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The Effect of Financial Fragility on Macroeconomic Variables: TVP_VAR Model for the Iranian Economy

Alireza Rezaee[1] **Dariush Fareed**[2] **Habib Ansari Samani**[3]

[1] PhD Candidate, Department of Financial Management ad Accounting, Yazd University, Yazd, Iran, Email: rezaei.oe@gmail.com
[2] Associate professor, Department of Financial Management and Accounting, Yazd University, Yazd, Iran. (Corresponding Author), Email: Fareed@yazd.ac.ir
[3] Associate Professor, Department of Economics, Yazd Univesrity, Yazd, Iran, Email: h.samani@yazd.ac.ir

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Abstract:
The present study aimed to investigate the effect of financial fragility on macroeconomic variables within a TVP-VAR model. For this purpose, first the financial fragility variable was calculated. Then, this study evaluated the effect of this variable on macroeconomic variables including economic growth rate, inflation rate, and exchange rate. In this study, the quarterly data for the period 2001-2020 were used. The results indicated that financial fragility had a negative effect on economic growth but a positive effect on exchange rate and inflation by creating uncertainty in the economy. In other words, financial fragility in Iran increased economic fluctuations by reducing economic growth and increasing inflation and exchange rates.

1. Introduction

After the financial crisis of 2007-2009 in the world, the issue of financial fragility was more considered and many researchers evaluated its effect on macroeconomic variables. Financial fragility is related to uncertainty and credit risk and thus can affect the performance of financial markets (Fostel and Geanakoplos, 2018; Geanakoplos, 2010). Based on the obtained results, financial fragility will lead to the inefficient allocation of resources and reduce investment and economic growth (Zwet and Swank, 2017). The effect of financial fragility has been studied on different variables at both micro and macro levels.

The studies on the relationship between financial fragility and corruption (Le and Doan, 202 and 2021, Jha, 2019), financial fragility and risk (Yavuz, 2010, Lee et

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al., 2013; Cevis et al., 2016; Bruno et al., 2017; Vasilenko, 2018; Francisco and Valenzuela, 2019; Silva et al., 2020; Gensler and Bailey, 2020), financial fragility and liquidity (Huang et al., 2020, Jiang et al., 2021) and fragility and financing (Rossi and Boccaletti, 2021; Anshuman and Sharma, 2021) were among the subjects studied in the micro sector, mainly focusing on financial companies and banks In the macro sector, the main issues were the effect of financial fragility on economic growth (Aßmuth, 2020; Dasgupta, 2020, Cómbita Mora, 2020; Demetriades and Roylak, 2020), the relationship between financial fragility and public and private debt (Cavalletti et al., 2020;Ghadamyari, 2020; Moritz et al., 2020; Bartscher et al., 2020, Ivan and van and Tatyana, 2021; Leclaire, 2021; Avritzer, 2021) the relationship between financial fragility and employment (Schneider et al., 2020; Jomo, 2020; Chletsos and Sintos, 2021), as well as the relationship between financial fragility and other economic variables such as investment and inflation were studied. However, with the spread of Covid-19, financial fragility at the time of the epidemic was highly regarded by of (Demertzis et al., 2020, Schneider et al., 2020, Falato et al., 2021; Clark et al., 2021; Chhatwani and Mishra, 2021). Financial fragility has always been considered as one of the issues of economic policy makers during the recent years, especially after the financial crisis. As mentioned, financial fragility from various channels can affect different variables in the economy and has been analyzed in multiple studies. Based on these explanations, this study aimed to evaluate the effect of financial fragility on macroeconomic variables in the framework of time-varying parameter vector autoregressions (TVP-VAR).

For this purpose, the present study is organized in five sections. After the introduction, Section 2 presents the review of the literature. Section 3 deals with the research methodology. In addition, the results are mentioned in Section 4. Finally, Section 5 presents the research suggestions.

2. Review of the literature

This concept was raised by Minsky in 1977 as an indicator of the financial system. According to his definition, a fragile financial system will enter a crisis in the event of an abnormal or unexpected event (Huang, 2019; Minsky, 1977). Financial fragility can be defined at the micro and macro levels. At the macro level, financial fragility refers to the risk of financial instability while there is a high dependence on debt financing at the micro level (Tymoigne, 2012; Chletsos and Sintos, 2021). Fiscal fragility is expressed at the micro level when liabilities on the balance sheet assets are sensitive to changes in interest rates, income, depreciation rates, and other indicators affecting liquidity and the ability to repay debt. At the macro level, it refers to financial instability and can affect the level of prices, economic growth, employment and other macroeconomic variables (Tymoigne, 2019). In general, financial fragility is considered as one of the indicators of financial uncertainty and risk in the financial sector and affects the

good performance of each country's financial system. The result is an effect on other sectors of the economy (Foster and Geanakoplos, 2008; Geanakoplos, 2010; Brunnermeier and Pedersen, 2009; Chletsos and Sintos, 2021). Financial fragility through disruption in the financing system will reduce the financing of investment projects, investment, economic growth, which is more significant in less developed countries (Demetriadeset al., 2017). Furthermore, financial fragility affects the banking sector as one of the most critical parts of the financial system in any country and can make depositors withdraw deposits from the bank when they see financial fragility in the bank and invest in other asset markets. A reduction in the bank's resources and its lending power will result in a reduction in investment financing and economic growth. Moreover, financial fragility undermines the effectiveness of monetary policy, leading to a rise in inflation and volatility in the price index. When banks, as a significant dimension of the financial system, face fragility, the significance of transferring monetary policy through the lending channel reduces and the supply of credit to the bank's capital will respond less to monetary policy instruments. Further, the depositors withdraw deposits from banks and the capital market by observing financial fragility and transfer them to other markets such as the gold and foreign exchange markets. Reduction in bank resources and lending power, as well as the outflow of resources from the capital market, results in the reduced financing of investments economic growth but the increase of inflation (El-Shagi and Turcuc, 2020; Bruneau et al., 2012). In addition, financial fragility increases economic fluctuations in production through the channel of creating financial stress and uncertainty in the economy, which isintensified if inappropriate monetary policies are created (Mallick and Sousa, 2013). The related literature indicated that stability in macroeconomic variables highly depends on stability in the financial sector. Thus, the stable economic growth can be regarded as a result of a stable financial system and financing; As a result, financial fragility creates inefficiency in investment by increasing the cost of financing and investment, resulting in a reduction in economic growth (Bezemer and Grydaki, 2014). Studies on financial fragility can be divided into several general groups. One part of the studies examined the effect of financial fragility on different variables and a group of studies investigated the effect of different variables on financial fragility. In another part of the study, an indicator was determined for financial fragility.

Pesola (2011) examined the effect of macroeconomic variables and financial fragility on the amount of uncollected bank receivables. In order to investigate the effect of macroeconomic shocks and financial fragility on the amount of uncollected loans, a nonlinear summarized form was estimated using panel data for nine European countries during 1982-2004. The results indicated that the

model fit well with the real data, indicating a large increase in uncollected bank loans in different financial crises.

Le and Doan (2020) evaluated the relationship between corruption and financial fragility in small and medium enterprises. This study, which was conducted using data from 62 countries and a method based on panel data, indicated a significant positive relationship between corruption and financial fragility in developing countries, while no significant relationship was found between corruption and financial fragility in the developing countries.

in another study, Mitkov (2020) evaluated the relationship between income inequality and financial fragility andindicated that government policies on income inequality, as well as financial fragility, can significantly affect inequality.

Wagner (2020) studied the relationship between financial fragility and liquidity to indicate that if liquidity policies by the government fail to lead to increased investment in the country, they will lead to higher fragility by stimulating the banking sector.

Tuzcuoğlu (2020) evaluated the effect of financial fragility on economic performance in Turkey. The results of this study indicated that increasing financial fragility by reducing economic fluctuations and increasing uncertainty will reduce the economic performance in active firms.

Chletsos and Sintos (2021) examined the relationship between financial fragility and employment. They find a significant negative relationship with an econometric model based on panel data and this effect was higher in the post-crisis period than in the previous period.

Obviously, the previous studies paid less attention to the effect of financial fragility on macroeconomic variables and no study was found to address this issue within the framework of a TVP-VAR model. As a result, the present study summarizes the past information and evaluates the effect of financial fragility on some macroeconomic variables in Iran.

3. Method

Time-Varying Parameter Vector Autoregression (TVP-VAR) is one of the most widely used methods in the recent financial and economic literature. The difference between this model and fixed VAR coefficient models is that it changes the parameters to over time and can flex the coefficients due to changes in conditions, structural fractures, and cyclic changes. Hence, it will result in to more accurate results (Korobilis, 2013; Eickmeier et al., 2011).

The initial VAR model introduced by Sims (1980) was one of the most significant models for evaluating the relationship between different financial and economic variables using impulse-response functions. In these models, the vector of variables y_t is estimated on its intervals and its functional form is as follows:

$$y_t = c_t + \sum_{j=1}^{L} A_j y_{t-j} + e_t \quad (1)$$

where e represents the error sentence with mean zero and the variance-covariance matrix Ω_e. In addition, c_t represents the vector of predetermined variables, and a indicates the matrix of coefficients by considering the intervals of the variables.
The above-mentioned model is a linear model where the predicted values for y are a function of some interrupts of variables and are independent of time. Nevertheless, different studies indicated that the torques of higher order vary over time, which began with the introduction of ARCH models by Engle (1982).
A modeler can have access to different approaches to have variable coefficients over time for the model presented in Eq. 1.
The first solution adds an imaginary variable as a predetermined variable over time. Alternative solutions can be sought in the estimation of VAR threshold models, hybrid VAR models, and Markov regime change.
In general, a flexible model for estimating coefficients over time can be better than using such nonlinear models.
In this regard, a standard TVP-VAR model will be obtained if the VAR model is written in Eq. 1 as a standard VAR model with variable coefficients. The following equation indicates this standard model:

$$y_t = c_t + \sum_{j=1}^{L} A_{j,t} y_{t-j} + e_t \quad (2)$$

The interrupt matrix of the variables is defined as the kronecker product as follows:

$$X_t' = I \otimes (1, y_{t-1}', \dots, y_{t-L}') \quad (3)$$

Furthermore, the coefficients of variable coefficients over time can be defined as follows:

$$\theta_t \equiv \mathrm{vec}([c_t \quad A_{1t} \quad A_{2t} \quad \dots \quad A_{Lt}]') \quad (4)$$

In this regard, Eq. 2 can be rewritten as follows:

$$y_t = X_t' \theta_t + e_t \quad (5)$$

The following relation can be written by assuming θ_t as a random walk:

$$\theta_t = \theta_{t-1} + u_t \quad (6)$$

where u_t has a normal distribution function with zero mean and constant variance and is independent of e_t. It is assumed that the variance-covariance matrix can be analyzed as follows:

$$\Omega_e = \Lambda^{-1} \Sigma \Sigma' (\Lambda^{-1})' \quad (7)$$

where Λ refers to a triangular matrix with elements one in the original diameter and Σ represents a diagonal matrix. In this equation, it can be proved that the parameters obtained from Ω_e will change over time.

The error term in the TVP-VAR model shown in Eq. 2 can be analyzed as follows:

$$e_t = \Lambda^{-1}\Sigma_t \epsilon_t \quad (8)$$

where the variance ϵ_t can be normalized as a unit matrix and it can be assumed that the error terms in all equations are related to the independent model.

The TVP-VAR models are estimated using the Bayesian method through the Markov Chain Monte Carlo (MCMC) (MCMC). The common posterior distribution for the parameters can be evaluated using this algorithm.

In addition, the dimensional problem of parameters is avoided in MCMC algorithm since this method mainly deals with recursive sampling of low dimensional goals and reduces the problems related to too many parameters.

As mentioned, this study used a TVP-VAR model to evaluate the effect of financial fragility on macroeconomic variables. For this purpose, first financial fragility was calculated, and then the effect of this variable on macroeconomic variables was studied. The financial fragility index can be calculated using the following formula:

$$FFI = \sum_{i=1}^{13} \alpha_i FI_i \quad (9)$$

where FFI represents financial fragility index, FI_i represents the financial index for each sector and α_i indicates the coefficient related to the i-th index for each sector. A critical issue in calculating the financial fragility index is how to calculate α_i. In this study, the index was calculated based on the coefficients obtained from the principal component analysis (PCA). To calculate this index, the variables of four sectors of the stock market, banking sector, foreign exchange market, government, and central bank were used.

For the stock market, the outflow ratio of financial resources to the capital market value, fluctuations in stock returns rate (calculating the fluctuations in stock price index returns using the GARCH model), fluctuations in trading volume and financial index (financial companies and stock exchange investments) were used. For the foreign exchange market, the difference between the free market exchange rate and the official market, fluctuations in dollar returns (calculating the dollar exchange rate fluctuations using GARCH model), and the volume of foreign exchange transactions of the central bank were applied. Regarding the banking sector, the ratio of overdue loans to total loans (credit risk index), the difference between long-term interest rates and short-term interest rates, the ratio of loans to total deposits, and share of mandatory loans in total loans were used. For the government and the central bank, the ratio of budget deficit to the government expenditures and the share of government borrowing from the central bank of the total budget deficit were applied and the results were normalized.

Figure 1 indicates the calculated values to measure the financial fragility index in Iran during 2001-2009. As shown, financial fragility had a stable trend until 2011 and increased slightly this year, which can be attributed to the fluctuations in the foreign exchange market, the downward trend of the stock market, and an increase in the government budget deficit. Financial fragility index decreased due to the reduction of the budget deficit in 2015 and the reduction of budget. After that year, the index took an upward trend with an increase in the public sector budget deficit due to a decrease in oil revenues in Iran and subsequent stock market fluctuations, foreign exchange market fluctuations, as well as increasing bank arrears and bank interest rate conditions in Iran. It seems that this sharp increase in financial fragility is a wake-up call for the Iranian economy.

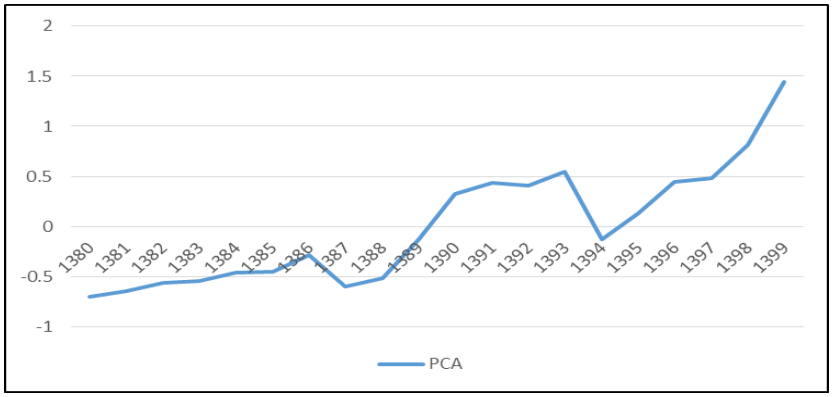


Figure 1. Financial fragility index in Iran during 2001-2020

Table 1 summarizes the definition and calculation method of variables used in this study. The data used in this study during 2001-2020 were quarterly and data analysis was conducted using MATLAB software.

Table 1. Variables used in the study and calculation methods

Variable name	Calculation method	References
Financial fragility	Researcher made	Research findings
Economic growth rate	GDP growth rate at base price 2016	Central bank
Inflation rate	GDP growth rate at base price 2016	Central bank
Liquidity growth	Total liquidity growth rate	Central bank
Investment	Changes in capital stock to the base year 2011	Central bank
Exchange rate	Rial price per dollar in the free market	Central bank

4. Data analysis

Explaining the number of interrupts is one of the first measures to estimate the models based on the VAR structure. In this study, the Akaike criterion was used to calculate the optimal number of interrupts and accordingly, the number of interrupts 1 was selected for the variables.

Furthermore, the number of iterations M = 10000 was used for the estimation. The following figures indicate the results for autocorrelation, sampling path, and posterior density.

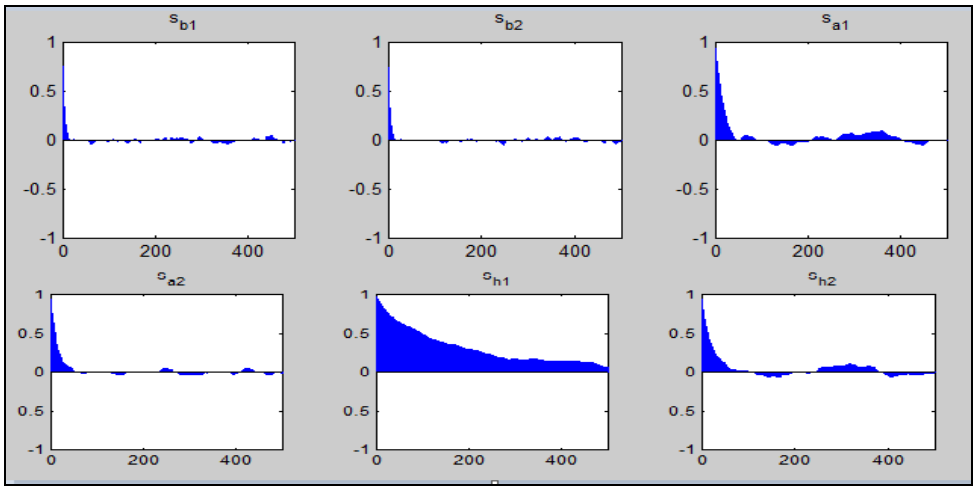


Figure 2. Coefficient autocorrelation

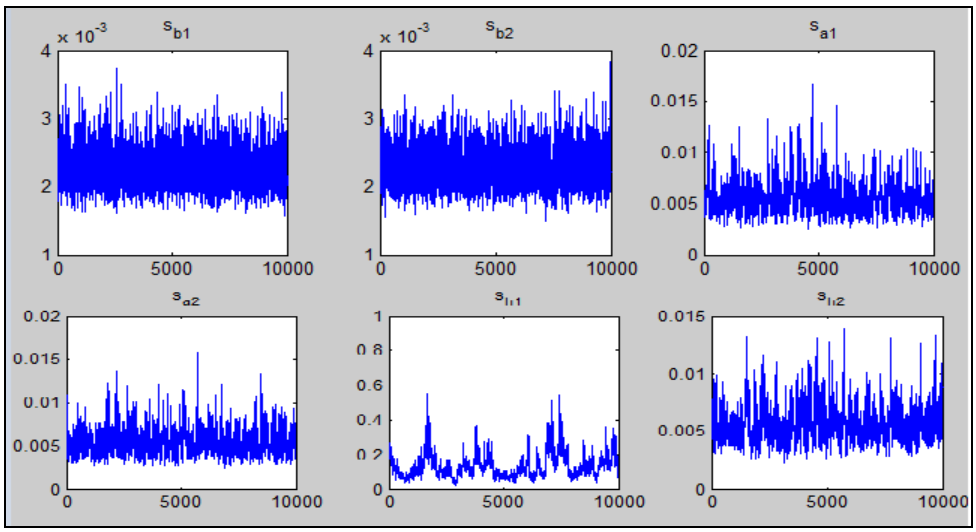


Figure 3. Variance of coefficients in iterations

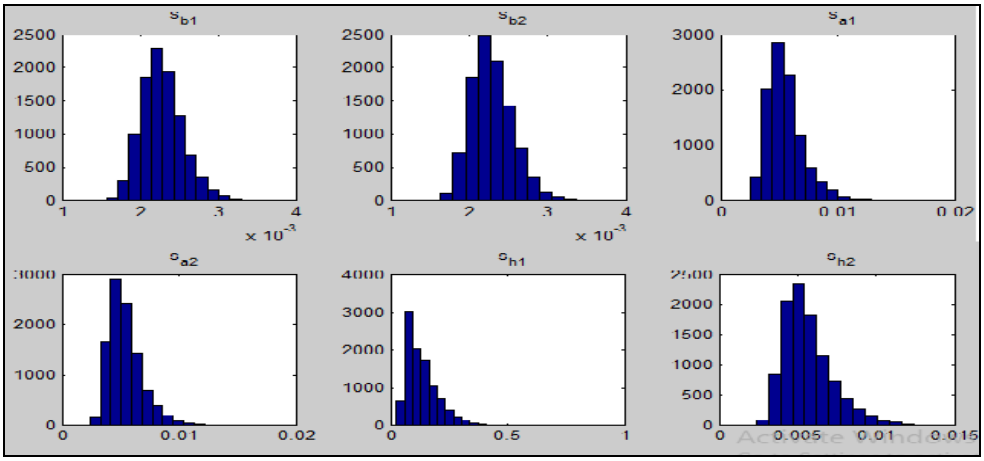


Figure 4. Distribution of posterior functions

Figure 5 displays the results for the mean posterior probability distribution with a standard deviation of the confidence interval.

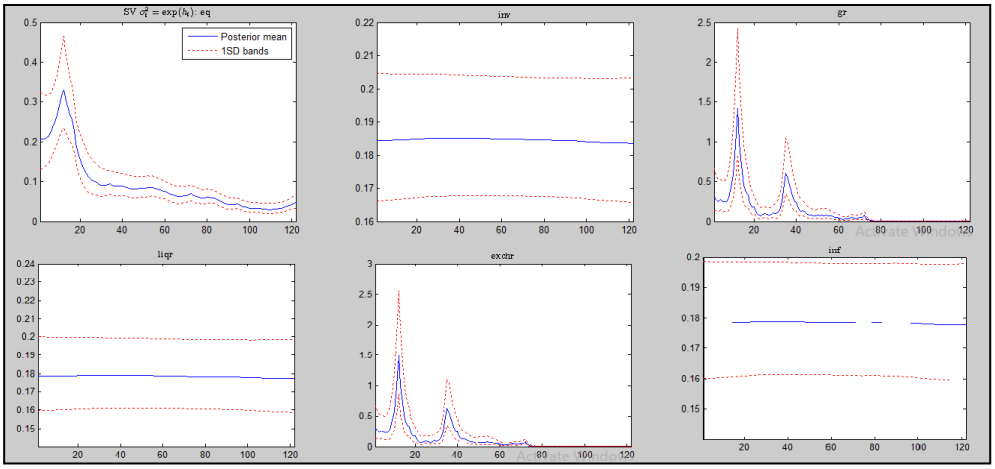


Figure 5. Average posterior probability distribution

Table 2 indicates the results for parameter estimation and Geweke test. Obviously, the mean coefficients and the confidence interval reveal the non-rejection of convergence assumption to the posterior distribution functions for the estimated parameters.

Based on the table, since the Geweke statistic is outside the confidence interval for all estimated parameters, the null hypothesis as the convergence to the posterior distribution function for the parameters is not rejected.

Table 2. Results of estimated coefficients in the TVP-VAR model

upper bound	lower bound	Inefficiency coefficient	Geweke statistics	Standard deviation	Mean	Parameter
0.0029	0.0018	5.39	0.192	0.003	0.0023/	Sb1
0029	0.0019	4.9	0.357	0.003	0.0023‧/	Sb2
0.0095	0.0034	29.78	0.754	0.0016	0.0055	Sa1
0.0091	0.0034	25.73	0.330	0. 0015	0.0054	Sa2
0.306	0.046	19.5	0.116	0.069	0.132	Sh1
0.0095	0.0034	37.87	0.026‧/	0.0016	0.0056	Sh2

Figure 6 displays the results of estimating the financial fragility coefficient on different macro variables in the model. As shown, some of the coefficients change over time. In addition, the coefficients are not the same over time and different parameters are obtained for all cases except for investment and financial self-fragility. Based on these results, the use of VAR models with fixed coefficients fails to result in the right results for studying the effect of financial fragility on macroeconomic variables.

Here are the impulse response functions in examining the effect of financial fragility on macroeconomic variables including economic growth, inflation, exchange rate, liquidity growth, and investment.

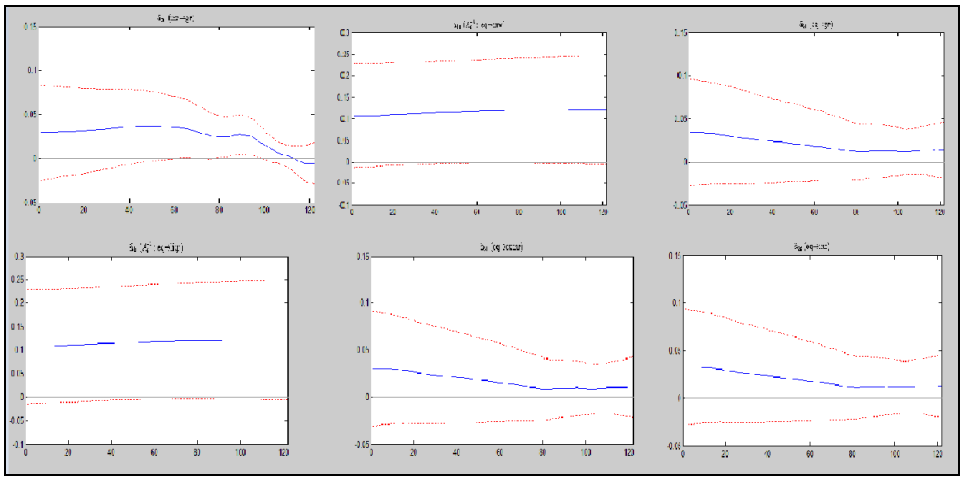


Figure 6. Coefficients obtained from TVP-VAR model estimation

Figure 7 indicates the impulse- response functions obtained from the TVP-VAR model estimation. As shown, the results and the effect of financial fragility on the variables are different while changing the time, which more obvious in the exchange rate response function than the shock in financial fragility. Moreover, the results indicated that financial fragility leads to economic growth in the short

term and during a period of less than two seasons but has a negative effect on economic growth after two periods.

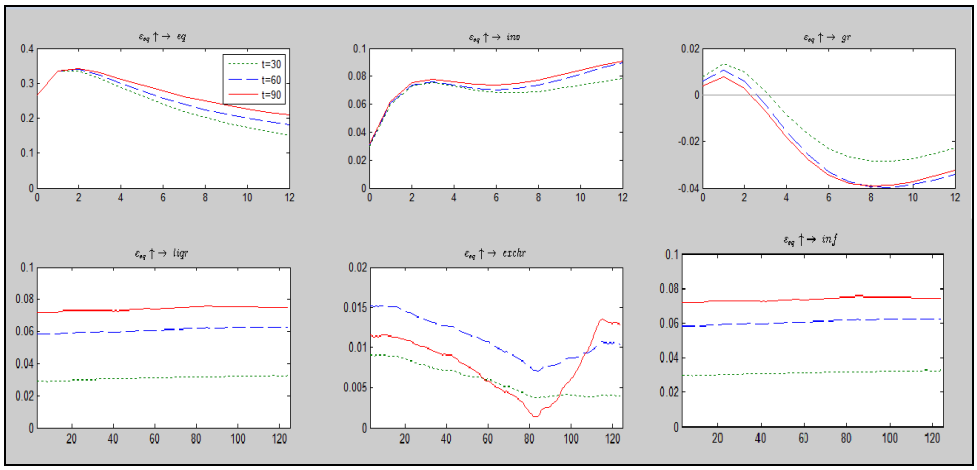


Figure 7. Impulse- response functions derived from TVP-VAR model estimation

As shown, the effect of financial fragility on liquidity growth rate and inflation rate is positive and stable so that a shock in financial fragility increases inflation and liquidity growth rate and this effect is stable over time.

It seems that an increase in financial fragility increased uncertainty in the economy due to fluctuations in financial markets leads to an increase in inflation. The increase in financial fragility and uncertainty has increased the cost of investment, resulting in the increased cost of production and inflation. On the other hand, when financial markets are fragile, the demand for durable goods for investment increases, raising inflation expectations and higher inflation in the economy. Furthermore, the results indicated that financial fragility had a positive effect on the exchange rate, which was higher at the beginning and reducing over time. With the increase of financial fragility and uncertainty in the economy, the demand for assets increased. As a result, an increase occurred in demand for currency which resulted in an increase in the exchange rate. As mentioned, financial fragility in Iran which was created due to fragility in the foreign exchange market, banks, central banks and government, as well as the stock market, had a negative effect on economic growth, but a positive effect on exchange rates and inflation. In other words, financial fragility in Iran caused economic fluctuations in Iran by reducing economic growth and increasing inflation and exchange rates.

5. Conclusion

Financial fragility has always been regarded as one of the concerns of economic policy makers during the recent years, especially after the financial crisis. As mentioned above, financial fragility can affect different variables from various channels in the economy and has been analyzed in numerous studies. Accordingly, this study aimed to investigate the effect of financial fragility on macroeconomic variables in the framework of a TVP-VAR model. For this purpose, first the financial fragility was calculated and then the effect of this variable on macroeconomic variables was evaluated. The data used in this study during 2001-2020 were quarterly and data analysis was conducted using MATLAB software. In this study, the effect of financial fragility, which was calculated based on research calculations, on economic growth rate, inflation rate, liquidity growth, investment, and exchange rate were analyzed. Based on the TVP-VAR model estimation, the mean coefficients and confidence intervals showed the non-rejection of the hypothesis on convergence to the posterior distribution functions for the estimation parameters. Since the Geweke statistic was outside the confidence interval for all of the estimated parameters, the null hypothesis on convergence to the posterior distribution function for the parameters was not rejected. On the other hand, the results of parameter estimation revealed that the coefficients were not the same over time and different parameters were obtained for all cases except for investment and financial self-fragility. The results of impulse-response functions indicated that financial fragility led to economic growth in the short term during a period of less than two seasons, but could have a negative effect on economic growth after two periods. Meanwhile, the effect of financial fragility on liquidity growth rate and inflation rate was positive and stable so that a shock in financial fragility increased inflation and liquidity growth rate and such an effect was stable over time. Furthermore, the results indicated that financial fragility had a positive effect on the exchange rate, which was higher at the beginning and could decrease over time. In other words, financial fragility had a negative effect on economic growth but a positive effect on exchange rates and inflation. In other words, financial fragility in Iran caused economic fluctuations by reducing economic growth and increasing inflation and exchange rates. The results of this study indicated that financial fragility in Iran had an upward trend and increased economic fluctuations in Iran. Thus, the economic policymakers are suggested that the first step in controlling inflation and stimulating economic growth will be the control of financial markets such as banks, stock markets, and foreign exchange markets, as well as more accuracy in monetary and fiscal policies in government and the central bank. In other words, it would be better to reduce the financial fragility in Iran by controlling the financial markets and government policies, and this issue could control economic fluctuations to some extent by creating confidence.

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تأثیر شکنندگی مالی بر متغیرهای کلان اقتصادی: مدل TVP_VAR برای اقتصاد ایران

چکیده:
مطالعه حاضر با هدف بررسی تأثیر شکنندگی مالی بر متغیرهای کلان اقتصادی در مدل TVP-VAR انجام شد. برای این منظور ابتدا متغیر شکنندگی مالی محاسبه شد. سپس به بررسی تأثیر این متغیر بر متغیرهای کلان اقتصادی شامل نرخ رشد اقتصادی، نرخ تورم و نرخ ارز پرداخته شده است. در این تحقیق از داده‌های فصلی دوره ۲۰۲۰-۲۰۰۱ استفاده شده است. نتایج حاکی از آن است که شکنندگی مالی با ایجاد نااطمینانی در اقتصاد اثر منفی بر رشد اقتصادی داشته اما بر نرخ ارز و تورم اثر مثبت داشته است. به عبارت دیگر، شکنندگی مالی در ایران با کاهش رشد اقتصادی و افزایش تورم و نرخ ارز، نوسانات اقتصادی را افزایش داد.
واژه های کلیدی: شکنندگی مالی، تورم، رشد اقتصادی، ایران، مدل.TVP-VAR .
طبقه بندی:JEL ، E42، E61، C18.