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EVALUATION OF COMMON STOCK IN RISKY CONDITIONS USING THE COMPARISON OF ARBITRAGE AND MONTE CARLO METHODS IN COMPANIES LISTED ON TEHRAN STOCK EXCHANGE

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ABSTRACT

This study aims at investigating the common stock valuation in risky conditions by comparison of Arbitrage and Monte Carlo methods in companies listed on Tehran Stock Exchange. The time domain of research is from 2007 to 2013 (7 years) and its spatial domain of research refers to the companies listed on Tehran Stock Exchange. According to the research observations, the data of 180 listed companies is collected as the statistical sample during 7 years (2007-2013) as the research period. This study investigates the causal relationship between the price indices of crude oil, currency, gold, etc, using Markov switching models (Monte Carlo) and taking into account different variables in estimation by non-linear Markov method under the risky conditions, and also studies the common stock value of Tehran Stock Exchange under the risky conditions during the target period. The results of model estimation indicate that the effect of all variables are significant and except for the inflation risk, currency and oil price volatility, other variables have significant and positive effects on stock price valuation and they are finally applicable considering the limits of arbitrage pricing theory on the unconstrained linear models. It seems that the arbitrage pricing model adequately explains the return of securities traded on Tehran Stock Exchange. Furthermore, the computational t statistics and the values of confidence level of 95% are statistically significant for studied variables such as the political risk, the whole country risk, law stability (as the institutional variables), the unexpected exchange rate, inflation, oil price, indices of financial leverage and firm size. Therefore, among eight studied economic variables, all factors play the roles in stock pricing. Among the significant variables, only the difference in interest rates has a positive risk premium and other variables have negative risk premiums. Finally, after eliminating the insignificant variables and using the results of unconstrained model, the risk premiums are again estimated by seemingly repeated and unrelated non-linear regression method.

Keywords: Markov Switching, Arbitrage, Political Risk, Law Stability

INTRODUCTION

The mobilization and allocation of optimal financial resources play a very important role in economic growth and development of countries; and the Stock Exchange as a symbol of economic development in any country can play an active role in the ease of financing in companies, directing the small capital to production path, preventing the possible stagnation of small capital, earning the income for public and other benefits. At the same time, the stock exchanges provide the possibility of obtaining the return from previous investment as a wealth increase method. Under these circumstances, the investors largely pay attention to the investment return of a particular share in order to buy, hold or sell that share. If they are able to predict the rate of stock return and rank them, then making the investment decision will be simple. Various models and methods have long been presented for estimating the expected rate of return; these models (methods) consider the relationship between the risk and expected return and provide a good model for indicating the relationship between the risk and stock valuation or their return. The Capital Asset pricing Model (CAPM)is one of the most important models in this regard and introduced by Sharpe *et al.,*. Sharpe *et al.,* (1985) developed the Capital Asset pricing Model (CAPM) with a single-index

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effective variable indicating the relationship between the return and risk in efficient market conditions; this model was under much criticism; for instance, Roll was among the critics of this model and since the nature of real market portfolio is unknown in CAPM, the asset pricing by this method is practically useless. The conducted studies in this regard also led to the discovery of other problems in the late seventies and questioned the efficient market hypothesis because the utilization of Capital Asset pricing Model (CAPM) led to the continued abnormal return in some cases. Therefore, multiple edits were done on the Capital Asset pricing Model to solve these problems; for instance, the multi-index models. Arbitrage pricing theory was first introduced. According to the basic assumption of this model, the variables are identified and multivariate model designed for determining the stock return in a way that the identified variables are linearly related to the expected stock return. There are a variety of methods for valuation of corporate stock. Utilization of these methods in capital markets can be different depending on the inputs and variables of these models. The arbitrage method is one of the common methods of stock valuation in capital markets. On the other hand, the stock value can be extracted using Monte Carlo computational algorithm by simulating the effects of variables affecting the stock price. Each of these two methods, Arbitrage and Monte Carlo, plays the role according to the effect of certain variables such as the inflation, exchange rate, etc, on the stock value. However, according to the economic conditions and the existence of other effective variables, which are not taken into account (for prevention of complex models), the calculated value for stocks may be different from the real value. Therefore, the possibility of individual use of these models should be investigated with respect to the variables predicted in stock valuation, and finally it should be determined whether there is a difference between the calculated values by them. This study seeks to identify the factors affecting the common stock valuation in risky conditions by comparison of arbitrage and Monte Carlo methods in companies listed on Tehran Stock Exchange and provide the solutions for effective implementation.

MATERIALS AND METHODS
The statistical population of this study consists of companies listed on Tehran Stock Exchange during 2007-2013.
This study analyzes the information of 180 sample companies during a seven-year period from 2007 to 2013 in order to investigate the correlation between the variables for research hypothesis test. The descriptive statistical methods are initially utilized for data analysis, and then the normality test of dependent variable is done in order to prepare the data for correlation tests. The regression is utilized in hypothesis analysis, and then its statistical results are identified as discussed below.
This research has the correlative and post-event type and utilizes the fundamental analysis and reasoning method based on the library studies and it is according to the applications, which can have in investors' decisions, and is based on the nature in the field of applied studies.

RESULTS AND DISCUSSION
Results
The estimation of general model using the panel analysis and model estimation:
The panel analysis is utilized to evaluate and investigate the general model.
Model Identification Test

Table 4: Model identification test (Fixed effect test)

Model No.	Fisher-sectional statistics	P-Value	Result	Applied model
1	1.01	0.41	Intercepts are equal	Pooled
2	1.39	0.21	Intercepts are equal	Pooled

As shown, since the P-Values are greater than 5%, the null hypothesis based on the equality of intercepts is rejected and the Pooled method can be utilized for hypothesis test.

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Table 5: Summary of auto-regression results (Systemic with panel data)

Variable	Number of optimal lag	t-statistics	prob	Akaike
Price_vol	2	-3.4922	0.0012	3.9910
EXE	4	3.4461	0.0014	21.564
LNTA	2	-4.7377	0.0000	13.569
Lev	1	30.35998	0.0000	5.924
CPI	2	2.0609	0.0457	-1.8693
Price-oil	2	4.2340	0.0001	17.599
TOPSHARE	1	8.775	0.0000	23.85
Rule- law	2	18.632	0.0000	8.924
Rickplicy	1	-3.0757	0.004	-2.8312
Rickcontry	2	-3.4241	0.002	7.85452

Source: Research results
Arbitrage Pricing Model Estimation

Arbitrage pricing model estimation is done at several stages. At the first stage, the unconstrained linear factor model is estimated by ordinary least squares through creating an equation system for sample companies.

At the second stage, the limitations of Arbitrage pricing model theory are applied on the unconstrained linear model and this model is estimated by nonlinear seemingly unrelated regression method.

At the third stage, the variance-covariance matrix of residuals is compared for constrained and unconstrained systems. The result of this stage determines the validity of arbitrage pricing model.

Table 6: Estimation of risk premium in six-factor model

Independent variables	Estimates	t-Ratio	Prob.
Price_vol	-0.09179	-0.58554	0.5583
EXE	-0.1254	-6.27773	0.0000
LNTA	-0.8441	-5.34348	0.0000
Lev	0.30264	0.45474	0.6494
CPI	0.03216	2.34283	0.0193
Price-oil	-489.493	-4.31215	0.0000
TOPSHARE	-0.242	-5.34348	0.0000
Rule- law	0.1742	5.45474	0.0004
Rickplicy	0.2426	-2.34283	0.0003
Rickcontry	-0.214	-5.353	0.0002

$$H_0 : \alpha_i = \sum_{j=1}^{k} b_{ij}\lambda_j \quad \chi^2_{24} = 34.71$$

Source: Research results

According to the results of Table 5, the Chi-square likelihood statistics ($\chi^2_{24} = 34.71$) is less than Chi-square of tables at the error level of 5% ($\chi^2_{24} = 36.42$), thus theH0is not rejected and data is consistent with this model. The important points are obtained from the primary results of Arbitrage pricing model estimation. First, the null hypothesis is not rejected in investigating the validity of pricing constraints. Therefore, the constraints of arbitrage pricing theory are applicable on the unconstrained linear model. Thus, it seems that the arbitrage pricing model adequately explains the return of securities traded in Tehran Stock Exchange. Second, the calculated t statistic and also the values of confidence level of 95% in this table indicate that the estimated risk premiums are statistically significant for variables namely the political risk, risk of whole country, law stability, non-predicted exchange rate, inflation, oil price,

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financial leverage indices, and firm size. Therefore, among eight studied economic variables, all factors play the roles in stock pricing. However, the non-predicted inflation factors and the oil price are not priced. Third, among the significant variables, only the difference in interest rates has a positive risk premium, but other variables have negative risk premiums. After removing the meaningless variables and by using the results of unconstrained model, the risk premiums are again estimated through the nonlinear and repetitive seemingly unrelated regression method. The validity of research model constraints also shows the validity of arbitrage pricing model.

Markov Switching Vector Autoregressive Model (MS-VAR)
Markov switching model was introduced by Hamilton in 1989. It is also known as the regime change model. Table (1) summarizes different modes of Markov switching model.

Table 7: Summary of different modes of MS-AR models

MSI		MSM			
Constant C	Variable C	Constant μ	Variable μ	Constant (Markov Switching Mean)σ	Constant A_i
Linear AR	MSI (Markov Switching Intercept Autoregressive)	Linear AR	MSM (Markov Switching Mean) - AR		
MHA-AR	MSIH (Markov Switching Intercept heteroskedasticity) -AR	MSH-AR	MSMH (Markov Switching Mean heteroskedasticity) -AR	Variable (Markov Switching Mean)σ	Variable A_i
MSA-AR	MSIA (Markov Switching Intercept Autoregressive) - AR	MSA-AR	MSMA-AR	Constant (Markov Switching Mean)σ	
MSAH-AR	MSIAH (Markov Switching Intercept Autoregressive heteroskedasticity) -AR	MSAH-AR	MSMAH (Markov Switching Mean Autoregressive heteroskedasticity) - AR	Variable (Markov Switching Mean)σ	

Source: Krolzig, *1997*

Numerous studies have utilized these models to study different economic topics, for instance: to study and predict the interest and exchange rates (Chen, 2006; Smith, 2002), to study the stock market (Guidolin and Timmermann, 2006; Gallo and Otranto, 2007), to study the asymmetric effects of economic variables and oil on the economy (Clements and Krolzig, 2002), the study of unemployment rate (Krolzig *et al.,* 2002) and finally to determine the business cycles (Hamilton, 1989).

Introduction of Model Variables
In this section, we provide a descriptive overview of utilized variables including the exchange rate, inflation, oil as well as the institutional factors including the law stability, political risk and total risk of country (volatility of governmental costs). Data of 180 companies is annually examined for a period of 2007 to 2013. In this regard, the econometrics softwareStata11and OX is applied (software code is provided by Krolzig).

Unit Root Test
Before analysis of VAR models, the evaluated characteristics should be investigated in terms of stability or non-stability. If the applied variables in VAR model are unstable, the model does not meet the stability

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condition, thus the review of Granger causality between variables will not have the sufficient validity. Different tests are now introduced in order to investigate the hypothesis of presence or absence of unit root in time series; the most important ones are as follow: Augmented Dickey-Fuller Unit Root Test (ADF), Phillips-Perron (PP) Test, GLS-Detrended Dickey-fuller, and KPSS test (Kwaitkowski, Philips, Schmidt, and Shin). Since the KPSS test has advantages compared to other tests, for instance, the null hypothesis is unlike the Dickey-Fuller test for the stability of studied variable in this test, this study utilizes this test to investigate the presence or absence of unit root in variables. According to the results of unit root test on the target variables, all variables are not at the probability level of 5% for unit root. Therefore, the hypothesis of stable studied variables cannot be rejected. According to this interpretation, the use of VAR models is permitted at the variables, and the stability of models is provided.

Model Specification and Estimate

In this section, the Tsay, RESET (Regression Equation Specification Error Test), and BDS tests are utilized to investigate the non-linear relationship between the variables determining the stock valuation. Tsay test was introduced by Tsay (1985). This test is utilized based on the arranged auto-regression and prediction of error terms. The linearity of relationship between the variables is the null hypothesis of this test and the F-statistic is the test statistic. Furthermore, the RESET testis introduced by Ramsey (1961) and the null hypothesis and test statistic of above test are similar to Tsay test. BDS test is introduced by Brock *et al.,* (1996) and the data is independently and identically distributed (IID) in the null hypothesis of above test, so that it has the asymptotic normal distribution in the samples with sizes of less than BDS statistic. The results of above-mentioned tests in Table (3) indicate the nonlinear relationship between the variables of this study.

Table 8: Results of non-linear test for relationships between variables

Variable	BDS	Tsay	RESET	
Price_vol	6.741	5.681	12.014	
	(0.000)	(0.014)	(0.000)	
LEXE	4.306	5.774	10.630	
	(0.002)	(0.000)	(0.000)	
LCPI	3.787	4.7452	8.211	
	(0.001)	(0.001)	(0.000)	

The numbers in parentheses are the p-values of variables.
Source: Research calculations

Afterwards, Akaike information criterion (AIC) and Likelihood Ratio test (LR) (the statistic of this test is as $LR=2(lnL_{MSAR} - lnL_{AR})$) are utilized to determine the degree of VAR model and all these criteria determine the optimal lag equal to 3. To determine the number of optimal regime in MS model and according to the nuisance parameters in null hypothesis, the LR test will not have the standard distribution, and thus this test cannot be used to determine the optimal regime (Krolzig, 1997). Ang and Bekaert (1998) have argued that the asymptotic distribution of LR statistic between regimes can be estimated using the chi-square distribution in certain cases, so that the degree of freedom of this distribution is equal to the number of nuisance parameters in addition to the number of applied linear restrictions. In addition to LR test, the information criteria, namely, HQ, SBC and AIC, can also be used to determine the number of regimes. The study by Saridakis *et al.,* (2003) indicates that in cases where the number of studied observations and changes in parameters are large enough, the use of Akaike information criterion (AIC) determines the correct number of regime. However, in most of the experimental studies, the number of regime is determined based on the researcher's cognition of variables. This study also uses the Akaike information criterion (AIC) according to the large sample size. According to the results of AIC statistic, the number of regime is obtained equal to 3; and the MSIAH (3) model is also selected as the optimal model of this research based on AIC and LR statistics. All parameters depend on regime in the above-mentioned model.

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Heteroscedasticity Test and Autocorrelation of Variables

Before estimation of model, this section summarizes the results of diagnostic tests after estimation in order to study the goodness of fit in the following table. As shown, the lack of autocorrelation between the error terms is confirmed by Portmanteau test. Furthermore, the Autoregressive conditional Heteroskedasticity (ARCH) and LM tests approve the homoscedasticity among the error terms.

Table 9: Results of tests after estimation

Test name	Test method	Result
Autocorrelation test	Portmanteau test	The lack of autocorrelation hypothesis is confirmed.
Heteroskedasticity test	ARCH LM	Approved homoscedasticity hypothesis

Source: Research calculations

Interpretation of Estimation Results

This study investigates the causal relationship between the price indices of crude oil, currency, gold, etc, using Markov switching models (Monte Carlo) and taking into account different variables in estimation by non-linear Markov method under the risky conditions, and also studies the common stock value of Tehran Stock Exchange under the risky conditions during the target period. The results of model estimation indicate that the effect of all variables are significant and except for the inflation risk, currency and oil price volatility, other variables have significant and positive effects on valuation of stock price.

Investigating the Efficiency of Nonlinear Markov and Arbitrage Methods

Since the non-linear Markov method is based on the autoregressive models (ARCH-GARCH) and the arbitrage pricing models are based on the linear regression of panel data, the autoregressive models in Markov method are more based on the data of time series under the uncertain conditions, and thus this method has high efficiency and less error than the models of panel data for prediction.

Hypotheses Analysis

First Hypotheses Analysis

In the first hypothesis, the researcher is seeking to answer the question whether the use of Monte Carlo mechanism in risky conditions is better in valuation of common stock at Tehran Stock Exchange than arbitrage method and whether it has a significant difference to arbitrage method? According to the investigation of different stock pricing methods, these methods suggest that the arbitrage pricing theory considers the real return of bonds depending on the mainly macroeconomic variables. Unlike the Capital Asset pricing Model (CAPM), this model provides the possibility of using more than a systematic risk factor. The specific stock risk is not important in the stock portfolio. The factors of individual stock error are not interrelated, and their correlation coefficient is zero. Under this circumstance, the risk of variables is only important and shows that the systemic risk cannot be deleted, but the unsystematic risk can be eliminated according to the diversity in investment.

On the other hand, the conducted studies have been conducted on the valuation of stock price under the more uncertainty by using multiple regression models; arbitrage and non-linear Markov methods are among these methods. This research is innovative in using the nonlinear Markov method, and there is no study in this regard. This research is also conducted by considering the institutional variables. Finally, it should be concluded that the nonlinear Markov method has higher efficiency than arbitrage method in valuation of common stock under the risky conditions for studied companies in Tehran Stock Exchange since it has considered the institutional variables, which had not been considered in previous studies, and has higher coefficient of determination and less error than arbitrage method.

Second Hypothesis Analysis

In the second hypothesis, the researcher is seeking to answer the question whether the arbitrage pricing method is able to determine the value of common stock in stock exchange under the risky conditions or not? In this regard, we utilizes the variables namely, the oil price volatility, exchange rates, inflation, firm

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size, financial leverage, and institutional variables. The results of analyzing the whole model indicates that the probability of rejecting the null hypothesis is less than 5%, thus there is a significant correlation between the independent and dependent variables and the coefficient of determination is equal to 95% indicating that the independent variables in model can explain the value of stock price as the dependent variable at the level of 95 percent and this explanation power indicates the high direct correlation between variables. Finally, the important points are obtained from the initial results of arbitrage pricing model. First, the null hypothesis is not rejected in investigating the validity of pricing constraints. Therefore, the constraints of arbitrage pricing theory are applicable on the unconstrained linear model. Thus, it seems that the arbitrage pricing model adequately explains the return of securities traded in Tehran Stock Exchange. Second, the calculated t statistic and also the values of confidence level of 95% in this table indicate that the estimated risk premiums are statistically significant for variables namely the political risk, risk of whole country, law stability, non-predicted exchange rate, inflation, oil price, financial leverage indices, and firm size. Therefore, among eight studied economic variables, all factors play the roles in stock pricing. However, the non-predicted inflation factors and the oil price are not priced. Third, among the significant variables, only the difference in interest rates has a positive risk premium, but other variables have negative risk premiums. After removing the meaningless variables and by using the results of unconstrained model, the risk premiums are again estimated through the nonlinear and repetitive seemingly unrelated regression method. The validity of research model constraints also shows the validity of arbitrage pricing model.

Third Hypothesis Analysis

In the third hypothesis, the researcher is seeking to answer the question whether the mechanisms of common stock valuation in Monte Carlo method have the ability to explain value of common stock in Stock Exchange or not? In this regard, different variables of first hypothesis are utilized and the hypothesis is investigated according to the emphasis on the institutional variables (law stability, political risk, and total risk). In second hypothesis of research, we investigate the valuation of stock price by above-mentioned variables through nonlinear Markov models from the family of EGARCH. Each of the variables of model has different effects on stock return or valuation; and the inflation and risk have negative effect along other variables. On the other hand, the results of total analysis of model indicate that the possibility of rejecting the null hypothesis is less than 5%, thus there is a significant correlation between the independent and dependent variables. Furthermore, the coefficient of determination is equal to 98% indicating that the independent variables of model have the ability to explain the stock price valuation as the dependent variable at the level of 98% under the risky conditions of company. Moreover, the results indicate that there is no significant correlation in possibility of variable board size. Furthermore, the above coefficient is negative in model and this indicates an inverse relationship between the board size and stock price valuation of company. Therefore, these criteria have been able to adjust the risk and unreliability and make value in order to protect the stakeholders and especially the owners' rights. Ultimately, Markov Switching method and the results of model estimation indicate that all factors, except for the inflation risk, exchange rate, and oil price volatility, have significant effects; other variables have positive and significant effects on determining the value of stock price. Based on the research literature and reviewed empirical studies on Granger causality, the stock price valuation has the causality relationship from the volatility of variables, and the increased oil price has enhanced theper capita income of oil-producing companies, and also has led to the stock valuation and capital movement among the currency, gold and stock markets.

Discussion

The analysis of results indicates that since the people hold different things such as cash, stock, bank deposit, bonds, gold and currency in their portfolio, this will affect the changes in amount of money, exchange rate, inflation rate, and bank interest rate and individual demand for holding each mentioned assets such as the demand for stock and this in turn affects the stock indices. It is believed that the stock prices are determined by some of the fundamental macroeconomic variables such as the inflation rate, exchange rate, interest rate, institutional variables and volume of liquidity.

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The above-mentioned results indicate that the internal mechanisms largely affect the firms as well as the firm strategy and management method. Therefore, the strengthened mechanisms leads to the increased reliability in stakeholders and more control and supervision of companies listed on Stock Exchange. Thus, according to the weakness of Arbitrage pricing model, it has the structure which does not fully consider all variables, thus since the nonlinear Markov method seeks to create the scenario with different methods; it has higher accuracy and efficiency than Arbitrage method.

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