes depending on the conditions of financial markets in the economy in line with the credit and cost channels. The results provide evidence that contractionary monetary policy changes deteriorate economic growth more during the periods of high financial stress. However, it is found that there is not any sign asymmetry in the effects of monetary policy changes on economic activity. That is, the impact of contractionary and expansionary monetary policy changes on output growth are same in magnitude. A slight price puzzle is observed in the high financial stress regime in accordance with the cost channel. In the distressed regime the level of financial stress seems to react considerably stronger to a contractionary monetary policy.

Our results have important policy implications as they provide support to the proponents of financial stability as a goal of monetary policy. Due to the fact that most of the developed and developing countries have experienced some difficulties after the 2008-2009 financial crises we suggest that policy makers should provide a regulatory mechanism which will render the financial intermediaries to provide the markets depth and liquidity. In this way, businesses can operate more properly and smoothly.

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