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Financial Stress and Economic Activity: A Threshold VAR Analysis for Turkey

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Özet: Bu çalışmanın amacı, Türkiye için farklı finansal stres dönemlerinde ekonomik aktivitenin finansal stres şoklarını nasıl tepki verdiğini ampirik olarak analiz etmektir. Bunun için, 2002-2015 dönemine ait aylık frekansta veriler kullanılarak, sanayi üretimi ile özgün bir finansal stres endeksinin içsel değişkenler olarak yer aldığı Eşik VAR tahmini yapılmaktadır. Çalışmanın temel bulguları, veri bir finansal stres şokundan sonra ekonomik aktivite kaybının yüksek finansal stres döneminde normal stres dönemine kıyasla beş kat daha yüksek olduğuna işaret etmektedir. Ayrıca, yüksek finansal stres döneminde gerçekleşen bir finansal stres şokunun etkisi normal dönemdekine göre ekonomik aktivite üzerinde daha uzun süreli bir etki yaratmaktadır.

Abstract: This study aims to analyze empirically how economic activity reacts to financial stress during different stress episodes in Turkey. Thus, we use monthly data for the period 2002-2015 and estimate a Threshold Vector Autoregression Model (TVAR) with industrial production and an unique financial stress index as endogenous variables. The main findings show that, in case of a given financial stress shock the economic activity loss in a high stress regime is about five times larger than a shock in a normal stress regime. Also, the effect of financial stress on economic activity during a high financial stress episode is more long-lasting than a financial stress shock during a normal stress episode.

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1. Introduction

The world has witnessed one of the most unexpected, broad and prolonged economic breakdowns after the global financial crisis in 2008-09. The impact was so intense that almost no major economy around the globe was able to escape the perils of a deep economic recession. In the aftermath of the crisis, financial stress and its relationship with economic activity have become major research topics in academia and an important discussion among economic policy making institutions.

This study aims to investigate the non-linear relationship between financial stress and economic activity in Turkey. We ask whether economic activity reacts differently to financial stress depending on the level of stress. With this in mind, we construct a non-linear Threshold Vector Autoregression Model (TVAR) to estimate the reaction of economic activity to financial stress shocks in Turkey for the period 2002-2015 with monthly data.

Our results show that the response of economic activity to financial stress is asymmetric. First, in case of a financial stress shock the economic activity loss in a high stress regime is much larger than a shock in a normal stress regime. Second, the effect of financial stress shock on economic activity during a high financial stress episode is more long-lasting than a shock during a normal stress episode.

2. Literature

The relationship between financial stress and economic activity is a subject empirically more closely examined after the global financial crisis. Claessens et al. (2008) study the link between macroeconomic and financial variables during recessions and episodes of financial stress for 21 OECD economies. They find that recessions after the high financial stress periods are longer and deeper than other recessions.

According to Hakkio and Keeton (2009) an increase in financial stress can lead to a decline in economic activity through three potential channels. The first channel is an increase in uncertainty about the prices of financial assets and the economic outlook in general. The second channel is the increase in financing cost to businesses and households. The last channel is banks' tightening their credit standards. They also showed with the help of a financial stress index (Kansas City Financial Stress Index-KCFSI) that an increase in financial stress leads to tightening of credit standards and decreases in economic activity in the US.

Davig and Hakkio (2010) find that the US economy fluctuates between a normal regime, in which financial stress is low and economic activity is high, and a distressed regime, in which financial stress is high and economic activity is low. In the latter, the effect of financial stress on economic activity can be quite large compared to the normal regime.

Cardarelli et al. (2011) identify episodes of financial turmoil in advanced economies using a financial stress index (FSI), and propose an analytical framework to assess the impact of financial stress –in particular banking distress– on the real economy. They conclude that financial turmoil characterized by banking distress is more likely to be associated with deeper and longer downturns than stress mainly in securities or foreign exchange markets.

Çevik et al. (2012) estimate a financial stress index for Turkey for the period 1997-2010. They examined the links between financial stress and economic activity by means of a bivariate linear VAR model. They conclude that the financial stress index is significant in affecting economic activity by applying granger causality tests and linear impulse response functions.

Elekdağ et al. (2012) introduce a monthly composite index used to measure financial stress episodes across Emerging markets (EMs). They examine the implications of domestic and external financial stress shocks on the Turkish economic activity and contrast the dynamics with that of other EMs. The findings show that financial stress matters quantitatively. They provide evidence that, even a temporary financial stress shock can drag industrial production substantially below the trend.

Adanur Aklan et al. (2015) construct a financial stress index composed of several sub-indexes for measuring the instabilities of different financial markets (such as stock market, foreign exchange market, banking sector, and public sector). They examine the implications of financial stress on Turkish economic activity with a VAR analysis. The results show that there is a one way direct causal relationship between financial stress and economic activity and that an unexpected rise in financial stress has a negative and diminishing impact on economic activity.

3. Methodology

3.1. Data

We use monthly data for the period 2002-2015. Economic activity is measured by the annual growth rate of monthly seasonally adjusted industrial production data. The industrial production index is taken from Turkstat.

The financial systemic stress index (FSSI) used in this paper is estimated based on the method outlined in Çamlıca and Güneş (2016).[1] The main characteristic of the financial stress index for Turkey is that it takes into account the systemic component of stress. The innovative feature of the index is the application of the standard portfolio theoretic principles to aggregate sub-indices (money, bond, stock market, banking and forex) to form a final composite stress indicator. By applying the portfolio theory, the final index puts relatively higher weights on situations in which stress prevails in a number of sub-markets at the same time as a result of taking the cross-correlations between five sub-indices into account when aggregating sub-indices. We believe that it is important to have a good measure of the financial stress as we presume that the response of economic activity to an important extent is driven by the systemic component of financial stress.

Table 1: Test Results for Threshold Effects

Variables	ADF Test		KPSS Test	
	Constant	Constant&Trend	Constant	Constant&Trend
Annual Growth Rate of IP	-2.81	-2.89	0.24	0.080409
Financial Systemic Stress Index	-4.17	-4.19	0.11	0.060855
Test Critical Values 1%*** 5% ** 10% *	-3.47 -2.88 -2.58	-4.01 -3.43 -3.14	0.74 0.46 0.35	0.22 0.15 0.12

To carry out a VAR analysis, one needs to check for the stationarity of the variables. In Table 1, the stationarity test results for FSSI and IP growth rate are presented. According to the ADF test, the IP growth rate is stationary at the %10 level in a model with constant and non-stationary in a model with constant and trend. The FSSI is stationary at the %1 significance level based on the ADF test. Hence, we continue to cross-check the stationarity of the IP growth rate with KPSS test. The KPSS test indicates that the null hypothesis of stationary IP growth rate cannot be rejected at the %10 significance level.

[1] Portfolio theoretic weighting method is previously used in Kilimci et al. (2014) and Kilimci et al. (2015) in which they estimated a forex market stress index and bond market liquidity index respectively. However, these studies differ from Çamlıca and Güneş (2016) in terms of data standardization and transformation.

3.2. Model:

3.2.1. Threshold VAR Model:

The assumption that exogenous financial stress shocks have a stronger impact on economic activity in times of higher financial stress requires an approach based on regime dependent estimation. In this respect, we apply the TVAR model developed by Balke (2000) in this study.

$$Y_t = A^1 Y_t + B^1[L]Y_{t-1} + (A^2 Y_t + B^2(L)Y_{t-1})I[s_{t-d} > \gamma] + u_t \tag{1}$$

In this model, Y_t is a vector of endogenous variables; I, is the indicator function that takes the value of 1 when financial stress in *t-d* period is above the threshold value, otherwise it is zero. S_{t-d} is the threshold variable indicating the regime of the system, d is the lag of the threshold variable and γ is the threshold value. $B^1(L)$ and $B^2(L)$ are the polynomial lag matrices and A^1Y_t and A^2Y_t represent the contemporaneous terms. It is reasonable to assume that contemporaneous terms might change across regimes. Also, matrices A^1 and A^2 have a recursive structure.

3.2.2. Test for Threshold and Regime Identification:

It is important to test whether there is a threshold effect between financial stress and economic activity. If the threshold value γ was known, the conventional F-test for the null hypothesis $A^2 = B^2(L) = 0$ could give reliable results. However, in our case the threshold value is not known a priori, and the testing procedure involves non-standard inference, because γ is not identified under the null hypothesis of no threshold (Afonso et al., 2011).

A commonly used approach is to estimate the model for each possible value of the threshold variable using the least squares. The range of possible thresholds is trimmed by a certain percentage (15%) to allow for sufficient observations in each regime. Conditional on each threshold, the Wald statistic that evaluates the hypothesis of equality between the regimes is computed. Three different summary test statistics are generated: the maximum Wald statistic (sup-Wald), the average Wald statistic (avg-Wald) and a statistic calculated as a function of the sum of the exponential Wald statistics for all possible thresholds (exp-Wald). For the reason that the distributions of these test statistics are non-standard, the bootstrap technique proposed by Hansen (1996) is applied to simulate the unknown asymptotic distributions. At the end of the exercise, the p-values associated with the test statistics are derived and used to evaluate the significance of the threshold effects. The estimated threshold value is the one that minimizes the log determinant of the variance-covariance matrix of residuals (Balke, 2000; Van Robays, 2012).

3.2.3. Impulse Response Function:

In a linear model, impulse responses are calculated through estimated coefficients and the estimated responses show a symmetric nature in terms of the size of the structural shocks and sign. Nevertheless, these impulse responses do not change as long as the structure of the covariance changes. However, the linear model (and its inferences) cannot be valid in this context, because shocks to the system are allowed to lead to regime changes as outlined by Potter (2000) and Koop, Pesaran and Potter (1996). That is, when estimating non-linear models no assumption is made about whether any other shocks will play a role after the first shock is given to the system. Hence, the impulse response cannot be obtained according to the path the variables follow after the first shock. In other words, the lags of the variables in the model play a role together with the size and sign of the shock in non-linear impulse response functions and regime changes might occur as a result of the shocks.

According to Balke (2000), the difficulty in estimating impulse response functions in TVAR estimation is due to the fact that the moving average representation is not linear in the shocks (either across shocks or across time). As a result, unlike linear models, the impulse response function for the non-linear model is conditional on the entire past history of the variables and the size and direction of the shock. Hence, the impulse response function (IRF) in equation (2) implies that the response at horizon k (k=1 to h) of a variable Y to a shock at time t (u_t) is given by the difference between (1) the expected value of variable Y given the shock and conditional on a particular history (Ω_{t-1}) of the shocks at time t-1 and (2) the expected value of Y in the absence of such shock (Calza and Sousa, 2005).

$$\mathrm{IRF}_k = \mathrm{E}(\mathrm{Y}_{t+k}|\mathrm{u}_t, \Omega_{t-1}) - \mathrm{E}(\mathrm{Y}_{t+k}|\Omega_{t-1}) \tag{2}$$

To calculate a non-linear IRF one needs to specify the nature of the shock (sign and size) and the initial condition, Ω_{t-1}. In addition, the conditional expectations, $\mathrm{E}(\mathrm{Y}_{t+k}|\mathrm{u}_t, \Omega_{t-1})$ and $\mathrm{E}(\mathrm{Y}_{t+k}|\Omega_{t-1})$ must be calculated by simulating the model. This is done by randomly drawing vectors of shocks u_{t+j}, for *j=1* to *k* and then simulating the model conditional on an initial condition (Ω_{t-1}) and a given realization of u_t. The simulation is repeated for $-u_{t+j}$ in order to eliminate any asymmetry that might arise from sampling variation in the draws of u_{t+j}. This procedure is repeated 500 times for each set of initial conditions, and the resulting average is the estimated conditional expectation as outlined in Balke (2000).

3. Empirical Results

Equation (3) shows the bivariate TVAR model where the $FSSI_t$ and $IP_{growth,t}$ are introduced as endogenous variables: [2]

$$X_t = c^Y + \theta_1^Y X_{t-1} + \theta_2^Y X_{t-2} + e_t^Y \ \ if\ s_{t-d} > \tau \ \ (High\ Stress\ Regime) \tag{3}$$

$$X_t = c^N + \theta_1^N X_{t-1} + \theta_2^N X_{t-2} + e_t^N \ \ if\ s_{t-d} \ll \tau \ \ (Normal\ Stress\ Regime)$$

Here X_t=(FSI_t, IPI_t) is the endogenous variables vector; C^R is the regime dependent constant variable vector (R=Y,N) and θ_j is the slope coefficient matrix of the regime and number of lags (j=1,2) of variables. The threshold variable is the FSSI and is described as s_{t-d} (d=1,…,d_0), while the maximum threshold lag (d_0) is 2. Threshold parameter is shown as τ, while e_t^R indicates the regime dependent regression residuals. The number of lag of the endogenous variables is set as 1 (p=1) determined by the Schwartz information criterion.

We select the method introduced by Hansen (2000) and Balke (2000) to test the statistical significance of the variable that is determined as the threshold indicator. Here, the TVAR model is estimated for all threshold values according to the identified lag numbers and other specified conditions and thereafter the threshold values that minimize the log determinants of the structural error terms are estimated in order to be used in the hypothesis testing procedure of the threshold value.

In this context, by giving the values d=1,2 to the lag of the threshold variable, the threshold effect is tested in the relationship between IP_{growth} and $FSSI_t$. With this exercise, we obtain likelihood ratio (LR) test statistics and compute p-values as the following:

$$p_n = 1 - \left(1 - exp\left(-\frac{1}{2}LR_n(\gamma_0)^2\right)\right)^2 \tag{4}$$

In equation (4), p is the p-value of the LR test statistic and n is the sample size. Test results show that both d=1 and d=2 is statistically significant and gives the same threshold value for both lags. Even though the p-values are similar to each other for d=1 and d=2, we

[2] We also carried out linear structured and unstructured VAR models, where models with two and five endogenous variables are estimated. In addition to industrial production growth and financial systemic stress index we used consumer price index, credit growth and global manufacturing PMI index in order to account for other factors that might potentially affect industrial production growth. Overall, we found that the impulse response functions of the two-variable and five variable VAR models are very similar. Hence we chose to estimate the TVAR model with two endogenous variables for the sake of not complicating the non-linear analysis between financial stress and economic activity. The IR results for the structured and unstructured VAR analysis can be provided upon request.

continue with one lag for the sake of a higher ratio of the LR statistic when d=1 and to keep the sample size as big as possible for a statistically more robust estimation. If the p-value indicates significance at all levels, this means that the null hypothesis of the relationship between financial stress and economic activity being linear should be rejected. Hence, we conclude that the relationship between these variables is a non-linear one (Table 2).

Table 2: Test Results for Threshold Effects

d	LR Statistic	Degrees of Freedom	p Value	Threshold Value
1	57,44	13	0,0001	0,11949
2	52,15	13	0,0001	0,11949

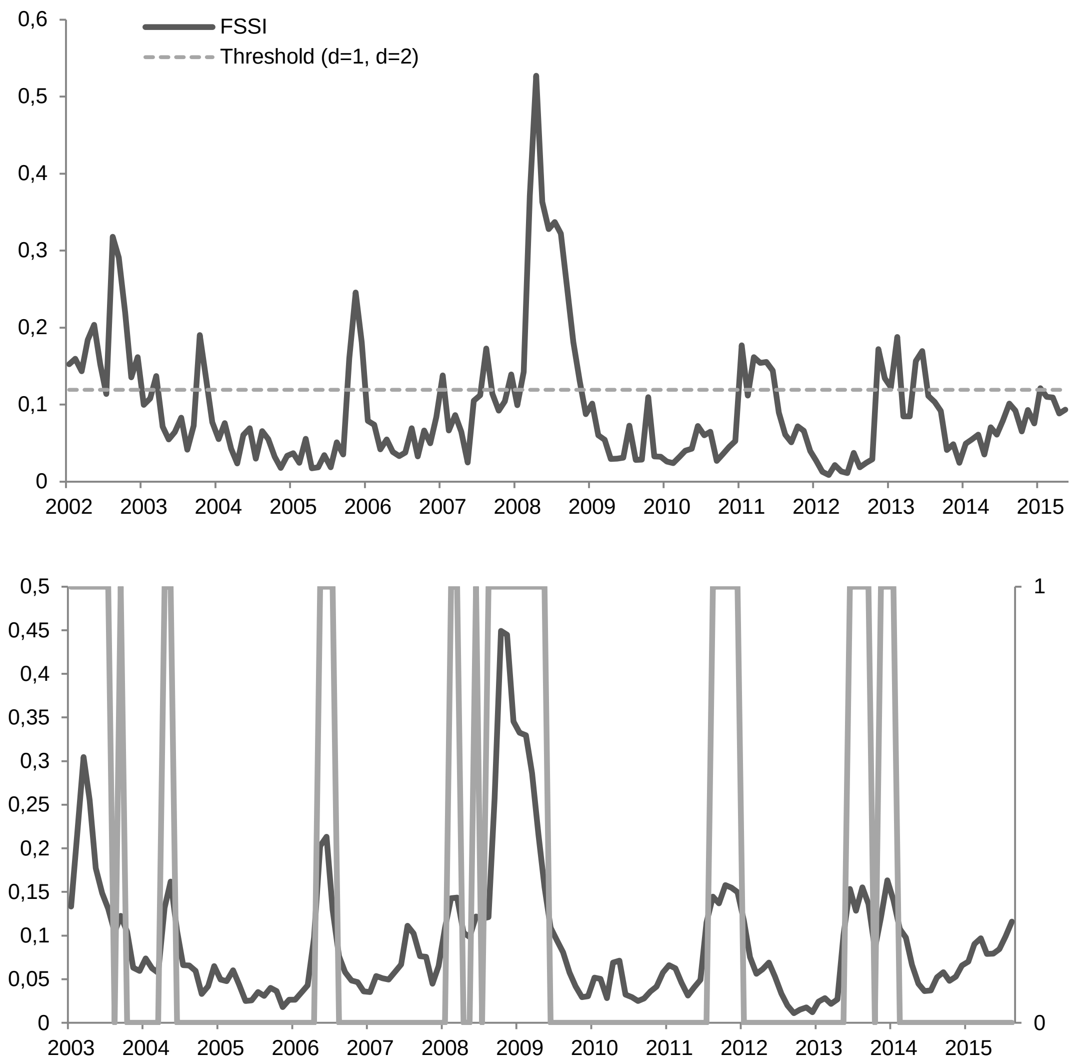
Note: The delay for the threshold variable is given by d =1, and the lag of the TVAR is 1. The p-values are calculated by Hansen's (1996) bootstrap method with 500 replications.

Test results show that the threshold value for financial stress in the TVAR model is close to 0.12. As indicated in Graph 1, the estimated threshold value splits the sample into two regimes reasonably well. While the number of observations in a high level stress regime is 42, the sample size of normal stress regime is 119. Also, when carefully inspected, the high stress sample overlaps with the most important financial stress episodes in the Turkish economy witnessed during the reference period (See Çamlıca and Güneş, 2016).

An alternative display is shown in the lower panel of Graph 1, where the indicator function ($I[s_{(t-d)}>\gamma]$) is used to check whether the sample split between normal and high stress regimes makes sense. The indicator function is 1 if financial stress in period t-d is above the threshold level (τ) and otherwise it is 0. Then, it is obvious that the indicator function during high stress periods is 1 and 0 during normal stress periods.

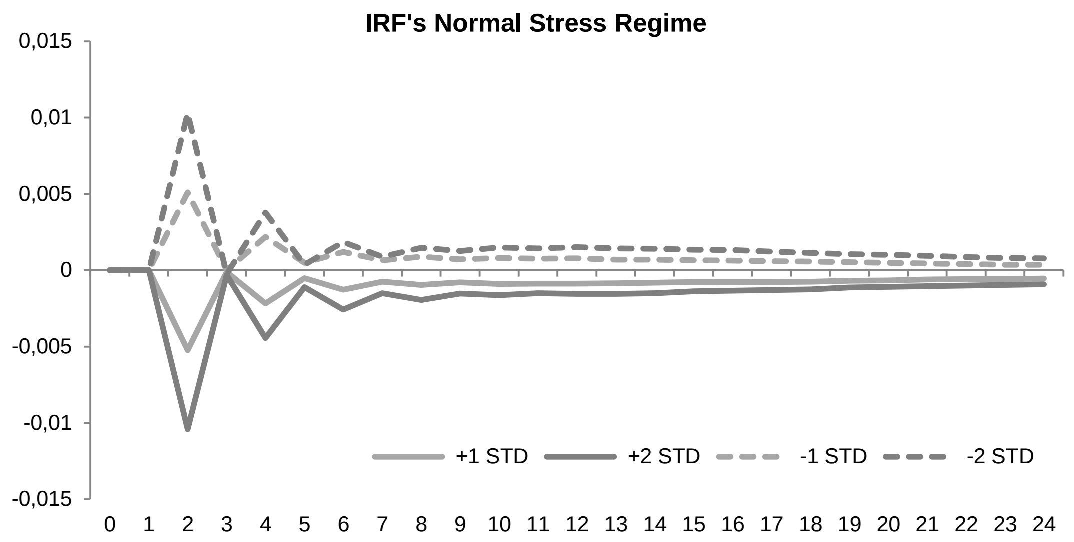
As explained before, given that non-linear impulse response functions are dependent on the size and sign of the shock along with the lagged values of the variables, both positive and negative one and two standard deviation shocks are given to financial stress to obtain the impulse responses under different regimes. The error terms of the variables are transformed into orthogonal innovations with the Cholesky decomposition method, which makes it possible to obtain structural impulse responses.

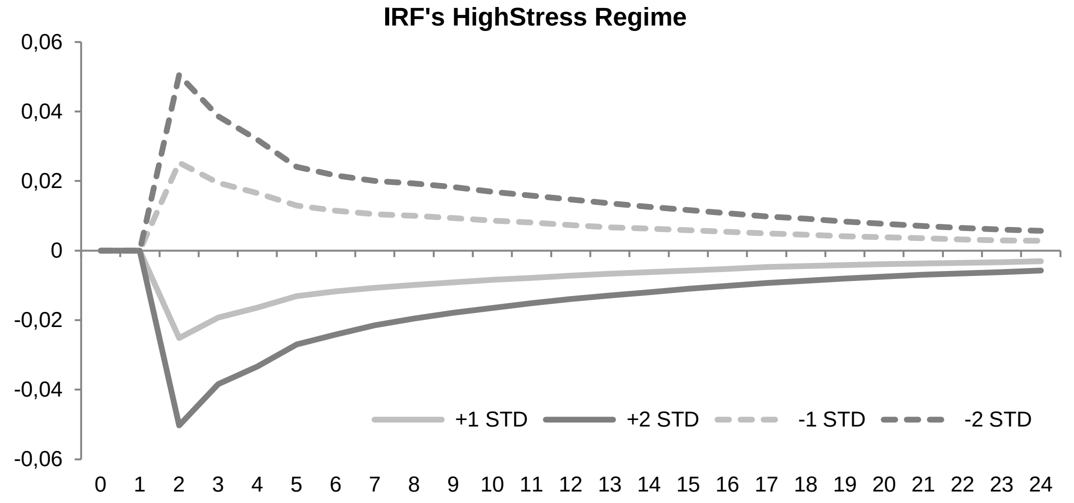
Graph 1: Sample Splitting According to the Indicator Function



In Graph 3, the impulse response functions under normal and high stress regimes are presented. The response of economic activity to financial stress shocks in Turkey is significantly different under the two regimes. The response of economic activity to financial stress is larger and longer in the high stress regime. The response of industrial production growth to a 1 standard deviation financial stress shock is 0.5 per cent and it lasts for about 3 months in normal stress periods. In high stress periods, a one standard deviation financial stress shock cause a loss of 2.5 per cent, while the effect lasts for more than 18 months.

Graph 3: Impulse Response Functions for the TVAR Model





4. Conclusion

To the best of our knowledge this paper is the first to study the non-linear relationship between financial stress and economic activity in Turkey with a Threshold VAR. The analysis shows that the response of economic activity to financial stress is asymmetric. Overall, in case of a financial stress shock, the economic activity loss in a high stress regime is about five times larger than that in a normal stress regime. Also, the effect of financial stress on economic activity during a high financial stress episode is more long-lasting than a financial stress shock during a normal stress episode.

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