The Effect of Uncertainty of Macroeconomic Indicators on Tehran Stock Exchange Return With an Approach of the TVP-SV Model

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ABSTRACT

One of the most important duties of financial economy is modeling and forecasting the volatilities of price of risky assets. From analysts and policy makers' view, price volatility is a key variable contributing to perception of market volatilities. Therefore, analysts need to have an appropriate of forecast of price volatility as a necessary input to perform duties such as risk management, portfolio allotment, assessment of at-risk value, pricing, authority of transaction and future contracts. Accordingly, in the present study, using TVP-SV and PLS models and comparison them with the method OLS in MATLAB and XLSTAT software in the period from 2003-01 to 2016-06 (monthly) the effect of actual variables (industrial production, investment of actual sector in housing, economic growth, share of government expenses to GDP and growth rate of nonoil export) and monetary variables (inflation, money arena, oil price, domestic price of gold) on return of the Tehran Stock Exchange is investigated. Based on the PLS model, it was concluded that variables of economic growth and oil price affected the efficiency of the Tehran Stock Exchange more than other variables. Then, variables of economic growth and oil price were entered to the TVP-SV model. According to results, the model TVP is more efficient than the OLS one. In addition, the TVP-SV model after pause of stock return, economic growth during the period had the highest efficiency on stock return.

Keywords: Time-Varying, Stochastic Volatility, Stock Return, TVP-SV.

1. Introduction

Financial markets play a key role in the development and economic growth of countries. Therefore, identifying variables of financial sector and relationship with the actual sector are highly important (Chen et al., 1986). Unforeseen changes of macroeconomic variables can be a factor affecting the efficiency of capital markets (Azeez, & Yonezawa, 2006). Thus, identifying the factors affecting the capital market can considerably help to direct investors' capital in choosing the optimal portfolio. Some experts regard the source of economic shocks as unforeseen changes of exchange rates, inflation and changes in the market. Gultekin (1983), Solnik (1983), Benderly and Swick (1985), Fama and Schwert (1977), Mayasmai and Koh (2000), Gan et al. (2006), Serletis (1993), Mudsen (2002) and Humpe and Macmillan (2004) concluded that creating a shock on macroeconomic variables generally caused by changes in monetary policies is effective on stock market return. Based on the results of the majority of domestic and foreign research, macroeconomic variables affect stock return. The main problem in most of the above-mentioned research is disregarding the instability of the estimated parameters over time. In other words, in the present study, using regime change and stochastic volatility models, instability of the estimated parameters over time is also taken into consideration. In classical regression methods, it is assumed that a relationship with constant parameters can be applied at different times. Incorrect results of this unrealistic assumption created dynamic models, being more similar to the reality of the outside world. According to Stock and Watson (2008), among the problems in previous models (traditional models based on restrictive classical assumptions) was the fact that they could not present an accurate forecast over time. In some cases, it was observed that some models could estimate forecast better only in recession and some other ones could estimate forecast better only at boom times, causing to consider a model incapable of solving this problem so that it would able to provide more reliable forecasts at all intervals (recession and boom times). Time-varying parameter stochastic volatility (TVP-SV) approach is one of the latest techniques and methods used in econometric literature, providing the estimation of unobservable variables or state variables in the equation system. TVP-SV approach has examined structural instability in the model parameters and allows the possibility of changing the model parameters over time. In addition, one of the most important benefits of this methods over other traditional and conventional time series methods such as ordinary least squares (OLS) is that in this approach, there is no need to examine the unit root tests in the time-series variables, and there is no necessity concerning the reliability of the variable at the level. Thus, in this approach, the researcher should not worry about the variables and differencing the time series variables. This caused the advent of TVP that could have predicted huge models (with large number of variables) over time. This paper is written in five sections. After the introduction, in the second section, theoretical principles and the foreign and domestic literature concerning the issue are presented. In the third section, the research method and estimated models are analyzed. Finally, in the fifth section, results are summarized and policy suggestions are offered.

2. Literature Review

Pricing model and Capital Assets

Lucas states that identifying factors affecting the stock market and predicting changes in the market have always been of interest to economists and policy-makers. To identify the factors affecting price in the stock market, way of determining the price of securities should be considered. In the capital assets pricing model, the price of assets such as stocks reflects current price of the expected return of assets. Therefore, in the stock price, each factor affecting the expected stock return will affect the stock price.

Lucas, in his paper, considers a quite simple economy with a product and a consumer with the following conditions. In this economy, the consumer maximizes his expected utility function as Equation 1 shows:

$$E[\sum_{t=0}^{\infty} \beta^t U(C_t)] \tag{1}$$

where C_t is level of consumption in t period, U(0) utility function, ß discount factor and E the math expectation operator. In this economy, the production is (y) conducted by n production unit that their production can be considered in the t period in the form of the vector $Y_t = (Y_{1t}, Y_{2t}, ..., Y_{nt})$. Therefore, concerning level of consumption in the t period, we will have:

$$0 \leq C_t \leq \sum_{t=1}^{n} Y_{it} \qquad (2)$$

Furthermore, ownership of each production unit will be determined in stock in each period in a competitive market. Stock price of each unit is determined based on the actual future payment to each and price of the units for the t period can be shown in a vector $P_t = (P_{1t}, P_{2t}, ..., P_{nt})$. Moreover, share of a consumer of ownership of the unit vector in the t period is shown in the vector $Z_t = (Z_{1t}, Z_{2t}, ..., Z_{nt})$. Lucas points out that there is only one product and consumer in this economy. In this regard, all values are certain. In other words, consumption of each period for its production is $C_t = \sum_{i=1}^{n} Y_{nt}$ and share of consumer of all units of production is equal for all periods ($Z_t = (1,1,...,1)$ for all t periods). Therefore, the main point of the analysis would be determining the behavior of the stock equilibrium price (Lucas, 1978).

Lucas, to determine the equilibrium price behavior, emphasizes that all information concerning the present and future physical state of the economy is gathered in the current production vector (Y) gathered. Moreover, considering recursivity of preferences and assuming stability of the function P(0) in all periods, it is shown that the stock market solves a problem identical for each period, therefore, the equilibrium price (on the condition that always follows a systematic behavior) should be shown as a function of the economic conditions ($P_t = P\ (Y_t)$.

According to Lucas, level of consumption and a decision on a consumer's portfolio (Z_{t+1}, C_t) depend on his initial portfolio (Z_t), prices to be faced (P_t) and information received on the current status and future of the economy (Y_t). Thus, his behavior can be explained by fixed decision-making laws C(0) and g(0) as follows:

$$C_t = C(Z_t, Y_t, P_t) \qquad (3)$$

$$Z_{t+1} = g(Z_t, Y_t, P_t) \qquad (4)$$

Therefore, if the future behavior of prices $P\ (Y_t)$ is determined and specified, then the consumer has the ability to optimize the aforementioned functions. Considering the above, on the one hand with the price, the consumer's behavior can be determined, on the other hand, by determining the consumer's decision rules g(0) and C(0), the current stock prices facilitating the market-clearing can be determined (Lucas, 1978). Given the above, a model close to the model presented by Lucas can be indicated as follows where the price of stock is the present value of the expected stock profit (Kia, 2003a, 38).

$$P_t = E_t\left[\frac{D_{t+1}+P_{t+1}}{(1+R_t)^n}\right] \qquad (5)$$

where P_t is the stock price in time t, D_{t+1} the interest payments between the periods t and t + 1 (payment to shareholders between the two periods), R_t interest rates in time t, E_t expectation operator based on information in time t. For P_{t+1}, this equation can be written as follows:

$$P_{t+1} = E_t\left[\frac{D_{t+2} + P_{t+2}}{(1 + R_{t+1})}\right] \qquad (6)$$

That by substituting it for P_t, we will have:

$$P_t = E_t\left[\frac{D_{t+1}}{(1 + R_t)} + \frac{D_{t+2} + P_{t+2}}{(1 + R_t)(1 + R_{t+1})}\right] \qquad (7)$$

Now, if the same thing is repeated n-1 and by assuming that the discount rate of all periods is equal, in other words:

$$\frac{1}{(1 + R_t)} = \frac{1}{(1 + R_{t+1})} = \cdots = \frac{1}{(1 + R_{t+n-1})} \qquad (8)$$

And the current value of future expected stock price is equal to zero as follows:

$$\lim_{n \to \infty} E_t\left[\frac{P_{t+n}}{(1 + R_{t+n-1})^n}\right] = 0 \qquad (9)$$

The current stock price (P_t) will be equal to the following equation:

$$P_t = E_t\left[\sum_{n=1}^{\infty}\frac{D_{t+n}}{(1+R_{t+n})^n}\right] \qquad (9)$$

The validity of this model (present value on the stock market model) has been discussed in several studies. Akdeniz et al. (2007) in a study using the general equilibrium assets pricing model, investigated the validity of this model and market efficiency. They used conditional variance bound to test this model. The test results indicated that variance bound does not become distorted. Therefore, the model is not rejected and the market is efficient.

An efficient capital market is characterized by one in which security prices adjust rapidly to the arrival of new information. Therefore, the current prices of securities reflect all information about the security. Championed by Fama (1970), the semi strong form of efficient market hypothesis states that stock prices must contain all relevant information including publicly available information. This has important implications for policy-makers and the stock-broking industry alike. Policy makers should feel free to conduct national macro-economic policies without the apprehension of influencing capital formation and the stock trade process. In addition, economic theory suggests that stock prices should reflect expectations about future corporate performance. Corporate profits generally reflect the level of economic activities. If stock prices accurately reveal the underlying fundamentals, then the stock prices should be employed as leading indicators of future economic activities. Therefore, the causal relations and dynamic interactions among macroeconomic variables and stock prices are important in the formulation of the nation’s macroeconomic policy.

The relationship between the total economic indicator and stock returns is as follows.

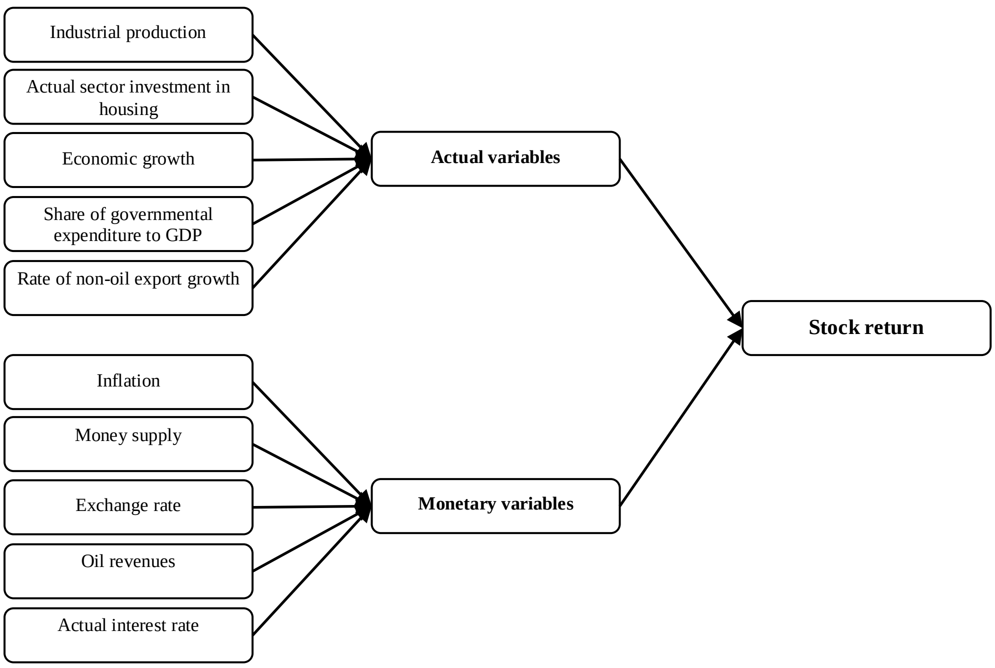


Diagram 1: Macroeconomic factors on stock returns

Owing to existence of various researches concerning the current issue, results researches are briefly divided into two main categories. The first category is in favor of the fact that macro factors are effective on stock return and the other is against it. Table 1 summarizes the research results of these two groups.

According to the results of Table 1, it is observed that in the majority of researches, the result is that the volatilities in macroeconomic variables affect stock return.

Table 1: Summary of results of domestic and foreign researches (Impact of macroeconomic variables on stock return)

Advocates	Opponents
Daisy Li et al. (2014); Kurov (2014); Hilde et al. (2013); Chang & Chena (2012); Atalia Sizva et al. (2011); Liwung et al. 2011, Aleve & Jemazy (2010), Chang (2009); Jamazy & Aleve (2009), Yang & Cheng (2008); Gay (2008); Anthony & Quam (2008); Agrawalla & Tuteja (2008); Polt et al. (2009); Liu (2008); Pooh et al. (2007); Avanidiz & Kantanicas (2007); Hump & McMillan (2006); McCurdy et al. (2005); Jernland and Litmu (2005); Hump & McMillan (2004); Madsen (2002); Shalit & Tizaky (2001); Avanidiz & Kantanicas (2007); Hump & McMillan (2006); McCurdy et al. (2005); Jernland and Litmu (2005); Hump & McMillan (2004); Madsen (2002); Shalit & Tizaky (2001) Mayasmay & Ke (2000); Gupta et al. (2014); Chan et al. (2016); Jones et al. (2014); Antonio et al. (2013); Yu (2011); Nakajima (2011); Gruen et al. (2011); Momtaz (2010) ; Klodilin et al. (2009); Gregorio et al. (2009); Sargent et al. (2005); Garat et al. (2011); Primisiri (2004); Bernanke & Kuttner (2004); Ibrahim (2003); Yunidis & Kontonikas (2008); Kati (2010); Alajideh et al. (2010); Zhao (2010), Subari & Salyho (2010); Chynzera (2011).	Apostolos Serlites (1993), Daly & Cerny (2005), Pune & Taylor (1991), Chen et al. (2007)

3. Methodology

In this section, we introduce the methods used in this study. In this research, two general categories of models are used, which are discussed below.

3.1. TVP-SV Regression Model with Stochastic Volatilities

The TVP-SV Model in a strong and flexible way enables us to record possible changes in the fundamental structure of economy. TVP regression model is considered as follows.

Regression:

$$y_t = x_t'\beta + z_t'\alpha_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_t^2), \quad t = 1, \dots, n, \tag{1}$$

Time-varying parameters:

$$\alpha_{t+1} = \alpha_t + u_t, \quad u_t \sim N(0, \Sigma), \quad t = 0, \dots, n-1, \tag{2}$$

Stochastic volatilities:

$$\sigma_t^2 = \gamma \exp(h_t), \quad h_{t+1} = \phi h_t + \eta_t, \quad \eta_t \sim N(0, \sigma_\eta^2), \quad t = 0, \dots, n-1, \tag{3}$$

where y_t is dependent variable matrix, x_t and z_t vectors of explanatory variables, β a vector of constant parameters, and α_t a vector of time-varying parameters and h_t stochastic volatilities. We assume $\alpha_0 = 0$, $u_0 \approx N(0, \sum_0)$, $\gamma \succ 0$ and $h_0 = 0$.

It is assumed that all parameters follow the first-order stochastic step process, leading to a permanent and temporary transfer in parameters. Stochastic volatilities play an important role in the TVP models. Although the idea of stochastic volatilities was originally proposed by Black (1976), following it, many different developments are formed in financial econometrics (Geisel, Harvey & Renault 2002; Shepard, 2005).

3.2. Partial Least Squares (PLS)

Partial Least Squares (PLS) is extremely appropriate to solve complex and non-linear models and analyze models simultaneously (Naik et al., 2000). This technique allows to investigate the relationship between latent variables (invisible variables) and measures (visible variables) simultaneously. In the

PLS models, two models are tested: outer models and inner models. The outer model is similar to measurement and inner model is similar to path analysis in structural equation models. After testing the outer model, it is necessary to present the inner model indicating the relationship between the research latent variables.

Path analysis + confirmatory factor analysis = SEM

Inner model + outer model= Partial Least Squares

Thus, the PLS method is capable to prioritize the most important factors affecting stock return according to process of data (inner model) and invisible factors (outer model).

3.3. Introduction of Research Data

The study time period is from 2003 to 2013 in the form of monthly data. Extracting the present paper data is as follows:

- Volume of money extracted from the website of the Central Bank of the Islamic Republic of Iran
- Oil revenues extracted from the website of the Central Bank of the Islamic Republic of Iran
- Inflation rate extracted from the website of the Central Bank of the Islamic Republic of Iran
- Exchange rate extracted from the website of the Central Bank of the Islamic Republic of Iran
- Actual interest rates extracted from the website of the Central Bank of the Islamic Republic of Iran (based on the researcher's calculations)
- Stock return on the Tehran Stock Exchange extracted from Codal Website of the Tehran Stock Exchange (Rahavard Novin Software)
- Economic growth extracted from the website of the Central Bank of the Islamic Republic of Iran
- Governmental expenditure to GDP ratio extracted from the website of the Central Bank of the Islamic Republic of Iran
- Industrial production index extracted from the website of the Central Bank of the Islamic Republic of Iran
- Non-oil export extracted from the website of the Central Bank of the Islamic Republic of Iran
- Actual sector investment in housing extracted from the website of the Ministry of Housing and Urban Development

4. Results

In this section, the research model is estimated.

4.1. Estimation of the PLS Model

In this section, using the PLS method, the most important actual and monetary indicators in stock return are determined. Monetary and actual variables are as follows:

Actual variables

- X1: Industrial production
- X2: Actual sector investment in housing
- X3: Economic growth
- X4: Share of governmental expenditure to GDP
- X5: Rate of non-oil export growth

Monetary variables

- X6: Inflation
- X7: Money supply
- X8: Exchange rate
- X9: Oil revenues
- X10: Actual interest rate. The research main model is as follows:

  $$y_t = f(X_1, X_2, \ldots X_{10})$$

Where Y is the dependent variable representing stock index return and the explanatory variables and X represents the effective monetary and actual factors. A summary of the results of the PLS model is presented below. According to Diagram 2, whenever vectors are closer to the center of the circle, the level of correlation between stock index return and components will be less.

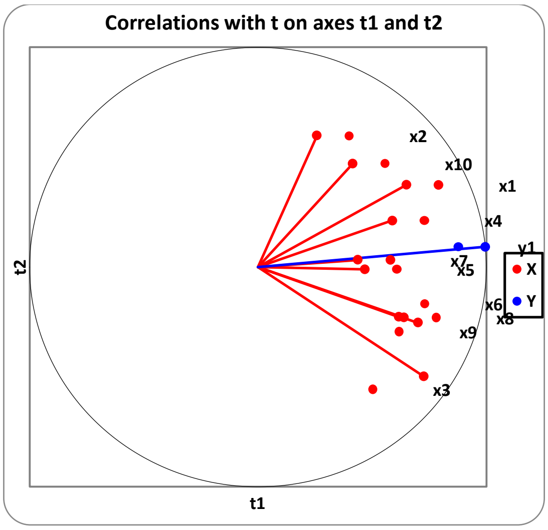


Diagram 2: Correlation of the model variable with estimation components

(Source: Researcher's calculations)

In Table 2, the variables are prioritized in order of importance from top to bottom with respect to their stock index return:

Table 2: Variables in order of importance in the first two components

Variable	VIP	Standard deviation	Lower bound (95%)	Upper bound (95%)
X3	1.368	0.174	1.026	1.710
X9	1.197	0.137	0.929	1.466
X6	1.119	0.117	0.889	1.349
X8	1.078	0.135	0.813	1.342
X4	0.960	0.153	0.660	1.261
X7	0.960	0.207	0.555	1.366
X1	0.892	0.202	0.496	1.289
X2	0.833	0.291	0.263	1.403
X10	0.809	0.164	0.487	1.131
X5	0.541	0.289	-0.026	1.108

(Source: Researcher's calculations)

According to Table 2, the variables x3 and x9 have the highest share of impact on stock index return. In other words, since these two variables have the highest share in the explanation of the stock exchange, then have the highest share in the reasons of changes in this index. Accordingly, the effect of uncertainty of economic growth variable X3 representing the actual sector oil revenues variable X9 representing the monetary sector is investigated. It should be noted that according to the PLS model results, we can conclude that:

Table 3: Prioritizing the research indices

Variable	Symbol	Priority	Nature
X3	Economic growth	1	Actual
X9	Oil revenues	2	Monetary
X6	Inflation	3	Monetary
X8	Exchange rate	4	Monetary
X4	Share of governmental expenditure to GDP	5	Actual
X7	Money supply	6	Monetary
X1	Industrial productions	7	Actual
X2	Actual sector investment in housing	8	Actual
X10	Domestic price of gold	9	Monetary
X5	Growth rate of non-oil exports	10	Actual

Source: Researcher's calculations

According to the results in Table 3, it is observed that monetary indices are more effective on the stock return than actual indices that this may be due to the country's shallow capital market.

4.2. Estimation of TVP-SV Model

$$y_t = x_t'\beta + z_t'\alpha_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_t^2), \quad t = 1, \ldots, n,$$

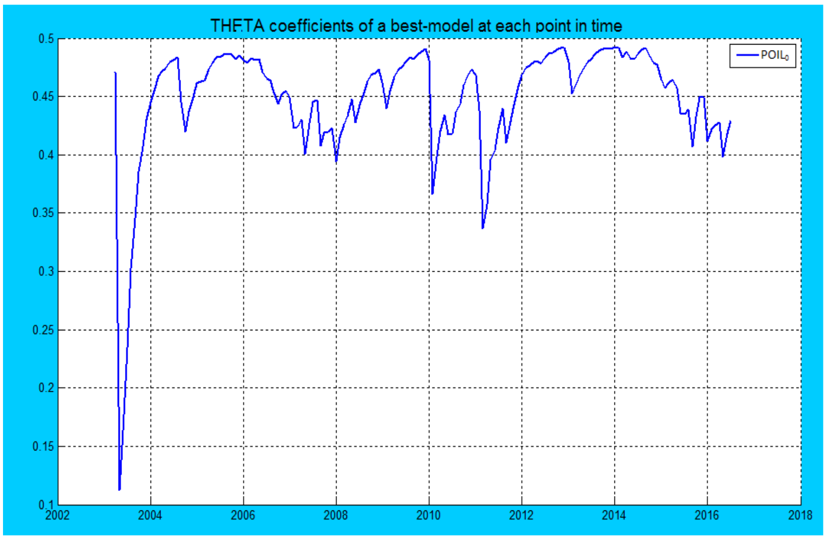
$$\sigma_t^2 = \gamma \exp(h_t), \quad h_{t+1} = \phi h_t + \eta_t, \quad \eta_t \sim N(0, \sigma_\eta^2), \quad t = 0, \ldots, n-1,$$

In the above equations, y_t is matrix of stock return, x_t and z_t are vectors of explanatory variables (monetary and actual variables), β a vector of constant parameters, α_t a vector of time-varying parameters, and h_t stochastic volatilities. In the following, the model estimation results are presented.

Diagrams 3 and 4 present time-varying parameters of the TVP model with stochastic volatilities for individual independent variables. In the following diagrams, the TVP models with advanced stochastic volatilities are used. In this method, a parameter is calculated for each period of time. As a result, for each parameter of the model, parameter can be calculated for each of the model parameters per period. The following diagrams show the estimated parameters (not the procedure of data for each variable) for each variable.

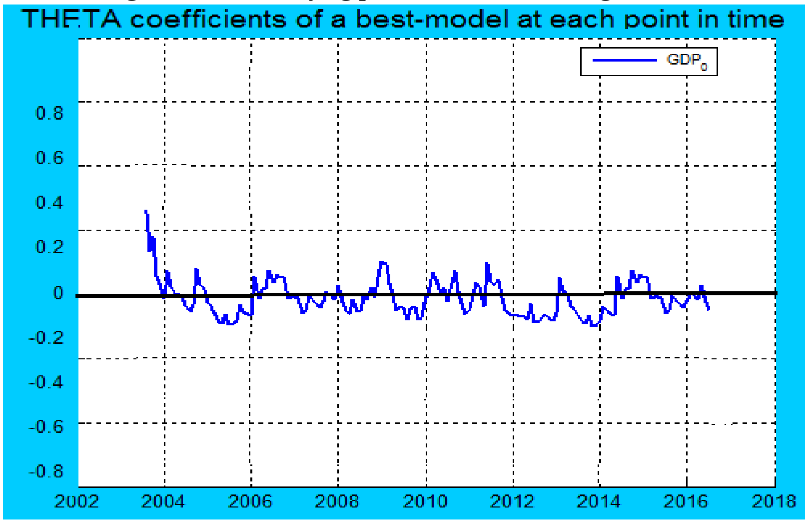
According to Diagram 3, it is observed that the time-varying parameter of oil price in the 2004-2006 period, 2008-2010 and 2012-2014 period as well as 2003-2004, 2006-2008 period and period in monthly form is low, high and average, respectively. The trend of parameter of other variables is as the following diagram.

Diagram 3: Time-varying parameter of oil price



Source: Researcher's calculations

Diagram 4: Time-varying parameter of economic growth rate



Source: Researcher's calculations

According to Diagram 4, it is observed that the time-varying parameter of economic growth rate in most courses, there is a negative effect on stock returns. This result is due to the phenomenon of Dutch Disease in Iranian economy

After estimating the TVP model with stochastic volatilities to compare its predictive results with the dynamic TVP models used in international studies in recent years, the TVP models are estimated and their results to predict stock return are compared. Therefore, in Table (4) the values MAFE and MSFE of the estimation of different OLS and TVP-SV models are provided in the forecast horizon one and four.

Table 4: A Comparison of different models based on Kalman's filter

Forecast Method	MAFE	MSFE
h = 1		
OLS	12.04	147.13
TVP-SV	5.11	95.44

Source: Researcher's calculations

Results of Table 4 show that all the study models of the OLS model (the traditional approach) have higher accuracy so that the TVP-SV model has better forecast accuracy than other methods. Based on Table 5, it is observed that at any time period which variables have had an impact on stock return. For example, it is observed that in the period 2003-1, the first interruption of stock return is effective on the stock returns. For instance, it is observed that in the period 2003-5, the first interruption of stock return and economic growth rate have the highest impact on the Tehran Stock Exchange. Such an analysis can be presented to other periods.

The results of the above table are presented as follows:

The first interruption of stock return in the period (162 periods) has had a significant impact on stock return.

Oil price has had a significant impact on stock return in 94 periods.

Economic growth has had a significant effect on stock return in 73 periods.

In conclusion, it is observed that after the first interruption of stock return, economic growth during the studying period has had the highest impact on stock return.

Table 5: Variables affecting stock return in different periods

Period	Variable			
2003-1	constant	AR_1		
2003-2	constant	AR_1		
2003-3	constant	AR_1		
2003-4	constant	AR_1	POIL_0	
2003-5	constant	AR_1	Y_0	
2003-6	constant	AR_1	POIL_0	
2003-7	constant	AR_1	Y_1	
2003-8	constant	AR_1	POIL_0	
2003-9	constant	AR_1	POIL_0	
2003-10	constant	AR_1	Y_1	
2003-11	constant	AR_1	POIL_0	
2003-12	constant	AR_1	Y_0	
2012-1	constant	AR_1		
2012-2	constant	AR_1	Y_0	
2012-3	constant	AR_1	Y_0	
2012-4	constant	AR_1	Y_0	
2012-5	constant	AR_1	Y_0	
2012-6	constant	AR_1		
2012-7	constant	AR_1		
2012-8	constant	AR_1		
2012-9	constant	AR_1		
2012-10	constant	AR_1		
2012-11	constant	AR_1	POIL_0	Y_0
2012-12	constant	AR_1	POIL_0	
2016-1	constant	AR_1	POIL_0	
2016-2	constant	AR_1	POIL_0	
2016-3	constant	AR_1		
2016-4	constant	AR_1	POIL_0	
2016-5	constant	AR_1	POIL_0	Y_0
2016-6	constant	AR_1	POIL_0	Y_0

Source: Researcher's calculations

5. Discussion and Conclusions

One of the problems that investors use to predict the expected return models is that these models are highly unstable and sensitive to different markets and situations. In fact, conducted studies show that although there may be evidence for the ability to predict the expected return forecasting models, it is so weak that investors cannot use them in practice.

On the other hand, based on the theoretical and experimental foundations, the foundation of Markowitz's Portfolio Theory (1952) is based on the relationship between turbulence and expected return.

Markowitz's model is good guidance and an appropriate method on which the investor creates his optimum portfolio based on the power of risk tolerance, expected return, variance (or standard deviation) of securities return and covariance or correlation between securities return. The capital assets pricing model (CAPM) developed by Sharp (1964), Linter (1965) and Mucin (1966) is based on theories and findings of Markowitz's Modern Investment and Investment Basket Theory, having undeniable effect on the financial and investment affairs. In applying regression to investigate relations between financial variables, the relation between variables is considered static and development of these relationships over time changing coefficients of equations is ignored. In these methods, it is assumed that an equation with fixed parameters can be applied at different times. Incorrect results of this unrealistic assumption created dynamic models, being more similar to the reality of the outside world. One of the main characteristics of dynamic systems is that their behavior can be described through changes of its components. Therefore, to resolve these problems, a combination of TVP-SV and PLS models was used. The present study results indicate more accuracy of dynamic models with TVP than traditional models in forecasting stock return. Thus, the results of this study are as follows:

1. Based on the results of the TVP-SV model, at various intervals, variables with different intensities (different parameters) are effective on stock return. This reflects the fact that forecasting stock return should be conducted at short-term intervals and long-term forecasts cannot be considered in stock investment.

2. Share of influence of variables during the studying period on stock return is different, and the impact of each variable on stock return at different times is different. As a result, developing the model to the TVP-SV methods and assuming time volatilities variable have made the stock return forecast model efficient. Therefore, the theory of stochastic volatilities changes in financial data is confirmed.

3. According to the results after the first interruption of stock return, economic growth in the studying period had the highest effect on stock return. Considering that different variables at different intervals have different effect on stock return. Therefore, using models capable of separating regime changes at different probability levels is proposed to forecast stock return. In this regard, it is recommended that policymakers and individuals active in financial markets should use general policies at all times to improve the status of financial markets and in each regime depending on what factors affects stock return, use tools suitable to that regime in order to make their policies.

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