Testing CAPM using Markov switching model: the case of coal firms

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TESTING CAPM USING MARKOV SWITCHING MODEL: THE CASE OF COAL FIRMS

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ABSTRACT

In this study, the relation between the coal firms that are traded in New York Stock Exchange and S&P500 index is analyzed. The return of the coal firms and the market return are analyzed by using traditional CAPM and two-state Markov regime switching CAPM (MS-CAPM). According to the Likelihood Ratio test, two-state regime MS-CAPM gives better results and indicates a non-linear relation between return and risk. It is found that beta shows variability in regard to low and high volatile periods making linear CAPM to provide deviated results.

JEL: G12, C32

Keywords: *Coal Firms, CAPM, Markov Switching Model*

1. Introduction

The Capital Asset Pricing Model (CAPM) has an important place in finance theory for pricing an individual asset with respect to its expected return and risk. It is also possible to make comparison between its price and expected return that should be for an asset of certain risk. The CAPM assumes that there is a linear relationship between expected returns and risk,

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and determines the risk-return trade-off accordingly. However, studies in the literature in recent years indicate that the expected return of an asset and the relationship between the degrees of risk is not always linear, and show that it changes over time. Many studies present that beta, which is a measure of systematic risk, is significantly different when the market prices fluctuate.

It is certain that energy is the most important necessity of human life and there is an increasing relation between the level of development and amount of energy consumed in a country. Coal, which has the greatest importance among the energy sources, is the primary factor for the industrial revolution in the world (Yılmaz and Uslu, 2007). Developing countries use about 55% of the world's coal and this share is expected to grow to 65% over the next 15 years (Balat and Ayar, 2004). World primary energy demands grows by 1.6% per year on average in 2006-2030 and demand for coal rises more than demand for any other fuel in absolute terms. World demand for coal advances by 2% a year on average, its share in global energy demand climbing from 26% in 2006 to 29% in 2030. Some 85% of the increase in global coal consumption comes from the power sector in China and India (World Energy Outlook 2008). Recently, tremendous volatility in the price of oil and natural gas and increasing coal demand reveal the importance of coal as alternative energy resources in the world. Increasing importance of coal brings coal mining companies in the foreground all over the world.

This study aims to investigate the relationship between the expected return and the degree of risk using non-linear CAPM model for the coal producing companies whose shares are traded in the U.S. equity markets. The main reason using the non-linear CAPM model is to investigate the differences of systematic risks of coal mining companies in the period of high and low market volatility. Systematic risks are measured using two-state Markov Switching Model for the coal producing companies in the period of high and low volatility.

2. Literature Review

In literature, there are many studies on testing CAPM using Markov switching model but there is a paucity of studies basing the analysis on coal firms.

Alexander et al. (1982) conduct a study to investigate both theoretically and empirically the appropriateness of describing the systematic risk of mutual funds with a different model of non-stationary-a first-order Markov process using the data consisting of the monthly returns for 67 mutual funds over the period January 1965 through December 1973. It will be shown that even if fund managers do not actively engage in timing decisions, the systematic risk of mutual funds theoretically can be modeled as being non-stationary. In particular, it is shown that the betas of such funds can be modeled as first-order Markov processes. Fridman (1994) finds out the high volatility state β can be more than double the size of the more stable state β, hence making it a higher risk state, and the duration of stay in the high risk state is typically shorter than the one for the low risk state for three oil industry corporation securities by means of two state Markov regime switching model.

Huang (2000) examines time varying CAPM for the Microsoft Corporation using monthly stock returns. He shows that the data from the low-risk state is consistent with the CAPM whereas the data from the high-risk state is not. Huang (2001) investigates that the data generating process of β can be well characterized by a regime-switching model for Taiwan Stock Market. The evidence shows that in the relatively high-risk state data are consistent with the CAPM, but they are inconsistent with the CAPM in the low-risk regime.

Fearnley (2002) tests a conditional multivariate international capital asset pricing model for US, Japanese and European stocks and government bonds. His findings indicated that the price of market risk is statistically significant, and the international CAPM risk premiums are validated, although currency risk premiums are not statistically significant.

Huang (2003) incorporates two specific features in the test of CAPM. The first one is to allow the systematic risk β to come from two different regimes to capture the instability found in the previous studies. The second one is to consider the censoring effect caused by the implementation of price limit regulation. His findings suggest that β's are unstable over time and the data may be consistent with CAPM in one regime but inconsistent in the other regime.

Hess (2003) compares competing Markov regime-switching model specifications and reported that for the Swiss security market index monthly returns, the market movement is optimally tracked by time-varying first and second moments, including a memory effect. Galagedera and Shami (2003) examine time varying CAPM for thirty the securities in the Dow Jones index. Their results indicate very strong evidence volatility switching behavior in a sample of returns in the S&P 500 index. In three of the thirty securities in the Dow Jones index, the estimated slope in the market model show strong switching behavior.

Ishijima et al. (2004) use TSE REIT (Tokyo Stock Exchange Real Estate Investment Trust) Index to derive an asset pricing model based on a growth optimal portfolio in a market. In an asset pricing model they employ a regime switching model, describing two equations, an observation equation which governs asset prices and a state equation which assumes that regimes conform to a first-order Markov processes. By dividing the analysis into two cases – the case where regime is taken into account and the case where it is not- it is shown that taking regime into account is better for estimating the risk premium of J-REITs.

Shami and Galagedera (2004) relate the security returns in the 30 securities in the Dow Jones index to regime shifts in the market portfolio (S&P 500) volatility. They find that there is strong volatility switching behavior with high-volatility regime being more persistent than the low-volatility regime. Galagedera and Fuff (2005) investigate whether the risk-return relation varies, depending on changing market volatility and up/down market conditions.

Three market regimes based on the level of conditional volatility of market returns are specified - “low”, “neutral” and “high”. For a set of U.S. industry sector indices using a cross-sectional regression, they find that the beta risk premium in the three market volatility regimes is priced. These significant results are uncovered only in the pricing model that accommodates up/down market conditions.

Huang and Cheng (2005) estimate and test for the Sharpe-Linter CAPM by allowing structural changes in betas. Their approach applies explicitly to the Sharpe-Linter CAPM using book-to-book market (BM) -and size- decile portfolios from July 1926 to December 2003, with a total of 930 monthly observations. Their study concludes that (1) there exists at least one break for all the portfolios under consideration, (2) the estimated break dates are quite similar for some of the portfolios, indicating the possible existence of a common break using multivariate time series, (3) the CAPM can be consistent with the data in some regimes but many appear to be inconsistent with the data in some other regimes. This particularly appealing feature has been completely ruled out under the conventional single-equation framework.

Gu (2005) develops regime-switching versions of the CAPM and the Fama French three-factor model, allowing both factor loadings and predictable risk premiums to switch across regimes. He finds that betas of value stocks increase significantly during bear market episodes. However, it is still rejected that the book-to-market premium is equal to zero for both the regime-switching conditional CAPM and the Fama-French model, even in the presence of regimes.

Tiwari (2006) develops a Bayesian framework for choosing a portfolio of mutual funds in the presence of regime switching in the stock market returns. He considers a two-state Markov regime switching model in order to capture the dynamics of stock market returns for the period 1962 to 2004. He finds that the existence of “bull” and “bear” regimes in market returns significantly impacts investor fund choices and ignoring the regimes imposes large utility costs. Wilson and Featherstone (2006) analyze the stock returns and market return for 21 food and agribusiness firms estimated in a threshold switching-regression framework. Their results indicate that risk parameters differ for alternative regimes and are not constant over time. Accounting for periods of temporary disequilibrium leads to notably more stable risk measurement estimates.

Hwang et al. (2007) propose generalized stochastic volatility models with Markov regime changing state equations (SVMRS) to investigate the important properties of volatility in stock returns, specifically high persistence and smoothness using S&P 500 daily index returns. According to their study, persistent short regimes are more likely to occur when volatility is low, while far less persistence is likely to be observed in high volatility regimes. Comparison with different classes of volatility supports the SVMRS as an appropriate proxy volatility measure. Their results indicate that volatility could be far more difficult to estimate and forecast than is generally believed. Chen and Huang (2007) examine the relation between stock returns and the World Index for four Pacific Rim economies, i.e. that of Taiwan, Hong Kong, South Korea and Malaysia. When the constant international capital asset pricing model (ICAPM) and the regime-switching ICAPM are considered, the evidence shows that the estimated beta coefficients from the constant ICAPM model underestimates systemic risk under the high-volatility regime, but overestimates systemic risk under the low-volatility regime.

Liow and Zhu (2007) focus on how the presence of regimes affects portfolio composition by means of regime switching asset allocation model for the six major real estate security markets (USA, UK, Japan, Australia, Hong Kong and Singapore). They conclude that optimal real estate portfolio in the bear market regime is very different from that in the bull market regime. The out-of-sample tests reveal that the regime-switching model outperforms the non-regime dependent model, the world real estate portfolio and equally-weighted portfolio from risk-adjusted performance perspective. Li (2007) uses Markov-switching model to identify the volatility state of G7 (Canada, France, Germany, Italy, Japan, the UK and USA) stock markets. His empirical results are consistent with the two following notions. First, the situation of both the individual and world stock markets during high volatility states will be associated with the minimum benefit of risk-reduction from international diversification and a maximum cross-market correlation. Second, by incorporating the character of state-varying correlation into the establishment of an international portfolio, it can be created a more efficient investment strategy with less risk, or greater return for a given risk.

3. Capital Asset Pricing Model

The CAPM, as first proposed by Sharpe (1964) and Lintner (1965a, b), is central to financial theory. The CAPM was developed, at least in part, to explain the differences in risk premiums across assets. Inherent to the CAPM, these differences are the results of variations in the riskiness of the returns on assets. The model asserts that the correct assessment of riskiness is its measure – known as 'beta' – and that the risk premium per unit of riskiness is the same across all assets. Given the risk free rate and the beta of an asset, the CAPM predicts the expected risk premiums for that asset (Chen and Huang, 2007).

The CAPM assumes the marketplace compensates investors for taking systemic risk but not for taking a specific risk. For this simple reason that a specific risk can be diversified away. When an investor holds a market portfolio, each individual asset in that portfolio entails a specific risk, but through diversification, the investor's net exposure is just the systemic risk of the market portfolio. Systematic risk can be measured using beta coefficients. Based on the CAPM, the expected return on a stock equals the risk-free rate plus the portfolio's beta multiplied by the expected excess returns on the market portfolio (Chen and Huang, 2007).

CAPM model can be written as:

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{it} - R_{ft} \right) + \varepsilon_{it} \quad (1)$$

where i = 1, 2, …, n and t = 1, 2, …, T. The returns on asset i, the market portfolio and the risk free-rate at time t are denoted by R_{it}, R_{mt} and R_{ft}, respectively. The error term ε_{it} is assumed to be iid N (0, σ^2).

While the theory maintains a linear and stable relationship between return and risk, there is overwhelming evidence documenting significant time variation in market betas. One of the reasons, argued by Jagannathan and Wang (1996), might be due to the relative risk of a firm's cash flow varying over the business cycle. During a recession, the financial leverage of those firms in relatively poor shape may increase sharply compared with other firms, causing their stock betas to rise. As a result, the risk measure betas are expected to depend on the nature of the information available at any given time and can vary over time (Huang, 2003).

To assess the validity of the test, one important question is the stability of the measure of systematic risk, i.e. β. Nonetheless, empirical investigations such as Blume (1971), Levy (1971), Fabozzi and Francis (1977) and Chen (1982) generally found that the betas tended to be volatile over time and challenged the assumption of constant beta coefficient (Huang, 2000).

To overcome nonlinearity in CAPM model Huang (2000, 2001, and 2003) and Chen and Huang (2007) use a two state, first order Markov switching model. In this study, we consider three different models to obtain systematic risk of coal firms in the U.S.A. First, we consider that Model I (linear regression based-model with constant alpha and beta) following by:

Model I: $r_{it} = \alpha_i + \beta_i r_{mt} + \varepsilon_{it}$ (2)

where r_{it} = R_{it} - R_{ft} and r_{mt} = R_{mt} - R_{ft} indicates excess return on asset and on the market portfolio at time t. In Model I, alfa and beta are assumed constants. However, in the literature, it has been reported that beta is not constant and it is switching according to low and high volatility regime. Thus, we consider that Model II allows beta to come from low and high volatility regime following by:

Model II: $r_t = \alpha_i + \beta_{s_t} r_{mt} + \varepsilon_t$ (3)

where ε_t ~ iid N (0, σ^2) and the unobserved state variable, s_t, evolves according to the first order Markov-switching process described in Hamilton (1994):

$$
\begin{aligned}
&P\left[s_t = 1 \middle| s_{t-1} = 1\right] = p \\
&P\left[s_t = 0 \middle| s_{t-1} = 1\right] = 1 - p \\
&P\left[s_t = 0 \middle| s_{t-1} = 0\right] = q \\
&P\left[s_t = 1 \middle| s_{t-1} = 0\right] = 1 - q \\
&0 < p < 1 \quad 0 < q < 1
\end{aligned}
\tag{4}
$$

where p and q are the fixed transition probabilities of being in low or high volatility regime, respectively.

Finally, in Model III, we consider alpha and beta are not constant and they are switching across two different regimes.

Model III: $r_t = \alpha_{s_t} + \beta_{s_t} r_{mt} + \varepsilon_t$ (5)

where ε_t ~ iid N (0, σ^2) and the unobserved state variable, s_t, evolves according to the first order Markov-switching process. As there are many studies in literature that deal with the procedures that use Makov-switching model in estimation, we prefer not to give detailed information about this. Hamilton's (1994) and Krolzig's (1997) studies are being considered as good references for Markow Switching Model.

We consider three different empirical models in this study and we use likelihood ratio (LR) test to select the most appropriate model. The Likelihood Ratio (LR) test can be based on the statistic (Krolzig, 1997):

$$LR = 2\left[\ln L(\lambda) - \ln L(\lambda_r)\right] \tag{6}$$

where λ denotes the unconstrained maximum likelihood estimator and λ_r the restricted maximum likelihood estimator. Under the null, LR has an asymptotic χ^2 distribution with r degrees of freedom.

4. Data and Empirical Results

In this study, the monthly price series of the 21 coal firms traded in U.S. stock markets covering the period of January 2000 and January 2009 are used. As market values, S&P 500 index and as risk-free interest rate, monthly government bonds' interest rates are used as variables. The data that the prices of the securities of the firms and S&P 500 index are taken from www.finance.yahoo.com web-site and the monthly government interest rate is taken from Kenneth W. French's web-site. The coal firms and the codes are given in Table 1.

Table 1

The Coal Firms Used in the Study and its Codes

Code	Firms	Code	Firms
ATI	ALLEGHENY TECHNOLOGIES INC.	NANX	NANOPHASE TECHNOLOGIES CORP.
ACI	ARCH COAL INC.	RTI	RTI INTERNATIONAL METALS INC.
ARLP	ALLIANCE RESOURCE PARTNERS LP	SFEG	SANTA FE GOLD CORPORATION
BHP	BHP BILLITON LTD.	SWC	STILLWATER MINING CO.
BW	BRUSH ENGINEERED MATERIALS INC.	TIE	TITANIUM METALS CORP.
CCJ	CAMECO CORP.	USEG	US ENERGY CORP.
CCRE	CAN-CAL RESOURCES LTD.	USU	USEC INC.
CNX	CONSOL ENERGY INC.	WLT	WALTER INDUSTRIES INC.
BOOM	DYNAMIC MATERIALS CORP.	WLB	WESTMORELAND COAL CO.
MEE	MASSEY ENERGY CO.	YZC	YANZHOU COAL MINING CO. LTD.
MFN	MINEFINDERS CORP. LTD.		

S&P 500 index and the return of the firms' descriptive statistics are given in Table 2. According to the results in Table 2, the lowest monthly return in the period and the highest deviation belong to CCRE coal firm. According to the kurtosis value, the characteristic of the whole coal firms returns' distribution is observed as fat tail. Jarque-Bera normality test statistics indicate that coal firms' returns do not have a normal distribution except ACI, BW, SFEG and WLB.

Table 2

Descriptive Statistics on Security Returns

	N	Mean	Std. Deviation	Skewness	Kurtosis	Jarque-Bera
S&P500	109	-0.418	4.474	-0.859	4.731	27.022 [0.000]
ACI	109	1.188	16.441	-0.287	3.772	4.201 [0.122]
ARLP	109	2.052	8.450	-1.140	7.286	107.039 [0.000]
ATI	109	0.398	17.290	-0.099	4.246	7.230 [0.027]
BHP	109	1.540	9.335	-0.553	3.869	8.979 [0.011]
BOOM	109	3.251	23.024	2.308	14.714	719.976 [0.000]
BW	109	-0.191	15.976	-0.302	3.451	2.580 [0.275]
CCJ	109	1.991	12.133	-0.605	3.263	6.967 [0.031]
CCRE	109	-1.811	33.646	0.933	4.692	28.830 [0.000]
CNX	109	1.957	14.829	-0.725	3.720	11.898 [0.003]
MEE	109	0.412	18.234	-0.540	4.231	12.182 [0.002]
MFN	109	2.135	15.885	0.283	4.792	16.030 [0.000]
NANX	109	-1.410	22.451	0.519	3.980	9.253 [0.010]
RTI	109	0.658	14.034	-0.572	4.219	12.684 [0.002]
SFEG	109	-0.427	29.041	0.404	3.551	4.351 [0.114]
SWC	109	-1.629	19.866	0.049	4.238	7.007 [0.030]
TIE	109	1.954	22.034	-1.376	10.340	279.096 [0.000]
USEG	109	-0.636	17.107	0.832	4.798	27.260 [0.000]
USU	109	0.092	15.242	-0.392	3.852	6.084 [0.048]
WLB	109	1.146	15.623	-0.237	3.245	1.291 [0.524]
WLT	109	1.301	16.477	-1.474	8.557	179.694 [0.000]
YZC	109	1.629	14.779	-0.654	5.225	30.270 [0.000]

The correlation of the security returns and S&P 500 index are given in Table 3. According to the results given in Table 3, the companies' returns except CCRE, MFN and SFEG, and the market returns (S&P 500) move parallel and also they are significantly correlated. Moreover, the returns of CCRE, MFN and SFEG companies move independently compared to other companies' returns.

Table 3

Correlation among the Returns of the Coal Firms

	S&P500	ACI	ARLP	ATI	BHP	BOOM	BW	CCJ	CCRE	CNX	MEE	MFN	NANX	RTI	SFEG	SWC	TIE	USEG	USU	WLB	WLT	YZC
S&P500	1.000																					
ACI	0.268*	1.000																				
ARLP	0.283*	0.554*	1.000																			
ATI	0.521*	0.324*	0.414*	1.000																		
BHP	0.527*	0.416*	0.418*	0.421*	1.000																	
BOOM	0.287*	0.281*	0.263*	0.298*	0.326*	1.000																
BW	0.553*	0.302*	0.302*	0.553*	0.424*	0.349*	1.000															
CCJ	0.405*	0.527*	0.480*	0.479*	0.551*	0.289*	0.422*	1.000														
CCRE	0.074	-0.089	-0.042	-0.008	0.030	-0.052	-0.049	-0.065	1.000													
CNX	0.365*	0.715*	0.509*	0.440*	0.476*	0.221*	0.335*	0.565*	-0.032	1.000												
MEE	0.427*	0.726*	0.662*	0.463*	0.439*	0.251*	0.324*	0.531*	0.017	0.747*	1.000											
MFN	0.089	0.117	0.119	0.138	0.196*	0.098	0.135	0.179	0.293*	0.166	0.084	1.000										
NANX	0.484*	0.104	0.102	0.183	0.211*	0.111	0.339*	0.067	0.069	0.151	0.104	-0.074	1.000									
RTI	0.463*	0.469*	0.433*	0.609*	0.424*	0.241*	0.463*	0.409*	-0.084	0.446*	0.463*	0.175	0.206*	1.000								
SFEG	0.075	0.009	-0.009	0.225*	-0.001	0.007	0.016	0.025	0.126	0.029	-0.024	-0.017	0.085	0.121	1.000							
SWC	0.459*	0.358*	0.262*	0.503*	0.366*	0.156	0.438*	0.473*	-0.024	0.410*	0.366*	0.115	0.326*	0.348*	0.227*	1.000						
TIE	0.412*	0.267*	0.244*	0.397*	0.405*	0.229*	0.489*	0.271*	-0.067	0.349*	0.286*	-0.010	0.244*	0.411*	-0.042	0.297*	1.000					
USEG	0.224*	0.338*	0.223*	0.301*	0.152	0.409*	0.251*	0.310*	-0.015	0.207*	0.308*	0.110	0.125	0.304*	0.031	0.288*	0.064	1.000				
USU	0.377*	0.330*	0.305*	0.423*	0.346*	0.314*	0.381*	0.428*	0.054	0.300*	0.396*	0.075	0.102	0.376*	0.066	0.259*	0.286*	0.326*	1.000			
WLB	0.293*	0.482*	0.417*	0.258*	0.297*	0.173	0.335*	0.375*	0.115	0.378*	0.480*	0.174	0.184	0.226*	0.036	0.268*	0.155	0.358*	0.371*	1.000		
WLT	0.363*	0.418*	0.545*	0.382*	0.323*	0.349*	0.269*	0.352*	-0.085	0.391*	0.536*	0.198*	0.158	0.419*	0.094	0.256*	0.183	0.278*	0.193*	0.274*	1.000	
YZC	0.403*	0.380*	0.379*	0.471*	0.590*	0.178	0.376*	0.487*	-0.048	0.446*	0.389*	0.431*	0.062	0.487*	0.068	0.221*	0.160	0.084	0.368*	0.259*	0.356*	1.000

* indicates significance at %1 level.

Using the Coal Firms' return series and the risk-free interest rate, the excess return series are formed and it is aimed to investigate whether they are stationary or not by using PP test which is proposed by Phillips and Perron (1988) and KPSS unit root test which is proposed by Kviatkowski et. al (1992). According to the unit root test results which are given in Table 4, all the variables that are used in models are observed as stationary.

Table 4

Unit Root Test Results

Variable	PP	KPSS	Variable	PP	KPSS
RM	-8.737*	0.215*	**MFN**	-10.216*	0.392*
ACI	-8.441*	0.237*	**NANX**	-11.538*	0.280*
ARLP	-10.528*	0.383*	**RTI**	-10.235*	0.323*
ATI	-9.488*	0.205*	**SFEG**	-6.986*	0.158*
BHP	-10.091*	0.162*	**SWC**	-9.640*	0.075*
BOOM	-11.715*	0.139*	**TIE**	-9.584*	0.177*
BW	-10.023*	0.122*	**USEG**	-10.778*	0.143*
CCJ	-8.977*	0.381*	**USU**	-9.400*	0.155*
CCRE	-13.701*	0.136*	**WLB**	-9.457*	0.369*
CNX	-9.723*	0.156*	**WLT**	-8.536*	0.083*
MEE	-8.989*	0.117*	**YZC**	-8.915*	0.108*

Unit root tests are examined with constant term model. * indicates that null hypothesis of unit root is rejected at 1% significance level.

In this study, as there are three different models that are taken into consideration, the most suitable model should be investigated. For this reason, three models are formed for all the firms and LR test is used to select the best model. The results of the LR test are given in Table 5. The $H_i|H_j$ notation in Table 5, shows that in LR test Model i is tested against Model j. As a result, if test statistics are greater than critical values than null hypothesis is rejected and superior model is selected as Model j. According to these results, Model I, linear model shows a low performance and null hypothesis is being rejected. This result proves that the beta as a measure of systematic risk shows a variability during high and low volatility periods. Alpha is also tested with LR test whether it shows a meaningful difference in both regimes. Consequently, Model II and Model III provided better results. Not only beta that is calculated for BHP, BW, MFN, RTI and WLB but also alpha showed variability during low and high volatility periods. For this reason, Model III is found as the best suitable model for these companies; however, for the rest of the companies Model II gives better results.

Table 5

Likelihood Ratio Test Results

Firm	$H_1 \mid H_2$	$H_1 \mid H_3$	$H_2 \mid H_3$	Firm	$H_1 \mid H_2$	$H_1 \mid H_3$	$H_2 \mid H_3$
ACI	19.072*	21.588*	2.516	**NANX**	16.372*	16.798*	0.426
ARLP	14.886*	15.282*	0.396	**RTI**	5.38	16.54*	11.16*
ATI	15.962*	16.044*	0.082	**SFEG**	31.546*	21.26*	-10.286
BHP	5.196	15.488*	10.292*	**SWC**	12.416*	12.438*	0.022
BOOM	55.662*	58.698*	3.036	**TIE**	29.82*	30.79*	0.97
BW	22.462*	28.426*	5.964*	**USEG**	12.796*	16.432*	3.636
CCJ	11.014*	8.102*	-2.912	**USU**	17.838*	18.194*	0.356
CCRE	21.186*	16.024*	-5.162	**WLB**	6.718*	11.754*	5.036*
CNX	11.178*	8.862*	-2.316	**WLT**	22.674*	22.988*	0.314
MEE	12.362*	11.806*	-0.556	**YZC**	19.608*	19.82*	0.212
MFN	7.344*	15.416*	8.072*				

H_1 represents Model I, H_2 represents Model II and H_3 represents Model III. * indicates that null hypothesis is rejected at 5% significance level.

The results of MS-CAPM model are given in Table 6. According to the results in Table 6, beta parameter, the systematic risk measure shows different results in low and high volatile periods. Low and high volatile periods are decided according to the standard error of regression. When the standard error is low, the period is named as low volatility, and when the standard error is high, the period is named as high volatility.[1]

[1] The normality test, heteroscedasticity and autocorrelation tests are done with the error terms taken from the MS-CAPM and at %1 significance level for the model results no diagnostic error is observed. These test results are available on request from the authors.

Firstly, if we are to interpret the results of low volatile period; the beta parameter of the securities of ACI, BOOM, CNX, NANX, RTI, SWC, USEG, USU, and WLB is greater than one and statistically significant at 5% level. This result indicates that the firms during the low volatility periods are riskier. This provides a chance to the investors of such securities to have higher returns. The beta parameter of ATI and BHP firms which is less than one and statistically significant shows that the securities of such firms are less risky. Whereas, during the low volatile period, the beta parameters of the securities of CCJ, CCRE, MFN are less than zero and statistically significant indicating that the returns of the securities move in the opposite direction to the market return. During the low volatile period, the beta parameter of ARLP, MEE, SFEG and YZC firms is not found statistically significant. This result indicates that during the low volatile period it has no relation with the market return. The betas of CCJ, CCRE and MFN firms are negative and statistically significant showing that during the low volatile period, the return of the securities move in the opposite direction to the market.

According to the results during the high volatile period; the beta parameter of the securities of ATI, BHP, BW, CCJ, CCRE, MEE, RTI, WLT and YZC is found greater than one. This result shows that during the high volatile periods the systematic risk is higher. The beta parameter of ARLP and MFN firms is less than one and statistically significant indicating that during the high volatile period, the systematic risk is lower. Finally, the beta parameters of ACI, CNX, NANX, SFEG, SWC, TIE, USEG, USU and WLB are not found statistically significant showing that such firms' returns during high volatile period move independently from the market return. There is a considerable difference between the results of the linear CAPM and MS-CAPM model. If we investigate the coal firms' returns and the market returns with the linear CAPM, then β was going to be estimated from the MS-CAPM model. This result can be misleading and the risk can be higher than (or lower) the market making a firm to have lower (or higher) risk than the market. For this reason, when the CAPM and firms' risk level is investigated the existence of the non-linear relation should be taken into consideration.

Table 6

MS-CAPM Results

	α_{low}	α_{high}	β_{low}	β_{high}	σ_{low}	σ_{high}	LogL	p_1/q_1	p_2/q_2
ACI	1.748 (1.189)	-	3.010* (0.601)	-0.444 (0.861)	8.762	12.284	-428.743	0.443	0.705
ARLP	2.490* (0.692)	-	0.352 (0.268)	0.902* (0.585)	6.100	13.244	-375.264	0.950	0.795
ATI	1.202 (1.197)	-	0.946* (0.335)	4.205* (1.201)	8.697	17.603	-439.426	0.668	0.488
BHP	9.776* (1.220)	-2.496* (1.111)	0.938* (0.161)	1.440* (0.163)	3.793	5.318	-371.515	0.227	0.548
BOOM	1.071 (1.367)	-	1.248* (0.305)	1.131 (2.781)	12.502	49.212	-464.468	0.973	0.805
BW	3.253* (1.005)	-0.820 (2.217)	2.206* (0.215)	1.843* (0.512)	5.310	16.903	-422.227	0.020	0.216
CCJ	2.284* (0.820)	-	-0.532** (0.292)	1.583* (0.311)	5.904	9.026	-393.300	0.818	0.928
CCRE	-4.260* (0.535)	-	-11.798* (0.087)	1.416* (0.679)	1.001	30.641	-526.477	0.133	0.952
CNX	2.546* (1.213)	-	2.556* (0.389)	-0.066 (0.580)	9.288	15.143	-435.339	0.878	0.863
MEE	1.109 (1.592)	-	-1.059 (0.722)	3.115* (0.561)	9.610	15.581	-453.225	0.328	0.642
MFN	21.269* (4.081)	0.686 (1.438)	-5.426* (1.001)	0.579** (0.309)	9.341	13.765	-447.485	0.651	0.969
NANX	-0.705 (1.558)	-	3.731* (0.515)	1.339 (0.871)	12.310	26.501	-471.450	0.905	0.834
RTI	13.541* (0.527)	1.029 (1.139)	7.008* (0.097)	1.187* (0.251)	0.932	11.371	-420.681	0.375	0.972
SFEG	-0.522 (0.845)	-	0.177 (0.174)	0.210 (1.023)	6.840	18.730	-402.542	0.964	0.895
SWC	-0.690 (1.486)	-	2.125* (0.387)	1.221 (2.329)	12.934	31.330	-461.720	0.807	0.107
TIE	4.043* (1.526)	-	1.627* (0.361)	3.763 (2.377)	13.980	46.155	-466.509	0.942	0.457
USEG	-1.156 (1.384)	-	1.174* (0.344)	-2.912 (2.870)	13.077	28.374	-448.899	0.918	0.020
USU	1.156 (1.047)	-	1.516* (0.242)	0.990 (0.812)	7.955	20.418	-433.221	0.864	0.758
WLB	-1.897	6.744*	2.209*	-0.393	12.233	13.378	-442.954	0.839	0.762

	(2.126)	(3.146)	(0.489)	(0.527)					
WLT	2.510* (1.143)	-	1.570* (0.590)	1.275** (0.700)	8.001	22.407	-440.028	0.865	0.779
YZC	2.577* (1.173)	-	0.099 (0.348)	3.322* (0.468)	11.015	11.954	-427.749	0.943	0.902

* indicates significance level at 5%. The values in parenthesis show the standard errors. σ_{low} shows the standard error of regression during the low volatile period, σ_{high} shows the standard error of regression during high volatile period. p_1/q_1 shows the probability of low volatile period after low volatile period, p_2/q_2 shows the probability of high volatility period after high volatility period. LogL represents the log likelihood function.

The relation between the returns of the coal firms that are derived from MS-CAPM and market return is also summarized in Table 7.

Table 7

The Relation between Coal Firms and the Market during Low and High Volatility

Firms	**Low Volatility**				**High Volatility**			
	Risky	**Low Risk**	**No Relation with the Market**	**Opposite to the Market**	**Risky**	**Low Risk**	**No Relation with the Market**	**Opposite to the Market**
ACI	●						●	
ARLP			●			●		
ATI		●			●			
BHP		●			●			
BOOM	●						●	
BW	●				●			
CCJ				●	●			
CCRE				●	●			
CNX	●						●	
MEE			●		●			
MFN				●		●		
NANX	●						●	
RTI	●				●			
SFEG			●				●	
SWC	●						●	
TIE	●						●	
USEG	●						●	
USU	●						●	
WLB	●						●	
WLT	●				●			
YZC			●		●			

Results obtained from MS-CAPM are important three aspects. First of all, we conclude that betas of coal companies are not stable through time and changes related to volatility of stock return. This result indicates that linear CAPM doesn't describe excess return of the coal companies. Secondly, investors who want to invest in coal companies should consider time-varying beta to optimize their portfolios because beta obtained from linear CAPM is found between betas obtained from MS-CAPM. Finally, investors and academicians should use nonlinear models to forecast stock return of coal companies because likelihood ratio test results indicate that nonlinear models capture better behaviors of stock return of coal companies than linear models.

However, these results bring with questions that why the betas of coal companies are time-varying and why the coal companies behave differently from each others. Therefore some studies in the literature try to answer these questions. The first interpretation of these questions suggested by Stattman (1980), Rosenberg et al. (1985), and Fama and French (1992) emphasizes the book-to-market anomalies in which average returns on stocks with high ratios of book value to market value are higher than those with low ratios of book value to market value. It is expected related to finance theory because companies grow and invest new projects through time and these lead to change risk profile of companies. Therefore, book-to-market values of companies cause to change their betas over 10 or 20 years horizon even in short periods.

The second interpretation proposed by Banz (1981) emphasizes the size effect that the average returns on stocks of small firms are higher than the average returns on stocks of large firms. The third interpretation argued by Jegadeesh and Titman (1999) is the momentum effect that stocks with higher returns in previous 12 months (winning stocks) tend to have higher future returns than stocks with lower returns in the previous 12 months (losing stocks). In this context, Tai (2003), Ang and Chen (2007), In and Kim (2007) and Abdymomunov and Morley (2009) determine book-to-market, the size effect and the momentum effect anomalies in the stock markets. In addition to these, Ang and

Liu (2004) argued that discounting cash-flows of firms lead to change market risk premiums, risk-free rates and betas over time.

Also, it is well known that changes in the oil price have significant effect on stock returns of energy companies and any shocks in the oil price lead to change betas of energy companies over time. Faff and Brailsford (1999), Sadorsky (2001), Trück (2008) and Boyer and Fillon (2007) determine that changes in the oil price effect positively and significantly to stock returns of energy companies.

5. Conclusion

CAPM which measures the relationship between securities' return and the market return has a significant place in finance theory. In CAPM, the systematic risk of the securities is measured with beta parameter and with the value of the parameter; the risk level of the securities can be interpreted accordingly. In traditional finance theory, the return of the securities and the market return relation are assumed as linear and when the return of the securities increase than systematic risk also increases. In recent years, with the development of the behavioral finance theory, the return and risk relation is proved not to be linear at all times and with the effect of the anomalies in the market, this relation is found in opposite direction. On the other hand, with the development in nonlinear time series analysis, in lots of studies, beta shows variability in high and low volatile periods. Especially when the return of the securities and the risk are taken as linear, the beta parameter can be misleading. For this reason, this study investigates the risk level of the securities of coal firms that are traded in U.S. securities markets with the linear and nonlinear models. According to the results, the relation between the return of the firms and the market return is found as non-linear. In the study, two non-linear models are used. The first one is the CAPM where alpha is constant and beta is a variable. In the second non-linear model, alpha and beta parameters are assumed to be variable in high and low volatile periods. According to the findings, the first model gave better results and only BHP, BW, MFN, RTI and WLB fit better to the second model.

To summarize the results from the MS-CAPM, it can be noted that in low and high volatile periods BW, RTI and WLT firms have higher systematic risk. ACI, BOOM, CNX, NANX, SWC, TIE, USEG, USU and WLB firms in the periods of low volatile period have higher systematic risk whereas, ATI, BHP, CCJ, CCRE, MEE and YZE firms have low systematic risk during low volatile periods. ARLP firm in both periods, MEE, SFEG and YZC firms, and the return of the MFN firms during high volatile period is observed as unrelated. Finally, the return of the securities of CCJ, CCRE and MFN and the market return move completely in the opposite direction during low volatility period.

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