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Forecasting Tehran Stock Exchange Return; Kalman Filter Approach

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ABSTRACT

Return forecasting is an important topic in stock markets. The aim of this paper is forecasting return of Tehran Stock Exchange with Kalman Filter approach. Also, we tested efficiency hypothesis in Tehran Stock Exchange. Results indicate that TSE is inefficient market. So, investors can use forecast return based on historical data of return.
KEYWORDS: Forecasting, Tehran Stock Exchange, Return, Conditional, Kalman Filter.

1. INTRODUCTION

Return forecasting is an important topic in stock markets.A good forecast of rate of return is a good start point for investment in stock market. Investors, agents and policy makers in stock markets seek good forecasts for their aims. The focus of this paper is on Tehran Stock Exchange (TSE) as a emerging market in middle east.
TSEis largest stock exchange in Iran. TSE opened in 1967 which is an emerging market.Main indicators for TSE reported as Table 1.

Table 1. Main Indicators for TSE

	2006	2007	2008	2009
Number of Listed Companies	417	415	346	337
Market Capitalization (USD Millions)	43,794	45,574	49,040	58,698
Total Value of Share Trading (USD Millions)	6,230	7,872	15,252	16,875
Daily Average Trading Value (USD Millions)	26.1	32.5	63.8	65.4
Total Number of Trade in Share (Millions)	15,839	23,401	37,975	82,479
No. of Transactions (in thousands)	1866	2107	1978	2646
No. of Trading Days	239	242	239	258
Share TurnoverVelocity (%)	15.6	16.37	26.5	28.74
P/E ratio	5.4	5.2	4.1	5.5
Dividend yield (%)	10.44	14.5	12.3	15.8
Market Capitalization/GDP (%)	17.9	15.4	14.1	15.2

Exchange rate: 1 US $=10,004 IRR (2009)

The trading system is an order driven system, which matches buying and selling orders of the investors. Investors can place their orders with TSE accredited brokers, who enter these orders into the trading system. Then, the system automatically matches buy and sell orders of a particular security based on the price and quantity requirements.

A variety of GARCH models have been employed to model time-varying betas for different stock markets (see Bollerslev*et al.* (1988), Engle and Rodrigues (1989), Bodurtha and Mark (1991), Koutmos*et al.* (1994), Giannopoulos (1995), Braun *et al.* (1995), Gonzalez-Rivera (1996), Brooks *et al.* (1998) and Yun (2002). Similarly, the Kalman filter technique has also been used by some studies to estimate the time-varying beta (see Black *et al.*, 1992; Well, 1994).

The Brooks et al. (1998) paper investigates three techniques for the estimation of time-varying betas: GARCH, a time-varying beta market model approach suggested by Schwert and Seguin (1990), and Kalmanfilter. According to in-sample and out-of-sample return forecasts based on beta estimates, Kalman filter is superior to others. Faff et al. (2000) finds all three techniques are successful in characterising time-varying beta. Comparison based on forecast errors support that time-varying betas estimated by Kalman filter are more efficient than other models. One of the main objectives of our paper is to compare the forecasting ability of the GARCH models against the Kalman method.

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The aim of this paper is forecasting return of Tehran Stock Exchange with Kalman Filter approach. This paper is organized by four sections. The next section is devoted to research method and data description. Section 3 presents empirical results and final section devoted to conclusion.

2. RESEARCH METHOD

2.1. Econometric Methodology

A state space model defines an observation (or measurement) equation and a transition (or state) equation, which together express the structure and dynamics of a system.
In a state space model, observation at time *t* is a linear combination of a set of variables, known as state variables, which compose the state vector at time *t*. Denote the number of state variables by *m* and the $(m \times 1)$ vector by θ_t, the observation equation can be written as

$$y_t = z_t^{'} \theta_t + u_t \qquad (1)$$

where z_t is assumed to be a known the $(m \times 1)$ vector, and u_t is the observation error. The disturbance u_t is generally assumed to follow the normal distribution with zero mean, $u_t \sim N(0, \sigma_u^2)$. The set of state variables may be defined as the minimum set of information from present and past data such that the future value of time series is completely determined by the present values of the state variables. This important property of the state vector is called the Markov property, which implies that the latest value of variables is sufficient to make predictions.

The Kalman filter method estimates the conditional beta, using the following regression,

$$R_{it} = \alpha_t + \beta_{it} R_{it-1} + \varepsilon_t \qquad (2)$$

where R_{it} is return of market at time *t*, and ε_t is the disturbance term. Equation (2) represents the observation equation of the state space model. However, the form of the transition equation depends on the form of stochastic process that betas are assumed to follow. In other words, the transition equation can be flexible, such as using AR(1) or random walk process. According to Faff *et al.* (2000), the random walk gives the best characterisation of the time-varying beta, while AR(1) and random coefficient forms of transition equation encounter the difficulty of convergence for some return series. Failure of convergence is indicative of a misspecification in the transition equation. Therefore, this paper considers the form of random walk, and thus the corresponding transition equation is

$$\beta_{it} = \beta_{it-1} + \eta_t \qquad (3)$$

Equation (2) and (3) constitute a state space model. In addition, prior conditionals are necessary for using the Kalman filter to forecast the future value, which can be expressed by

$$\beta_0 \sim N(\beta_0, P_0) \quad (4)$$

The first two observations can be used to establish the prior condition. Based on the prior condition, the Kalman filter can recursively estimate the entire series of conditional beta.

2.2. Hypothesis:

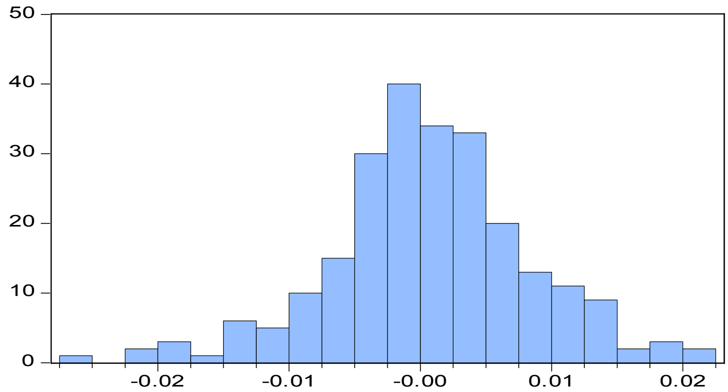
Tehran stock exchange has weak form inefficient.

2.3. Data Description

This research has used daily data of price index in Tehran Stock Exchange. Rate of return in this paper is calculated by growth rate of price index at February of 2011 (Bahman of 1389 Hejri) to February of 2012 (Bahman of 1390 Hejri). Number of observation is 240 observations.

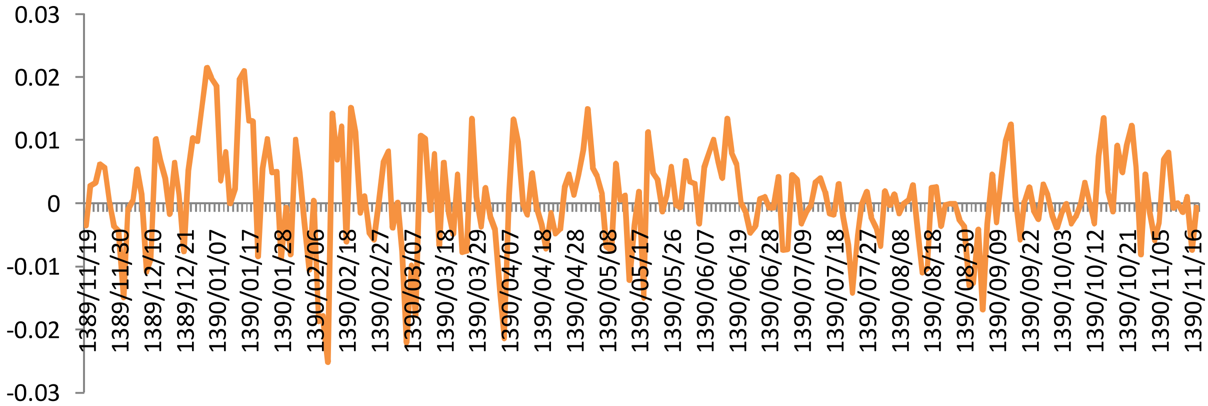
Table 1 indicates descriptive statistic for rate of return series. Mean is about 0.00067, median is 0.00045, maximum is about 0.022, minimum is -0.0251, Standard deviation is about 0.0077, Skewness is -0.1967 and Kurtosis is about 3.86. Finally, Jarque-Bera test indicates no normality in series of return.

Table 1. Descriptive Statistic of Return

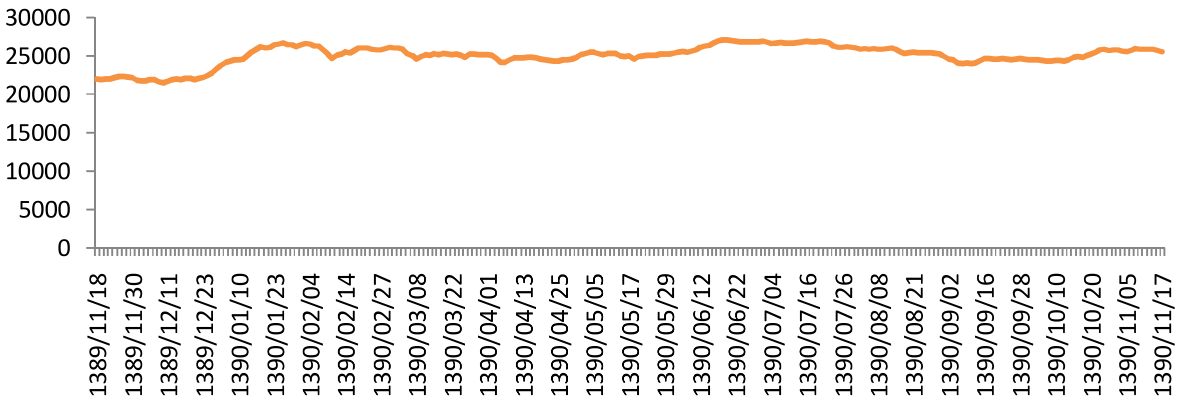


Series: R	
Sample 1000 1240	
Observations 240	
Mean	0.000668
Median	0.000455
Maximum	0.021536
Minimum	-0.025133
Std. Dev.	0.007666
Skewness	-0.196735
Kurtosis	3.859805
Jarque-Bera	8.940835
Probability	0.011443

Plot 1. Rate of Return



Plot 2. Price Index



The TSE is open for trading five days a week from Saturday to Wednesday, excluding public holidays. Trading takes place through the Automated Trade Execution System from 9am to 12 noon, which is integrated with a clearing, settlement, depository and registry system.

Table 2. Unit Root Test			
Exogenous: Constant			
Lag Length: 0 (Automatic based on SIC, MAXLAG=14)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.974750	0.0000
Test critical values:	1% level	-3.457630	
	5% level	-2.873440	
	10% level	-2.573187	
*MacKinnon (1996) one-sided p-values.			

Table 2 indicates Augmented Dickey-Fuller test statistic for testing unit root in return series. Results indicate that rate of return is stationary.

3. EMPIRICAL RESULTS

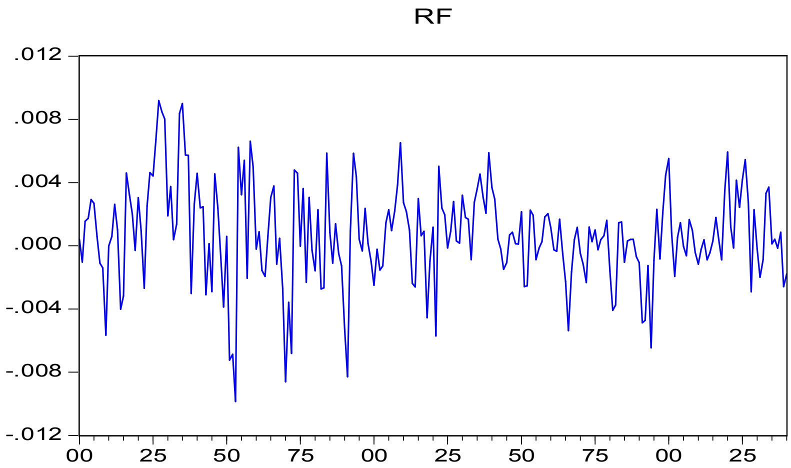
First of all, we estimated model with maximum likelihood method as Table 3. Then, we estimated the model with Kalman filter algorithm as Table 4.

Table 3. Estimation Model with MLE Method				
Method: Maximum likelihood (Marquardt)				
Date: 02/24/12 Time: 13:24				
Sample: 1000 1240				
Included observations: 241				
Valid observations: 239				
Convergence achieved after 11 iterations				
	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	-9.920604	0.074855	-132.5311	0.0000
C(2)	0.000403	0.000427	0.943801	0.3453
	Final State	Root MSE	z-Statistic	Prob.
SV1	0.407961	0.058988	6.915958	0.0000
Log likelihood	837.1512	Akaike info criterion		-6.988713
Parameters	2	Schwarz criterion		-6.959622
Diffuse priors	1	Hannan-Quinn criter.		-6.976990

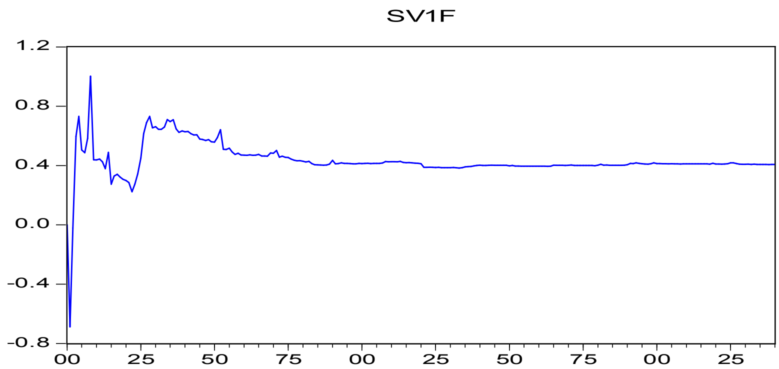
Table 4. Kalman Filter Estimation				
Method: Kalman filter				
Date: 02/24/12 Time: 13:26				
Sample: 1000 1240				
Included observations: 241				
Valid observations: 239				
	Final State	Root MSE	z-Statistic	Prob.
SV1	0.407961	0.058988	6.915958	0.0000
Log likelihood	837.1512	Akaike info criterion		-7.005450
Parameters	0	Schwarz criterion		-7.005450
Diffuse priors	1	Hannan-Quinn criter.		-7.005450

Sv1 is state series or time varying parameter. This parameter is significance at 1% level. Next step is forecasting rate of return as Plot 3.

Plot 3. Forecasting Rate of Return with Kalman Filter



Plot 4. State Series Estimation



Estimation the model is as following equations:

$$\text{SIGNAL R} = 0.000402662287723+SV1*R(-1) + [VAR = EXP(-9.92064461994)]$$

$$\text{STATE SV1} = SV1(-1)$$

Plot 4 indicates state series. This series implied efficiency as dynamic during sample period. If this series limited to one, this means stock market is efficient. If state series limited to zero, this means stock market is inefficient. Results indicate that TSE is inefficient market. So, investors can use forecast return based on historical data of return.

The hypothesis of this research is confirmed. In other word, Tehran stock exchange has weak form inefficient.

Innovation in this paper is using Kalman filter method for forecasting rate of return in TSE, also testing efficiency hypothesis with kalman filter.

4. Conclusion

Return forecasting is an important topic in stock markets. Many researchers forecast rate of return in different markets specifically developed market. The lack studies about developing markets were incentive for writing this paper. The aim of this paper is forecasting rate of return in Tehran Stock Exchange, also we tested efficiency hypothesis by Kalman filter method. Results indicate that TSE is inefficient market. So, investors can use forecast return based on historical data of return.

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