



Research Paper

Providing a Model for Measuring the Impact of Economic Policy Uncertainty on Information Asymmetry

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ABSTRACT

The purpose of this study is to provide a model for measuring the impact of economic policy uncertainty (EPU) on information asymmetry, unexpected profits and voluntary disclosure of information. The research method is applied and an attempt has been made to present a model for measuring the effect of EPU on information asymmetry over time (case study: companies listed on the Tehran Stock Exchange) in the EVIEWS12 and MATLAB2021 software environment. The research time period is determined from 2011 to 2020 and 101 companies are selected based on the applied restrictions to estimate the model. In this study, 40 variables affecting EPU are entered into the model and finally, using the BMA, the most important variables affecting this index are determined. According to the results of BMA, the most important variables affecting the EPU index are real interest rates, government debt to the central bank, liquidity (M2), inflation, current expenditures, land price index in urban areas, informal exchange rate, real exchange rate, economic growth, and oil revenues [2]. Based on the principal components approach, the EPU index is calculated using the most important variables affecting this variable. Then, with the GARCH model, the uncertainty part of the EPU index is extracted, and finally, using the powerful nonlinear TVPFAVAR model, the shock caused by the EPU variable on the information asymmetry indices in the research period is analyzed. The results show that the shock caused by the fluctuation of the variable of EPU has increased the index of information asymmetry in recent years. Based on the results, EPU shock on the index of information asymmetry has had a stronger effect on in the short and long term information asymmetry than the medium term.

1 Introduction

Investors' uncertainty about the value of the company is one of the main reasons for the reaction of many investors and management activities. On the one hand, in addition to the causes that affect investor uncertainty, there is a type of uncertainty that cannot be controlled by managers and investors and

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strongly affects the value of companies, and that is uncertainty about the economic policies of the government or "Economic policy uncertainty" (EPU), which can affect all corporate activities [16]. In the economic literature, uncertainty causes various economic sectors such as consumers or companies and other enterprises to lose the ability to predict and plan for economic processes and events that will occur in the future. Uncertainties in various economic areas such as decision making, stock portfolio management, etc. are influential factors at different levels. Various amounts of uncertainty of macroeconomic indicators, such as market fluctuations, affect the valuation of assets and capital markets, as well as the interval between which economists are able to predict economic events; therefore, it is necessary to study the degree of uncertainty in macroeconomic indicators to make decisions in different economic sectors and economic enterprises [4].

On the other hand, information asymmetry is the information advantage of some parties to the transaction over others in a commercial transaction and is a qualitative concept [18]. Theories suggest that information inequality may lead to market failure, leading to macro- and micro-inefficiencies through a tendency to invest less or more than real. The first cause of information asymmetry is inappropriate selection and occurs when one or more parties in a real or potential business transaction have an information advantage over the other parties. This gives policymakers and lenders the incentive to pay attention to and emphasize the integration of information among users of financial statements. The second factor in the information asymmetry is moral hazard, according to which either party in a real or potential commercial transaction is able to observe their actions in execution or violation of the terms, while the other parties are not able to observe other party's action [27]. Due to these factors, measuring and eliminating information asymmetry in practice is very difficult and collecting empirical evidence on the existence and importance of information inequality, especially in credit markets, is not easy [3].

Given the importance of the issues raised and the research gap in examining the relationship between EPU in Iran and information asymmetry of companies in a dynamic and nonlinear mode, the present study aims to answer the main research question that "What effect does EPU have on the variable of information asymmetry in companies listed on the Tehran Stock Exchange?"

2 Theoretical Foundations and Research Background

One of the hallmarks of any economic environment is environmental uncertainty, and sound and rational decisions are made based on information that describes or at least helps to identify risk and confidence conditions. In fact, what exists in our current real environment is that we may have an environment of complete confidence only in a vacuum, and the environment around us is an environment of uncertainty; therefore, we need to know more about the word uncertainty and its effect on the information based on which we make decisions. Uncertainty is a space in which the decisions of economic actors, including households, businesses and the public sector in various fields are accompanied by uncertainty. In expressing the concept of uncertainty, it can be said that it is a situation where future events or the probability of their occurrence cannot be predicted. Uncertainty exists when either future events are uncertain or their probability is unpredictable despite the certainty of future events. In other words, the main cause of uncertainty is the lack of forecasting knowledge. In fact, uncertainty is a state in which individuals' knowledge is limited and it is not possible to fully explain the state or the result that has been achieved or will be achieved. Accordingly, uncertainty in macroeconomics can be interpreted as the inability of brokers to accurately predict the results of their decisions [9]; uncertainty, therefore, means that in a given situation a person cannot organize the information quantitatively and qualitatively in a way that is suitable for explaining, predicting and presenting the verdict in a definite

and quantitative (numerical) way. Lack of information is the most common cause of uncertainty. Various definitions of environmental uncertainty have been proposed. For example, rezaei [19] state that environmental uncertainty is a kind of inability to predict the possible consequences of a decision. Environmental uncertainty is the conditions under which organizations adjust their framework and is due to environmental factors of the organization, which is related to the degree of change of environmental activities related to the organization's operations, including unforeseen activities of customers, suppliers, competitors, and legal institutes. Uncertainty in macroeconomics can usually be measured in terms of inflation, interest rates, currencies, economic growth, exchange rates, and stock values. Given that the uncertainty of economic policies causes a change in the risk and stock returns of companies listed on the stock exchange, it is tried to examine the type of risk and the EPU risk position (systematic risk) in changes in stock return behavior.

Information asymmetry and uncertainty

Most organizations and business units are influenced by the external environmental factors in which the organization operates. In such circumstances, managers adapt themselves to the constraints of the environment (the operations of the company) One of these constraints is an environment of uncertainty. Environmental uncertainty results from the unpredictable actions of customers, suppliers, competitors, and monitoring groups. The existence of these constraints will have adverse effects on stock prices, the cost of financing, and even the job security of managers [7]. For example, managers may reduce their confidence in the incentive to pay for internal resources and increase their budget, and managers have the incentive, within the accepted accounting principles, to reduce profit volatility in response to environmental uncertainty. Therefore, managers may use their authority to reduce excess volatility created by uncertain environments [7] Thus, the managed or reported earnings of the company may show the volatility of profits less than the unmanaged profit.

2.1 Research Background

Nagar et al. [15] conducted a study entitled " EPU and Information Asymmetry" and examined whether EPU exacerbates information asymmetry among investors. In this regard, they examined the daily data of American companies for the years 2009-2010. The results showed that the increase in EPU was associated with a decrease in stock liquidity, especially for companies that were more affected by EPU. Increasing EPU also reduces the investor response to profits for companies at high liquidity risk. Management, in turn, increases voluntary disclosure, which only partially reduces liquidity. These results show that information asymmetry is an important channel through which EPU affects asset pricing.

Nagar et al. [15] studied the effect of EPU on investor information asymmetry and management disclosure. Investors' uncertainty about the value of the company leads to collecting investor information and trading activities, as well as managers' choice of disclosure types. This study examines an important source of uncertainty (uncertainty about government economic policies) that is unlikely to be affected by most managers and investors. Findings show that this uncertainty is associated with an increase in the price gap and a decrease in the stock price response to abnormal profits. Managers respond to this uncertainty by increasing voluntary disclosure; but these disclosures only partially reduce the price gap. The results show that the uncertainty of government economic policies is an important part of the company's information environment and managers' decisions related to voluntary disclosure.

Nagar et al. [16] carried out a study entitled "The Impact of EPU on Information Asymmetry and Management Disclosure". By collecting daily data from state-owned companies from September 10, 2003

to December 31, 2016, and analyzing them, they found that EPU is associated with increased information asymmetry and decreased stock price responses to unexpected returns. Managers respond to this uncertainty voluntarily by increasing uncertainty. As a result, the uncertainty of government economic policies has been an important part of corporate information environments and managers' voluntary disclosure decisions. KeyGhobadi et al. [11] conducted a study entitled "the effect of quality of information disclosure and information asymmetry on the volatility of stock returns using the system of simultaneous equations". They examined 520 year-companies (104 companies during the years 2013 to 2017) and the simultaneous effect of disclosure quality and information symmetry on stock volatility using the method of simultaneous inflection equations and the direct effect of disclosure quality on volatility using cross-sectional regression. Findings showed that high quality of information disclosure reduces information asymmetry and thus low information asymmetry also leads to a reduction in volatility of stock returns.

In a study entitled "inadequacy of the components of voluntary disclosure between the corporate governance system and information asymmetry in companies operating in the Tehran Stock Exchange", Parsian et al. [17] used a survey method. They selected a targeted sample of 102 interviewees and 186 active companies in the fiscal year of 2016 using elimination sampling method. Using structural equation modeling and confirmatory factor analysis with partial least squares approach and SmartPLS software, the research findings show that the mechanisms of corporate governance system have a positive and significant effect on voluntary disclosure, financial performance and information asymmetry of companies. Voluntary disclosure of companies has a positive and significant effect on information symmetry in the capital market; also, the financial performance of companies did not have a significant effect on the information symmetry of companies. Finally, it can be said that with the establishment of appropriate corporate governance mechanisms, the ground is set for voluntary disclosure of corporate information, information transparency and information symmetry in the capital market and this can lead to the efficiency of financial market to improve corporate performance.

Hamidian et al. [8] investigated the reaction of investors to unexpected profits in the face of market uncertainty. The results of hypothesis testing showed that when there is high uncertainty in the market (compared to low uncertainty), investors react more to the announcement of companies' annual profits. In the face of high uncertainty, investors are more likely to react to bad news (unexpected losses), which is consistent with a conservative approach. Saboori and Karimi [23] tried to determine the common effects of EPU and company characteristics on the capital structure of companies listed on the Tehran Stock Exchange. According to the analysis of the regression model, the research findings show that the main hypothesis has been confirmed and it was found that EPU and company characteristics have a common and significant effect on the capital structure of companies listed on the Tehran Stock Exchange. The results showed that EPU has a direct and positive effect on financial leverage and capital structure; but the characteristics of the company have an adverse and negative effect on financial leverage and capital structure. In other words, EPU of 10.79 increases the capital structure and corporate characteristics by 5.20, which is in line with the research of Xiao and Qiu [22].

3 Research Methodology

This research is applied in terms of its objectives. In this research, to obtain data from the financial statements of companies listed on the Tehran Stock Exchange, the Codal site (www.Codal.ir) and the Central Bank statistics were used, and to calculate variables and process them, Excel and Eviews soft-

ware were used to analyze the obtained information and achieve reliable results. The statistical population of the study included all companies listed on the Tehran Stock Exchange. The number of samples studied in this research was selected using the screening method according to the following criteria:

The end of the fiscal year of the studied companies is March 20; companies have not changed their fiscal year during the investigation period; the companies surveyed entered the stock exchange before 2011 and were not listed until the end of 2020; they should not belong to banks and financial institutions (investment companies, financial intermediaries, leasing); and their required financial information is available. In this study, independent and dependent variables are as follows.

The dependent variables

Information asymmetry: Conceptual definition: Information asymmetry is the information advantage of some parties to the transaction over others in a commercial transaction and is a qualitative concept [18].

Operational definition: In this research, the following five measures are used to calculate information asymmetry:

- A. Trading volume: Many researchers have used trading volume as a measure of information asymmetry, which is calculated through the ratio of the total trading volume (in terms of shares) to the issued shares. This criterion controls the effects of differences in the total shares issued by companies. When a company's stock is traded in large volumes, this means that the liquidity of the company's shares is high and it can be acknowledged that there is information symmetry in the company; therefore, information asymmetry affects the volume of transactions and the amount of liquidity [10].
- B. Fluctuation of the company's stock price: It is measured based on the standard deviation of the monthly stock return during the year under review. It can be said that increasing the fluctuation limit can increase the efficiency and symmetry of information [26].
- C. Price to profit ratio: The higher this ratio in a company is, the greater the information asymmetry of that company in that year is.
- D. Number of trading days: Usually when a special event takes place in companies (such as EPS adjustment, meeting, capital increase, etc.), the company's symbol stops until it is transparent and officially announced by the stock exchange organization so that shareholders make decisions with proper knowledge of the event. On the other hand, failure to provide essential information or incomplete information provided by companies to the stock exchange organization is another reason for stopping the trading symbol of companies. All the reasons for closing the trading symbol of companies emphasize the possibility of information asymmetry between people within the organization and investors.
- E. Company life: It is assumed that there is less information asymmetry about companies with longer life. The life of the company is defined as the time of admission to the stock exchange. Obviously, the larger the company or the longer it has been in the capital market, the more information there is about it and is available to market participants; therefore, this variable is inversely related to information asymmetry.

To calculate the degree of information asymmetry of the sample companies, the five measures introduced above are combined. For this purpose, first the quarterly rank of the companies is calculated for all the mentioned proxies, so that a higher rank means a higher degree of information asymmetry. The rankings for each of the five proxies for each company are then aggregated. With this in mind, the largest (smallest) value of the INDEX_AI variable could be for companies with the highest (lowest) degree of information asymmetry.

Independent variables

EPU: Conceptual definition: EPU means uncertainty in decisions related to macroeconomic variables in such a way that by adopting policies and changes in economic and financial structures, it creates significant changes in the capital market [5].

Operational definition: Table (2) is used to introduce the variables affecting EPU. In the following, the models that will be used in estimating the model will be introduced. Then, Bayesian model averaging (BMA), TVPFAVAR and CFA models are introduced.

Bayesian Model Averaging (BMA model)

A distinctive feature of Bayesian approach to inference is the attribution of numerical probabilities to the degree of belief of the researcher. Of course, the degree of the researcher's belief in the correctness of a hypothesis depends on the amount of information he has at that moment. For example, in this method, based on the mastery of the subject and the relationship between the variables, the conditions of the study country, n variable is introduced to BMA as the most important variables affecting the dependent variable. If researcher's view is correct, the output results will confirm his/her views. For example, in order to examine the factors affecting US economic growth, Martin (2008) introduced 8 variables as factors affecting economic growth, and the results of the model were consistent with the researcher's view. Consequently, by changing the information about a term, the probability of the correctness or inaccuracy of the term must also be reconsidered (Koop, 2003). The process of revising probabilities by the new information identified by y is summarized in Figure 1 (Zellner, 1971).

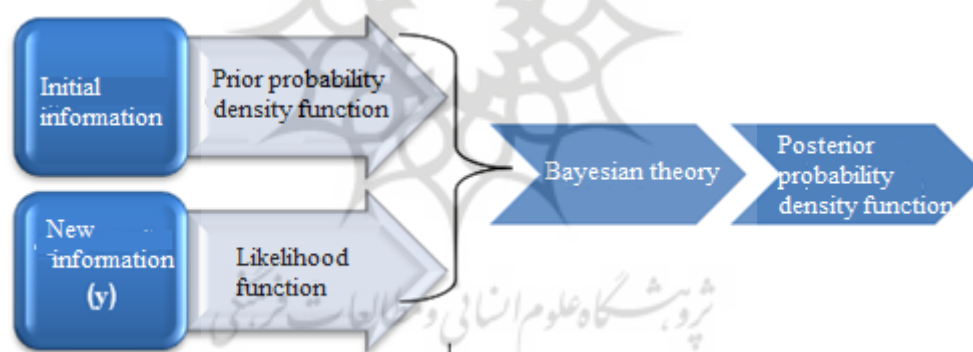


Fig.1: BMA

The prior probability density function for Hypothesis H is based on initial information. This information is usually a combination of previous data, empirical studies, observations, and theories. The posterior probability density function for new observations y is given by Hypothesis H . This probability density function is known as the likelihood function. To obtain the posterior probability density function, the prior probability density function must be combined with the likelihood function by Bayesian theory. The posterior probability depends on both the prior information I_0 and the y sample information. With the effect that the new data information has on the prior probability density function by Bayesian theory, the prior probability density function is transformed into the posterior probability density function. It should be emphasized that posterior probability includes the researcher's opinion about the parameter, data information, and prior information [25].

Time Varying Parameters- Factor Augmented Vector Autoregressive (TVP-FAVAR model)

The estimation coefficients of the model used in this research can change over time and in this respect, it is different from the models used in the experimental studies mentioned in the previous section. The TVP-FAVAR model used in this research eliminates the weakness of linear models in terms of structural fractures and cyclical changes in time series and allows a more detailed study of the relationships between model variables [12].

A number of researchers have concluded that in operating models, time-varying coefficients (TVPs) lead to more accurate results [62, 63, 64]. Suppose x_t for $t = 1 \dots, T$ is a vector of $n \times 1$ of the variables to estimate the invisible variable in the model. In addition, y_t is a $s \times 1$ vector of observable macroeconomic variables in the model. The TVP-FAVAR model is as follows:

$$\begin{aligned} x_t &= \lambda_t^y y_t + \lambda_t^f f_t + u_t \\ \begin{bmatrix} y_t \\ f_t \end{bmatrix} &= c_t + B_{t,1} \begin{bmatrix} y_{t-1} \\ f_{t-1} \end{bmatrix} + \dots + B_{t,p} \begin{bmatrix} y_{t-p} \\ f_{t-p} \end{bmatrix} + \varepsilon_t \end{aligned} \quad (1)$$

Here, λ_t^y is regression coefficients, λ_t^f is factor variable coefficient, and f_t is factor variable. Also, $(B_{t,1}, \dots, B_{t,p})$ is VAR coefficients. Moreover, u_t and ε_t are model residues that have a normal distribution with zero mean and covariance Q_t and V_t . Coefficients of $\lambda_t = ((\lambda_t^f)', (\lambda_t^y)')$ and VAR model coefficients $\beta_t = (c_t', \text{vec}(B_{t,1})', \dots, \text{vec}(B_{t,p})')$ are extracted based on a stochastic step process of the variable in time:

$$\begin{aligned} \lambda_t &= \lambda_{t-1} + v_t \\ \beta_t &= \beta_{t-1} + \eta_t \end{aligned} \quad (2)$$

Where, $\eta_t \sim N(0, R_t)$ and $v_t \sim N(0, W_t)$. All errors in Equation (2) are non-correlated to each other and to time, so they are structured as follows:

$$\begin{pmatrix} u_t \\ \varepsilon_t \\ v_t \\ \eta_t \end{pmatrix} = N \left(0, \begin{bmatrix} V_t & 0 & 0 & 0 \\ 0 & Q_t & 0 & 0 \\ 0 & 0 & W_t & 0 \\ 0 & 0 & 0 & R_t \end{bmatrix} \right)$$

Relationships (1) and (2) are called the TVP-FAVAR model. By applying several constraints, other models are derived from the above model, which are as follows:

Factor-Augmented Time-Varying Parameter VAR (FA-TVP-VAR): This model is obtained when the coefficients of the first equation in relation (1), (λ_t) are constant in all time periods ($W_t = 0$; in this case, $\lambda_t = \lambda_0$).

Factor-Augmented VAR (FAVAR): This is achieved when λ_t and β_t are constant over time ($W_t = R_t = 0$).

Time-varying parameter VAR (TVP-VAR): This model is obtained when the number of factors in the model is zero (i.e. $f_t = 0$).

VAR model: This model is obtained when the number of factors is zero and λ_t and β_t are constant over time.

Bayesian estimation of TVP-VAR and TVP-FAVAR models is performed using the Monte Carlo Markov Chain (MCMC) methods. Such Bayesian simulation methods are computationally heavy, even if the researcher estimates a single TVP-FAVAR model. When faced with multiple TVP-FAVARs and

when calculating recursive predictions (which repeatedly require MCMCs to be performed over a wide range of data), the use of MCMC methods is prohibitive due to the long execution time of the estimates.

***principal component approach
(PCA Model)***

The idea of a principal component approach, according to Ziegler & Eickmeier [28], dates back to Burns & Mitchell [1]. The main idea was to reduce the size of the large data set while maintaining the original variance as much as possible. Thus, the major changes in many variables can be explained by a small number of common factors or external shocks. The principal component analysis (PCA) method, using orthogonal conversion, converts observations from potentially correlated variables to non-correlated variables. New variables are principal components, a linear combination of principal variables; but less or equal number of them are replaced. The principal components are then sorted by their variance, with the first components indicating the highest variance. This avoids to some extent the uncertainty of the parameter, which is most likely due to poor performance of the forecast. In general, the main application of PCA method is to reduce the number of variables and find the relationship structure between variables, which is in fact the same as the classification of variables. The main advantage of using this method in econometrics is the elimination of collinearity in the models due to the large number of effective variables in the model.

4 Research Findings

Results of BMA

In this section, the purpose is performing regression test on all possible cases in the presence of 40 variables affecting EPU. According to Salai and Martin, from a number of estimates onwards (about 150 to 200 million regressions), the ratio of the significant presence of a variable to all states tends to a certain number; therefore, it is not necessary to estimate all states. Finally, there is a need for a decision threshold to remove variables. To determine the optimal limit, the ratio of K divided by the total variables will be used (k is the number of proposed variables that has the highest impact on the dependent variable from the researcher's point of view). This K is experimental and is selected based on the researcher's point of view.

To achieve the result, calculations on all models must be performed in the model space. According to the number of variables studied, the number of existing models (based on the presence or absence of each variable) in the model space is equal to 2^{40} models, which is more than 1100 billion regression models. In other words, the model space includes 2^{40} models, which according to the assumption of model uncertainty, i.e. without imposing personal opinion in model selection, all models should be examined and the information of all models should be used to achieve the result.

In BMA, because the results are based on the value of the meta-parameter K (in the above calculations, the number K was considered to be 10), the question arises as to whether the results of the research change if the value of the meta-parameter changes and if the answer is positive, what is the rate of change? In other words, will the choice of the expected size of the model affect the results?

Accordingly, by selecting different K 's and re-performing the whole sampling process and related calculations, the results were compared. It should be noted that in these three cases, the model space and

therefore the variables and data are the same and the only difference is the expected size of the model¹; of course, it is quite clear that by changing the expected size of the model, the samples and the consequent result will be different. This means that the variables may be fragile (or non-fragile) in all three \bar{K} values; the fragility of some variables changes by changing the value of \bar{K} and the variable that is assumed to be fragile with the assumption of \bar{K} becomes non-fragile by increasing the expected size of the model. Table 1 aims to identify the correct number of K^2 if the researcher mistakenly provided the number of initial variables proposed. The value of K in this paper is considered equal to one to 10 variables. This number is a reflection of what is expected to finally be introduced as 10 non-fragile variables by the calculation process; but it is quite clear that it is possible that in the end the number is less than or more than 10 non-fragile variables. The output results of K from 1 to 10 are presented in Table 1.

Table 1: Results of Non-Fragile Variables in Different Models

K	Non-fragile variables
K=1	Real interest rate.
K=2	Real interest rate, government debt to the central bank.
K=3	Real interest rate, government debt to the central bank, liquidity (M2).
K=4	Real interest rate, government debt to the central bank, liquidity (M2), inflation.
K=5	Real interest rate, government debt to the central bank, liquidity (M2), inflation, current expenditures
K=6	Real interest rate, government debt to the central bank, liquidity (M2), inflation, current expenditures, land price index in urban areas.
K=7	Real interest rate, government debt to the central bank, liquidity (M2), inflation, current expenditures, land price index in urban areas, informal exchange rates.
K=8	Real interest rate, government debt to central bank, liquidity (M2), inflation, current expenditures, land price index in urban areas, informal exchange rate, real exchange rate.
K=9	Real interest rate, government debt to central bank, liquidity (M2), inflation, current expenditures, land price index in urban areas, informal exchange rate, real exchange rate, ratio of non-current receivables to granted facilities.
K=10	Real interest rate, government debt to central bank, liquidity (M2), inflation, current expenditures, land price index in urban areas, informal exchange rate, real exchange rate, economic growth, oil revenues.

The following is a summary of the results of estimating the $k = 10$ model.

Initially, the coefficients and probabilities of each variable were calculated by obtaining a sample containing 1 million regressions from the model space. Then, 1 million regressions were added to the first sample and calculations were performed for 2 million regressions and later coefficients and probabilities were obtained. As this trend continued, convergence was obtained in the sample containing 100 million regressions³. Accordingly, there is no need to increase the sample size to determine non-fragile variables

¹ The expected size of the model is the number of explanatory variables that the researcher expects to have a significant effect on the dependent variable.

² It is noteworthy that determining the initial K will determine the threshold for deleting variables.

³ The convergence criterion is that the posterior coefficients do not change up to two digits.

(Table 2). In order to introduce a variable, two conditions must be met. 1) Increase the posterior probability of each variable compared to the prior probability; 2), the level of posterior probability is higher than the defined threshold level ("initial threshold level = 10 divided by 0.40 = 0.25").

In the first step, using the above double conditions, 10 variables were selected to determine non-fragile variables. That is, the 10 variables had a higher posterior probability value than the prior probability, and these 10 variables had a posterior probability level higher than the threshold level of 0.25. Then, in the third and fourth columns, the posterior coefficients and the deviation of the posterior criteria of the variables are stated, respectively. In the last column, the t statistics ratio of each variable is presented⁴.

Table 2: The First Stage of the Sampling and Calculation Process Assuming $\bar{K} = 10$

Variable	Sample including 1 million regressions ⁵		Sample including 100 million regressions	
	Prior coefficient	Prior probability	Posterior coefficient	Posterior probability
Net foreign assets of the banking system	-0.678813	1.05894	0.05894	-0.704285
Net foreign assets of the central bank	0.059116	0.8784	0.08902	0.030581
Foreign assets of the central bank	0.016154	0.14134	0.24134	0.017914
Foreign assets of banks	0.000223	0.14946	0.15016	0.000392
Foreign assets of the banking system	0.023119	0.32436	0.13224	0.022737
Debts of banks to the central bank	0.313336	0.124912	0.192066	0.172992
Non-governmental sector debt to the banking system	-0.015126	0.07208	0.13568	-0.024274
Foreign exchange debt of the central bank	0.42018	0.213802	0.10335	0.20511
Public sector debt to the banking system	0.09816	0.291394	0.033072	0.00774
Public sector debt to the central bank	0.02894	0.866738	0.922642	0.13315
Public companies and institutions' debts to the central bank	0.07823	0.203096	0.039326	0.05003
Public sector debt to banks and non-bank credit institutions	-0.108862	0.195676	0.061056	-0.067077
Net public sector debt to the banking system	0.00022	0.14946	0.05016	0.00039
Net government debt to the central bank	0.00579	0.21836	0.12048	0.00639
Ratio of foreign debt to foreign assets of the central bank	0.00588	0.09964	0.0226	0.01242
Foreign exchange debt of the central bank	-0.038701	0.52046	0.12542	-0.021221
Foreign exchange debt of the banking system	-0.087556	0.111216	0.160484	-0.046428
Foreign currency debt of banks	0.40937	0.138564	0.175358	0.12434
Foreign debt of the central bank	0.003975	0.22226	0.230512	0.003381
Net government debt to banks	0.05777	0.07208	0.14578	0.184069
Money Volume (M1)	0.47965	0.06042	0.11766	0.93688
Liquidity (M2)	0.18518	0.78798	0.90038	0.143375

⁴ It should be noted that the index is the ratio of t-statistic and not the t-statistic itself, because in this model, the ratio of significant states of a variable to total states is the criterion for the suitability of the variable. If this ratio becomes one, it means that the variable is the strongest variable explaining the dependent variable, because in all cases it has a significant effect on the dependent variable. Zero ratio of t-statistics ratio means that the variable had no significant effect on the dependent variable in any of the models present.

⁵ 1 and 100 million regression numbers are selected according to the number of variables, the combination of variables and the estimated number of regressions, which causes convergence and stability of probability in the presence of a variable affecting the EPU index in the prior and posterior distributions. Accordingly, the smaller the number of variables and the stronger the relationship between the variables, the smaller the number of regressions needed to converge the probabilities between the variables.

Table 2: The First Stage of the Sampling and Calculation Process Assuming $\bar{K} = 10$

Variable	Sample including 1 million regressions ⁵		Sample including 100 million regressions	
Current expenses	5.3E-05	0.83816	0.89646	0.10028
Oil revenue	0.01262	0.32084	0.45264	0.10536
Ratio of legal deposits of banks with the Central Bank	-0.016494	0.2332	0.12578	-0.014013
Ratio of bank deposits to liquidity	-0.001897	0.10388	0.09646	-0.03304
Real interest rates	0.059116	0.6784	0.99902	0.180581
Bank interest rates on one-year deposits	-0.033231	0.06254	0.12084	-0.01925
Loan interest rates	-0.183274	0.409478	0.163304	-0.056074
Informal exchange rates	0.002332	0.47208	0.69328	0.102438
Real exchange rate	0.000053	0.03816	0.09646	0.000276
Real effective exchange rates	0.005788	0.41836	0.62048	0.116392
Stock market price index	0.005883	0.09964	0.12206	0.012423
Economic Growth	0.0387	0.52046	0.81542	0.12122
Rental housing price index in urban areas	0.002205	0.05618	0.12614	0.001293
Land price index in urban areas	0.015126	0.67208	0.79568	0.094274
Old gold coin price	-0.0019	0.20388	0.19646	-0.03304
Inflation	0.012625	0.52084	0.55264	0.05364
Bank spreads	-0.002332	0.17208	0.24328	-0.002438
Risk reward	-0.185182	0.18798	0.13038	-0.043375

Table 3: Significance Ratio of Non-Fragile Variables Affecting the EPU Index

Priority	Variable	The sample containing 100 million regressions		Regressions with $2 \geq t - stat $
		Posterior probability	Posterior coefficient	
2	Public sector debt to the central bank	0.922642	0.13315	0.954
3	Liquidity (M2)	0.90038	0.143375	0.891
4	Current expenses	0.89646	0.10028	0.868
10	Oil revenue	0.45264	0.10536	0.482
1	Real interest rates	0.99902	0.180581	0.970
7	Informal exchange rates	0.69328	0.102438	0.609
8	Real effective exchange rates	0.62048	0.116392	0.557
5	Economic Growth	0.81542	0.12122	0.837
6	Land price index in urban areas	0.79568	0.094274	0.791
9	Inflation	0.55264	0.05364	0.497

According to the previous explanations, some questions are raised in the end. First, how do the variables entered affect the EPU index? Second, do the different scales of variables affecting the EPU index affect the results? Third, is it possible to have variables in the model that do not have strong theoretical support?.

The answer to the first question is based on the fact that BMA models offer only the most probable case from theoretical background and the results of other researches, and there is no need for the results to be the same as the theoretical background. In answering the second question, it should be stated that

given that the scale of the variables are not the same, some are presented in percentage terms (such as economic growth and inflation) and some in terms of level (M2 liquidity), and research data have been normalized. The answer to the third question lies in the existential philosophy of the BMA model. In this method, econometrics experts have always been faced with uncertainty in variable selection and uncertainty in model selection (type, number and composition of variables) in order to have a suitable model. Theoretically, a wide range of variables affect the index of EPU; but in conventional econometric methods, not all of these variables can be included in the model; therefore, researchers have used a combination of variables in the model based on theory and their taste (Mehrra et al., 2015). This article intends to overcome the uncertainty in model selection and selection of variables using BMA method and to comprehensively and thoroughly examine the factors affecting the EPU index and rank the share of each of these factors. Therefore, in this method, because the goal is to model and correctly explain the optimal regression model, there is the possibility of the presence of any potential variable affecting the dependent variable, whether there is a theoretical basis for the effective variable or the experimental perspective of the researcher.

In the second stage, from an economic point of view, the goal is to determine the variables that have a high impact on EPU. In BMA, because the results are based on the value of the meta-parameter k (in the above calculations, k was considered to be 10), the question arises as to whether the results of the research change if the value of the meta-parameter changes, and if so, what is the rate of change? In other words, will choosing the expected size of the model affect the results? Accordingly, the results were compared with different \bar{K} selections and re-performing the whole sampling process and related calculations. It should be noted that in these three cases, the model space and therefore the variables and data are the same and the only difference is the expected size of the model⁶; of course, it is quite clear that by changing the expected size of the model, the samples and the consequent result will be different. This means that the variables may be fragile (or non-fragile) in all three \bar{K} values; the fragility of some variables changes by changing the value of \bar{K} and the variable that is assumed to be fragile with the assumption of \bar{K} becomes non-fragile by increasing the expected size of the model.

Table 4: Comparison of Posterior Probabilities Based on Hypotheses of Different \bar{K} Values

Variable	Posterior probability $\bar{K} = 8$	Posterior probability $\bar{K} = 10$	Posterior probability $\bar{K} = 12$
Public sector debt to the central bank	0.91859	0.922642	0.93075
Liquidity (M2)	0.90485	0.90038	0.89385
Current expenses	0.88498	0.89646	0.89486
Oil revenue	0.44803	0.45264	0.44837
Real interest rates	0.99405	0.99902	0.98405
Informal exchange rates	0.70485	0.69328	0.68094
Real effective exchange rates	0.62988	0.62048	0.63855
Inflation	0.80484	0.81542	0.82747
Land price index in urban areas	0.78387	0.79568	0.79477
Economic Growth	0.56938	0.55264	0.54886

Source: Researcher Calculations

⁶ The expected size of the model is the number of explanatory variables that the researcher expects to have a significant effect on the dependent variable.

Due to the fact that the posterior probability of non-fragile variables in the states $\bar{K} = 12$ and $\bar{K} = 10$ is approximately the same with the state $\bar{K} = 8$, the studies were not generalized to higher \bar{K} values. Now the indicators affecting EPU have been determined. In the next step, it is necessary to create an index of these 10 variables that represent this index in the final models.

PCA model

The principal component analysis method will be used for indexing. Accordingly, in Figure (1), the first component or the first two components can be selected. The second criterion (eigenvalue): we consider the components whose eigenvalue is greater than one and ignore the other components. Third criterion (variance): the components that explain the highest percentage of scattering are sufficient to continue the work, usually the first component is considered with the most variance. To calculate the EPU index, multiply the probability of occurrence in the BMA model by the weight of the CFA model and multiply it by the value of the non-fragile variable in that year, and calculate all these actions for each of the top ten variables and sum them up.

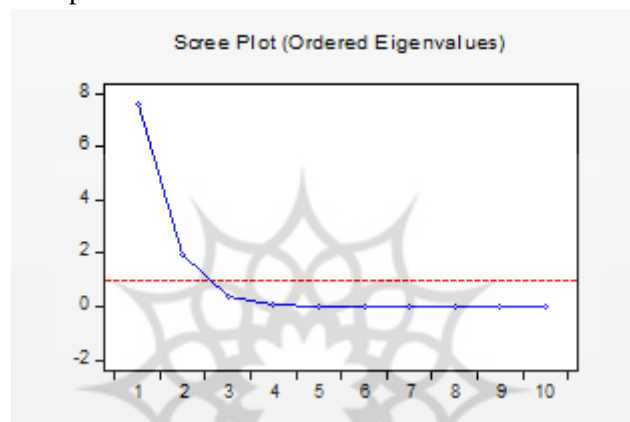


Fig.2: PCA Model Results Between Research Variables

According to the results, two main vectors can be identified, based on which we derive EPU index. After extracting the index, we will extract the uncertainties of the model based on the GARCH method, and finally, the effect of these variables on the variables of information asymmetry, unexpected profits and voluntary disclosure of information will be investigated.

GARCH model

In order to calculate the fluctuations of EPU, we will first extract the ARIMA model or the optimal series of EPU in the mentioned time period. Before doing anything, we need to make sure that the time series of EPU is stationary or non-stationary. The results of Dickey-Fuller test indicate that the variable is non-stationary in the mentioned time period. Based on the results, the EPU series is non-stationary and as a result, it is necessary to use the ARIMA model to determine the fluctuations of EPU. Next, the optimal ARIMA interval should be determined based on Akaike indicators. Based on the results of the Akaike index, in the case that the model has the lowest Akaike, the interval (3, 1 and 2) was selected to calculate the model. To ensure the optimality of the model, the error term of the model and stationary state of the error term of the optimal ARIMA were calculated. Since the error term is stationary, Box-Jenkins stages have been done correctly. Then, the ARCH test is estimated. If there is an ARCH effect, we will estimate the GARCH model and extract the fluctuations of EPU. Due to the significance of the $\text{RESID}(-1)^2$ coefficient, the effect of ARCH in the time series data is confirmed. Then, using the GARCH model, the time series of EPU is extracted.

Due to the significance of the GARCH (-1) coefficient, the existence of the GARCH model in the time series data confirms the changes in EPU.

Table 5: GARCH Model Results

Variable	Coefficient	Std. Error	z-Statistic	Prob.
ARIMA				
C	0.010813	0.284421	0.038016	0.9697
AR(1)	0.608821	0.414281	1.469584	0.1417
AR(2)	0.147202	0.352178	0.417977	0.6760
MA(1)	-0.462892	0.381883	-1.212132	0.2255
MA(2)	-0.181257	0.272657	-0.664779	0.5062
MA(3)	-0.209351	0.106864	-1.959037	0.0501
GARCH				
C	8.263864	2.497227	3.309216	0.0009
RESID(-1)^2	0.416008	0.129615	3.209555	0.0013
GARCH(-1)	-0.244483	0.078169	-3.127621	0.0018
GED PARAMETER	2.385282	0.586388	4.067757	0.0000
R-squared	0.161654	Mean dependent var		-0.040980
Adjusted R-squared	0.133138	S. D. dependent var		6.327110
S. E. of regression	5.890881	Akaike info criterion		6.188646
Sum squared resid	5101.265	Schwarz criterion		6.406520
Log likelihood	-462.4314	Hannan-Quinn criter.		6.277150
Durbin-Watson stat	1.382053			
Inverted AR Roots	.79	-.19		
Inverted MA Roots	.91	-.22+.42i		-.22-.42i

TVP-FAVAR model findings

In this section, the results of the research are presented using the TVP method. Table (6) presents the values of model goodness of fit indicators to determine the optimal model. The values of the forecast probability logarithm, MAFE⁷ and MSFE⁸ indices obtained from estimating different models are presented.

Table 6: Comparison of Different Forecasting Models

Forecasting method	MSFE	MAFE
$\alpha = \beta = 0.99$	0.025	0.094
$\alpha = \beta = 0.90$	0.046	0.124
$\alpha = \beta = 0.95$	0.043	0.121
$\alpha = 0.99; \beta = 0.90$	0.051	0.127
$\alpha = 0.99; \beta = 0.95$	0.045	0.124
$\alpha = 0.95; \beta = 0.99$	0.039	0.117
$\alpha = 1; \beta = 0.99$	0.041	0.117
$\alpha = 1; \beta = 0.95$	0.046	0.125
$\alpha = 1; \beta = 0.90$	0.052	0.128
$\alpha = 0.99; \beta = 1$	0.040	0.117
$\alpha = 0.95; \beta = 1$	0.038	0.117
$\alpha = 1; \beta = 1$	0.046	0.116

Source: Researcher Calculations

⁷ Mean Absolute Forecast. Error

⁸ Mean Square Forecast Error

The results of Table 6 are calculated based on $\alpha = \beta = 0.99\%$, which had the lowest level of prediction error. As a result, the research model is estimated based on $\alpha = \beta = 0.99$. Then, after estimating the TVP-FAVAR model using MATLAB software and two intervals of the model endogenous variables, the results of the instantaneous response analysis of the model variables are presented to investigate the effect of economic fluctuation uncertainty index on information asymmetry index, unexpected profits and voluntary disclosure. The instantaneous reaction function of the present study varies over time.

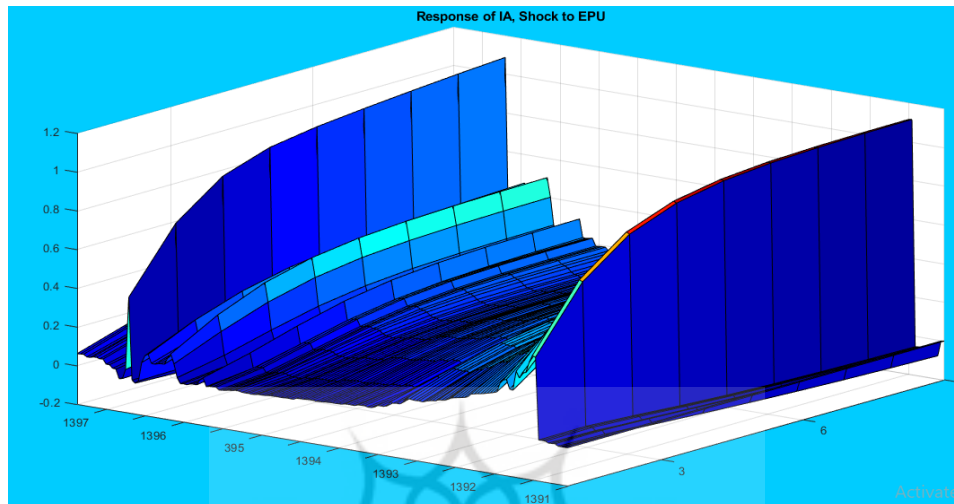


Fig.3: Instantaneous Shock of EPU Index on Information Asymmetry

According to the graph, changes of a standard deviation in the EPU index over time have caused a U-shaped movement (movement on the horizontal axis = ABC path). High inflation, sharp rise in liquidity, rising sanctions and housing prices and exchange rates are the main reasons for the increasing impact of the EPU on information asymmetry in recent years. Changes of a standard deviation in the EPU index in each period (moving on the transverse axis EF, GH and IJ) have a positive effect on information asymmetry. This effect is positive and strong in the short run (EF), positive and weak in the medium term (GH), and positive and strong in the long run (IJ).

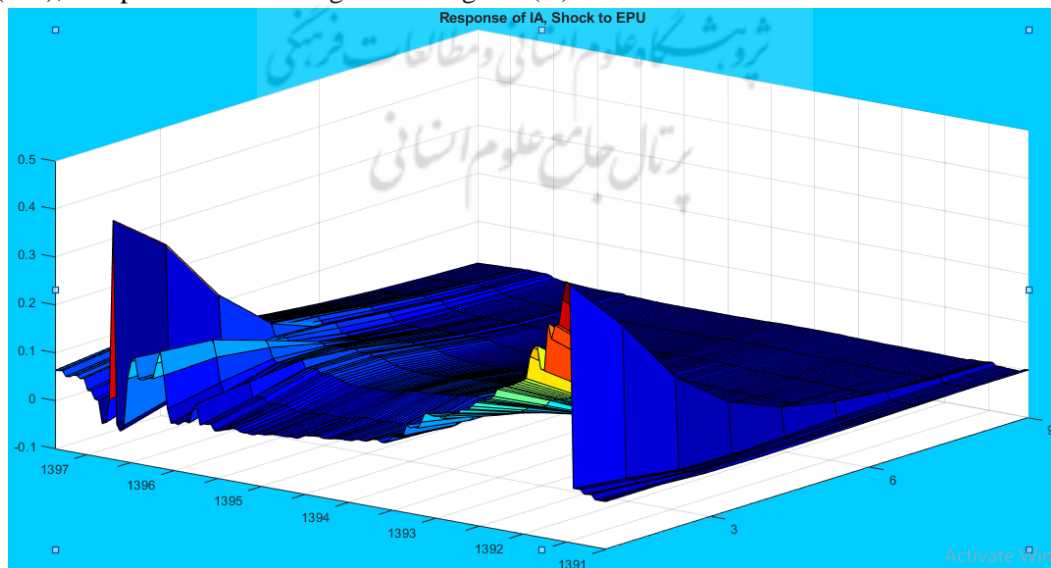


Fig. 4: Permanent Shock of EPU on Information Asymmetry

According to the diagram that shows the accumulated effect of changes of a standard deviation in the EPU index on information asymmetry, the effect of this variable on information asymmetry in three short-term, medium-term and long-term periods can be clearly shown as follows. The effect of this variable is evaluated to be 7 periods and strong in the short term, 3 periods and weak in the medium term, and 6 periods and relatively strong in the long term.

5 Conclusions

A: Information asymmetry policies

Given that the fluctuation of EPU has a positive effect on information asymmetry, the following policies should be applied:

Developers of capital market rules and regulations are advised to develop more detailed guidelines for the disclosure of company risks in order to provide clearer and better disclosure of risk information, thereby reducing uncertainty in reports and leading to better decisions and allocation of resources.

Voluntary disclosure of information: Recent research has shown that more voluntary disclosure increases the value of the company and reduces the cost of financing. Most previous studies have also concluded that more voluntary disclosure reduces information asymmetries between companies and investors. In environments with optional disclosure, the audit report can moderate the relationship between the internal control report and asymmetry. Increasing the level of information disclosure can affect information asymmetry in three ways. First, disclosing further information prevents the investor from seeking to disclose confidential information and trading on it; because the information gap or information asymmetry between investors is reduced with the disclosure of information. Second, market disclosure prevents wealth-generating transactions for those with confidential information, and as a result, the welfare of all investors increases as information asymmetry decreases. Third, in general, the level of information disclosure has a positive relationship with the amount of transactions made by both public information holders and confidential information holders. Voluntary disclosure of information also reduces the conditions of information uncertainty and asymmetry and increases investors' confidence in the company's management.

Disclosure of the weakness of internal controls: Audit reports increase the quality of disclosures related to the weakness of internal controls, increase trust, and ultimately reduce asymmetry. Reporting the weakness of internal controls is useful and, when mentioned in the audit report, can have a more positive effect on asymmetry.

Quality of company information disclosure: The quality of corporate information disclosure potentially affects information asymmetry in two ways. First, the quality of information disclosure affects information asymmetry by changing the trading behavior of uninformed investors. In this regard, according to Merton's investment recognition hypothesis, uninformed investors are more likely to invest and trade in companies that are well known and reputable; therefore, if the higher quality of disclosure raises the company's fame or reduces the cost of the disclosure process, the company's stock will be traded more by uninformed investors. Accordingly, the higher the quality of disclosure, the less uninformed transactions are, which in turn is accompanied by a reduction in information asymmetry. The second way that quality of information disclosure affects information asymmetry is to change the motivation to seek confidential information. Companies with higher-quality disclosure are more likely to disseminate general and forward-looking information quickly. As the quality of information disclosure increases, the likelihood of disclosure of information prior to its public disclosure decreases, and consequently, the

intended benefit of the search for confidential information and the motives for discovering confidential information decrease. As a result, higher quality of disclosure reduces the number of investors interested in obtaining confidential information and trading, and consequently reduces transaction costs.

Providing information about the company's operations and other activities

Providing this information helps investors evaluate the duty of stewardship or accountability of managers towards the resources available to them. In case the information enters the market randomly and regardless of whether it is good or bad, it can be said that the published information has a symmetrical distribution. In other words, if managers disclose all information quickly, this will cause the stock returns to have a symmetrical distribution.

Increasing the frequency of financial reporting: Frequency of financial reporting has a negative effect on information asymmetry and cost of capital. In fact, as the number of financial statements increases per year, the manager is given the opportunity to inform the market of information within the organization by transmitting signals to the capital market. On the other hand, the shorter the distance between providing periodic information from the company's management to individuals and external investors (capital market), the company will use less information rents to make a profit and will impose lower transaction costs to external investors due to having information because of having information. This is because having enough information will prevent a harmful transaction or will make them more profitable. Increasing information symmetry leads to increased awareness of companies and investors and provides a basis for better decision-making and selection.

Upgrading monitoring mechanisms: One way to deal with the negative consequences of information asymmetry confirmed by theoretical analysis and empirical evidence is corporate governance mechanisms. The role of corporate governance in reducing information asymmetry is to align the interests of managers with shareholders through the exercise of supervision. In other words, proper governance leads to timely disclosure and reporting by companies. The more and more robust the regulatory mechanisms that are directly involved in managers' reporting decisions, the less opportunistic earnings management occurs and thus reduces information asymmetry. Good governance provides the basis for timely disclosure of information; therefore, tighter monitoring and the provision of clearer information are expected to reduce information asymmetries and reduce the possibility of opportunistic profit management.

Conservatism: Information asymmetry causes accountants to choose conservatism as a solution to reduce agency costs. Shareholders, on the other hand, see conservatism as a regulatory tool that limits earnings management. In fact, conservatism imposes restrictions on accrual-based earnings management. Research shows the role of conservatism in reducing information asymmetry. Earnings management causes accountants to reduce information asymmetries through conservatism.

Financial analysts: Financial analysts, as professionals who are always looking for corporate information, play an important role in reducing information asymmetry. They process complex corporate information into understandable information for investors and, on the other hand, provide information that has not yet been widely disseminated in the stock market.

B: Economic stability policies

Due to the presence of liquidity as a non-fragile variable, given that the money market is one of the most dynamic economic markets, the imbalance in this market is quickly transferred to other markets, including the stock market, causing instability and uncertainty. Economic uncertainty shifts liquidity to real assets, which upset the equilibrium market of the desired assets, and therefore increase the price of

real assets, including housing and gold, and, on the other hand, reduce liquidity investment in the manufacturing sector, which is mainly financed by the stock exchange. This will lead to reduced production, economic growth and future employment. As a result, controlling the amount of liquidity in the economy in accordance with the economic needs of the country and the planned goal of inflation, can reduce price shocks and also create instability in the capital market, especially the stock market. In this regard, the Ministry of Economy and Finance has an important role in regulating and directing money market activities and coordinating monetary policy with the set of macroeconomic policies of the government. In order to coordinate cash flows with real flows to stabilize the national economy, the institution can put the efficiency of the country's banking network and also creation of the necessary conditions for the effective implementation of monetary policy on the agenda.

Given the presence of current expenditures in non-fragile variables, given that the stock market is affected by shock, or in other words, unexpected changes in government fiscal policy, unexpected changes in government fiscal policy can have a negative effect on the stock market. Given the size of the government in the Iranian economy and also the influence of politics on government economic decisions, the role of government is significant in economic instability; therefore, reducing or rationalizing the size of the government, reducing the volume of government economic activities' tenure, reducing the financial burden, and increasing government efficiency can increase the economic stability of the country and reduce its effects and consequences on the stock market. In this regard, creating and maintaining a stable macroeconomic environment, replacing fiscal discipline with financial instability in the government budget seems an appropriate policy. Given that the government budget deficit plays an important role in expanding the monetary base and creating inflation, reducing the budget deficit and limiting its fluctuations can be useful in economic stability, and thus, stability in the country's stock exchange. Also, by pursuing long-term economic policies and planned and non-surprise decisions, a more stable economic environment can be provided; because in the state of daily politics and the uncertainty of the long-term situation, people delay their decisions and avoid long-term planning due to the lack of a clear economic outlook for the future.

Given the presence of oil revenues in non-fragile variables, given that one of the main consequences of dependence on oil revenues is the inability of the economy to meet domestic needs as well as dependence on foreign economies, so it reduces economic stability. Under such circumstances, in addition to the impact of crude oil market shocks on the domestic economy, foreign economic shocks are also transmitted to the country. Rising oil prices increase the cost of products produced by industrialized countries, which in turn increases the Rial value of imports from developing countries, including Iran; therefore, under such circumstances, the government needs to seek to replace oil revenues with other revenues. This can reduce the effects of recession and prosperity on the economy and especially the effects of oil revenues on the capital market. Increasing the share of taxes and consequently reducing the share of oil revenues from government revenues can be a solution to the government's economic stability policy and reduce the impact of oil revenues on stock market.

Given the presence of liquidity in non-fragile variables, increase in the exchange rate, on the one hand, increases the amount of foreign debt, and on the other hand, increases the cost of imported products and services provided by these companies. Given that the increase in corporate debt leads to a lack of liquidity and the lack of liquidity of enterprises has a negative effect on profit distribution, stock returns and price index, as well as increasing the cost of products is followed by reduced profit margin, prices and stock returns, setting exchange rate policies in line with the goal of achieving economic stability and curbing fluctuations can be useful. By using appropriate exchange rate policies such as a floating

exchange rate system and curbing economic fluctuations, greater economic stability is provided. Of course, this requires the independence of the central bank. Given the effects of monetary and fiscal policies as well as exchange rate changes on fluctuations in EPU, changes in the basic banking financial system and the expansion of the insurance market can be useful in the short term to control capital market fluctuations. The superior role of the government in facilitating business, expanding and encouraging economic activities leads to improving the efficiency of the country's financial system. In other words, the transition to a stable economy requires a change in the financial system in order to support the private sector. The insurance market, as one of the components of the financial sector of the national economy, has an important function of providing economic security. On the other hand, the resources collected through the absorption of insurance premiums in themselves direct a significant financial resource to the expenditures of investing in the national economy, including investing in stocks. As a result, the expansion of the insurance market directly reduces the economic uncertainty of the stock market and by expanding investment, provides the basis for increasing economic stability and therefore the growth of the capital market.

The government is recommended to be very careful in determining policies, especially macroeconomic policies, and refrain from adopting hasty and unprofessional policies. This is because due to the low rate of adjustment of the above model, adopting such policies for the stock exchange during the long period will bring irreparable and harmful consequences.

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