Agricultural Marketing and Commercialization Journal
7(1), 94-105, 2023, ISSN Print: 2676640X, ISSN online: 2676-7570

The test of the Fama-MacBeth model to measure the relationship between the expected investment risk metrics and the expected rate of return for knowledge-based companies active in the Tehran Stock Exchange

***Shabnam Shayestehfar*[1]**

Received: 10 January 2023/ Revised: 21 March 2023/ Accepted: 01 May 2023/ Published: 01 June 2023

Abstract

The main purpose of this research is to measure investment risk indicators (standard deviation risk, half standard deviation, parametric and historical value at risk and parametric and historical; HR) and test their relationship with the expected price return rate for knowledge-based companies active in the stock market. For this purpose, a sample consisting of 31 knowledge-based companies active in the Tehran Stock Exchange was selected during the period of 2016 to 2021 and the risk indicators of standard deviation, half standard deviation and value at risk were selected based on We tested the McBeth Fama model in relation to the expected rate of return. The research results show that there is a significant relationship between volatility risk indicators and adverse risk for the expected rate of return. Also, the research findings showed that controlling factors such as company size, financial leverage, book value to market value, liquidity, momentum and inverse are not able to change the positive relationship of the risk criteria examined on the expected return.

Keywords: Expected Return, Knowledge-based Companies, McBeth Fama Model, Risk Indexes.

Introduction

Knowledge-based companies play a central role in new economic paradigms, and along with technological units located in universities and industrial centers, knowledge-based companies are practically the driving force of this sector of the economy. In the first step, the knowledge-based economy includes two areas of service and industry. In the service sector of knowledge bases based on existing ICT platforms, they have been able to play an effective role and, considering the country's market of about 85 million people, are approaching their maturity stage financially. In the field of industrial knowledge bases, these groups themselves have brought good power and taken significant actions, but they need serious support from other influential sectors of the country in order to be more successful and play a stronger role. The problem of asset pricing is one of the fundamental challenges of financial

[1] Department of Accounting, Tehran University, Tehran, Iran. shayesteh.acc@gmail.com

knowledge, the main focus of which is the identification of risk factors that can explain the expected return changes. A category that many experimental studies have not been able to resolve the challenges facing. Obviously, in the classical financial framework, higher volatility is expected to result in higher expected returns. In spite of the fundamental principles of positive support of risk and return and numerous empirical evidences supporting the aforementioned relationship, some empirical evidences such as Ang et al. (2006, 2009) showed that the relationship between recent variables is inverse and stocks with lower volatility compared to volatile shareholders. Higher acceptability implies higher expected returns. The recent finding was considered a classic financial challenge, so many studies were conducted to verify the findings of Ang et al. (2006, 2009). One of the points that lead to the clarification of the relationship between risk and return is to pay attention to the distribution of stock returns.

In classic asset pricing models such as CAMP, it is assumed that the distribution of asset returns is normal. However, much evidence suggests that the distribution of returns is not normal. As long as the distribution of stock returns is normal, the standard deviation as one of the appropriate measures will evoke risk. But as soon as the stock return distribution deviates from the normal distribution, the standard deviation loses its efficiency. (Li Rodney, 2020). If the return distribution is abnormal, the use of asymmetric risk measures such as value at risk (VaR) is considered. The present research examines the relationship between risk metrics and the expected return for knowledge-based companies, and also to ensure that other variables do not have an effect in order to make the relationship between risk and return metrics as transparent as possible, the factors are controlled, which previously Their effect on yield has been confirmed. (Turan G Bali., 2018)

Theoretical Background

The background of empirical studies on the relationship between risk and return is very extensive and has a long history. Early studies such as Lintner (1965) and Lyman (1990) confirm the direct relationship between risk and expected return. According to Merton (1987), in the presence of market barriers and investors' limited access to information, stocks with high unsystematic risk will have higher expected returns because investors are unable to fully diversify their portfolios. Bigdeli and Shahsoni (2013) came to the conclusion that providing a risk interpretation of the beta of the stock market in the Tehran Stock Exchange during the period under review is not justified, and it is only the size and value due to higher risk tolerance by investors.

Ang et al. (2009) confirmed the inverse relationship between unsystematic risk and average instantaneous stock returns using the stock market data of the United States and Group of 7 countries during 1980 to 2003. In their subsequent research, these researchers selected 23 stock exchanges of different countries as samples and showed that the same relationship as the countries of the group of seven exists in other markets as well. Hiwang et al. (2007) and Fu (2009) found

evidence that Ang et al.'s results were reversed using monthly data and confirmed the existence of a significant positive relationship between unsystematic risk and expected return.

Su Vivan et al. (2013) confirmed the standard deviation of the Fama and French model as a measure of unsystematic risk and monthly returns. Rahat Achtani (2019) confirmed the volatility anomaly in the Indian market and showed that portfolios with lower volatility have higher returns and vice versa.

Bali et al. (2004) in the study of non-financial companies listed on NYSE, AMEX, NASDAQ during the period from 1958 to 2001 found evidence that shows a positive relationship between value at risk (VAR) and average expected stock returns. Hoffman and Moll (2012) by examining the relationship between asymmetric measures of risk and past days' returns and expected returns, provided evidence that shows that there is a positive and significant relationship between asymmetric measures of risk and expected returns. According to him, the irregularity of volatility is caused by the use of traditional risk measures such as standard deviation, and if asymmetric measures are used, the direct relationship between risk and return is calculated.

Method and Methodology

Fama-McBeth (1973) model is used to test the relationship between risk measures and expected returns. In the following, the details of how to use each of these models are described. Data Analysis (Hypothesis Test). Also, The current research is an applied research. The statistical population of the present study includes 33 knowledge-based companies admitted to the Tehran Stock Exchange during the years 2016 to 2021. The statistical sample includes 31 companies from the mentioned society. Also, research data has been collected from Tseclient software and Rahavard Novin software and analyzed and tested using Matlab and Eviews software.

Fama-McBeth model: To test the relationship between asymmetric measures and expected return in the framework of Fama-Macbeth model, cross-sectional regression is fitted on a daily basis:

$$R_{it} = \alpha_t + \gamma_t = (Risk\ Measure_{it-1}) - \varepsilon_{it}$$

where Rit is the expected return of company i stock on day t and Risk Measure it-1 is the risk measures of company i on day t-1. These metrics are standard deviation, half standard deviation, value at risk (VAR). Then, the average of the time series of the coefficients obtained from the above model is calculated and a decision is made regarding the relationship between the asymmetric measures and the expected return. In previous research such as Fama and French (1992), (1993) and Hoffman and Mol (2012), the effect of variables such as financial leverage, size, book value to market value of equity (B/M) and liquidity on the relationship between volatility and return The expected confirmation has been received. Based on this, in the current research, like Hoffman and Mol (2012), the effect of the above variables is controlled using the Macbeth Fama model (1973). In this way, the research model is completed in the form of the following relationship:

$$R_{it} = \alpha_t + \gamma_t = (Risk\ Measure_{it-1}) - \delta_{it} In(size)_{it-1} + \lambda_t In(B/M)_{it-1} + \eta_t tda_{it-1} + \varphi_t LIQ_{it} + \varepsilon_{it}$$

where size, B/M, tda are the size of the company, the ratio of book value to the market value of equity and the ratio of total debt to total assets of company i, and LIQ is the measure of liquidity. In the present study, the effect of these variables on the relationship between asymmetric risk metrics and expected return is controlled by using montum and inverse virtual variables. In this way, the research model is completed in the form of the following relationship:

$$R_{it} = \alpha_t + \gamma_t = (Risk\ Measure_{it-1}) - \delta_{it} In(size)_{it-1} + \lambda_t In(B/M)_{it-1} + \eta_t tda_{it-1} + \varphi_t LIQ_{it} + \partial_t \text{Re}tPOS_{it-1} + \phi_t \text{Re}tNEG_{it-1} + \varepsilon_{it}$$

where RetPOS is equal to one if the previous day's return is positive, otherwise it is equal to zero, and RetNEG is equal to one, if the previous day's return is negative, otherwise it is equal to zero. In relation (3), if the RetPOS coefficient is negative and the RetNEG coefficient is positive, it can be concluded that there is an inverse return in the daily data, that is, companies that had a negative return on the previous day will have a positive return on the next day and are suitable for capital and vice versa. If the RetPOS coefficient is positive and the RetNEG coefficient is negative, it can be concluded that there is a momentum return in the daily data, that is, companies that had a negative return on the previous day will have a negative return on the next day and vice versa.

In order to control the effect of each variable of financial leverage, company size, B/M and liquidity, the portfolio analysis approach is used so that all the companies in the sample are divided into 5 equal portfolios based on financial leverage, company size, B/M and liquidity. is allocated in such a way that the first portfolio (P0) contains the smallest value of the variable and the fifth portfolio (P5) contains the largest one. Then, using the Fama and McBeth model, the relationship between risk metrics and expected return in each portfolio is evaluated and tested.

Research variables: The variables of the current research are measured as follows:

1. Expected return: Expected return is the estimated return on an asset that investors expect to earn in the future. How to measure the expected return is as follows:

$$\overline{R}_{it} = Ln(\frac{P_{it}}{P_{it-1}})$$

So that, Pit and Pit-1 are the final prices adjusted for cash profit and capital increase, respectively.

2. Standard deviation: It is calculated using the daily returns of the past 100 trading days according to the following formula:

Agricultural Marketing and Commercialization Journal
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$$Stdev_{it} = (\sqrt{252})\sqrt{(\frac{1}{n-1})\sum_{t=-1}^{n}(R_{it} - \bar{R}_{.it})^2}$$

So that, n is the number of returns of the past 100 trading days, Rit is the return of company i stock on day t and $\bar{R}_{.it}$ the average returns of company i stock over the past 100 trading days.

3. Semi standard deviation: It is calculated using the daily returns of the past 100 trading days according to the following formula:

$$Semi - Dev_{it} = (\sqrt{252})\sqrt{(\frac{1}{n_B - 1})\sum_{t=-1}^{n}([Min[0, R_{it} - \bar{R}_{.it}])^2}$$

So that, n=100, nB is the number of negative returns in the last 100 trading days, Rit is the returns of company i's shares on day t and $\bar{R}_{.it}$ the average returns of company i's shares over the past 100 trading days.

4. Value at risk: It is the maximum loss that is expected to occur within a certain period of time and with a certain probability. In this research, two methods are used to measure value at risk: parametric and historical.

4.1. Parametric value at risk: In parametric value at risk (VaR) measurement, it is assumed that the distribution of returns is normal and it is defined based on the mean and standard deviation in the following relationship:

$$VaR_{it} = \bar{R}_{.it} - S_{it}Z$$

where Sit is the standard deviation of company i on day t and Z is the confidence level. For example, at the 95% confidence level, Z is 1.65.

4.2. Value at historical risk: Historical value-at-risk is one of the non-parametric measures of risk that is estimated only based on historical observations. Historical VaR is measured by assuming non-normality of return distribution. For example, if an investment tends to measure its maximum loss at the 95% confidence level, the returns of the past 100 trading days will be classified from highest to lowest. The fifth return from the end is the investor's maximum loss during the next investment period at the 95% confidence level.

4.3. HR risk: It is the maximum profit that is expected to be lost within a certain period of time and with a certain probability. Two parametric and historical criteria are used to measure HR:

1. Parametric HR: In parametric HR measurement, it is assumed that the distribution of returns is normal and it is defined based on the mean and standard deviation in the following equation:

$$HR_{it} = \bar{R}_{.it} + S_{it}Z$$

Where, Sit is the standard deviation of company i on day t and Z is the confidence level. For example, at the 95% confidence level Z is 1.65.

Historical HR: historical HR measurement is similar to historical VaR, it is only estimated based on past observations of stock returns, historical HR is measured assuming non-normality of return distribution. For example, if an investment tends to measure its maximum return at the 95% confidence level, the returns of the past 100 trading days will rank the stock from highest to lowest. The fifth return from the beginning is the maximum return of the investor during the next period of investment at the confidence level of 95%.

5. Financial leverage: It is calculated by dividing total liabilities by total total assets.
6. Company size: Company size is measured using the natural logarithm of the total market value of the company's shares.
7. Book value to market value of equity (B/M): It is calculated by dividing the book value of equity by its market value.
8. Liquidity: The illiquidity criterion of Amihud (2002) is used to calculate liquidity.
9. Momentum: RetPOS is a virtual variable that is equal to one if the previous day's return is positive and zero otherwise.
10. Inverse: RetNEG is a virtual variable that is equal to one if the previous day's return is negative and zero otherwise.

Findings

In this research, using the Fama and McBeth model, the relationship between symmetric and asymmetric measures of risk and expected return has been investigated, and the effect of variables such as financial leverage, company size, book value to market value, liquidity, momentum, and reverse on the relationship. Asymmetric risk and expected return are controlled. To provide an overview of the important characteristics of the tested variables, some descriptive statistics of these variables, including mean, median, standard deviation, background, minimum observations, skewness and kurtosis, are presented in Table (1).

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Table 1. Descriptive statistics

liquidity	Book value To Market value	Size	Lev	Hist. HR	Hist. VaR	Paramet HR	Paramet. VaR	Semi SD	SD	return	VAR / STA/IND
0/00012	0/424	12/113	0/571	3..415	3.710	5.238	5.280	48460	50.450	0.045	Mean
0/001	0/378	12/142	0/467	3.972	3.499	4.561	4.412	42.312	45.236	0.002	Med
0/001	1/552	11/314	0..202	4.970	0.870	9.220	9.450	88.333	88.333	3.69	Mod
0/000	0/073	13/171	0.880	0.670	4.720	1.434	1.645	14.200	15.987	3.12	Min
0/000	0/261	0.628	0.226	1.170	0.997	2.110	2.236	21.021	20.357	2.178	SD
3/899	1/206	0/136	0.498	0.437	0402	0.493	0.695	0.653	0.558	0.095	Elon
18/004	4/866	1/605	1.826	2.131	2.281	2.458	2.374	2.373	2.364	2.245	Crooke

*, ** and *** indicate the significance level at 90, 95 and 99 percent, respectively, and the numbers in parentheses are the t-statistics.

As can be seen, the history of expected daily returns is 3.69 and its minimum is -12.3, its mean, median and standard deviation are 0.045, 0.002, and 2.17 respectively. The value at risk (VaR) is between -1.64 and -9.45. HR risk is in the range of 1.4 and 9.22 and the standard deviation of these two variables is 2.23 and 2.11, respectively. Value at risk is -3.7 on average and HR risk is 3.41 on average. The median of these two variables is -4.4 and 4.56, respectively. In table (2), the results of the test of the relationship between risk measures and expected return using the Fama and McBeth model are presented.

In table (2) and (3), according to the t statistics of standard deviation, half standard deviation, parametric value at risk, parametric HR, historical VaR and historical HR which are equal to 2.321, 1.924, 142 respectively. 2/324, 2/112 and 4/174, there is a positive and significant relationship between the above measures and the expected return, which shows that investors are risk averse, because risk averse investors take additional risk if they acquire They accept additional returns. The adjusted coefficients of historical HR are equal to 0.010, which is higher compared to other risk measures and indicates that it has more explanatory power. In table (4), the variables of financial leverage, company size, book value to market value and liquidity were added to model (1) to control the effect of these variables on the relationship between risk measures and expected returns using the Fama and McBeth model.

Table 2. The relationship between symmetric risk measure and expected return using Fama and Macbeth model

MODEL. 6	MODEL. 5	MODEL.4	MODEL. 3	MODEL. 2	MODEL. 1	Variables
0.002 (0.047)	0/050 (1.241)	***-0.185 (-1.172)	-0/150 (-1.45)	-0.136 (1.344)	***-0.179 (-1.184)	**C (Constant)**
					**0.004 (2.321)	**S.D**

Table 3. Asymmetric risk relationship and expected return

MODEL. 6	MODEL. 5	MODEL.4	MODEL. 3	MODEL. 2	MODEL. 1	Variables
				**0.003 (1.924)		**Semi SD**
			**0.0370 (2.142)			**VaR Parametric**
		**0.044 (2.324)				**HR Parametric**
	**0.692 (2.212)					**Hist. Parametric**
*2.244 (4.174)						**HR Hist**.
0.0105	0.0013	0.0015	0.0011	0.0010	0.0014	**R(Adjusted)**

In table (4), the effect of variables of financial leverage, company size, book value to market value, liquidity on the relationship between risk metrics and expected return is examined. According to the results of table (3), the negative and significant relationship between financial leverage and company size with expected return is consistent with the results of Barber and Lyon (1997) and Fama and French (1992). Also, the positive and significant relationship between book value and market value with expected return is consistent with the results of Fama and French (1992).

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Table 4. The relationship between risk measures and expected returns based on the Fama and Macbeth model after controlling the effect of variables

Model. 12	Model. 11	Model.10	Model. 9	Model. 8	Model. 7	Variables
**–318/0 (–215/2)	–057/0 (–776/0)	***035/0 (-967/1)	–	**–210/0 (-948/1)	*–456/0 (-773/2)	**C (Constant)**
**–440/0 (-389/2)	*–57/26 (-391/9)	*–201/27 (-588/9)	***205/0 (-842/1)	*–19/27 (-588/9)	**–402/0 (-171/2)	**Leverage**
*–54/13 (-578/12)	*–68/21 (-489/16)	*–55/20 (-780/15)	*–18/27 (-581/9)	*–55/20 (-783/15)	*–95/12 (-392/12)	**Size**
*429/0 (714/2)	*385/0 (595/2)	**379/0 (541/2)	*56/20– (-770/15)	**326/0 (149/2)	**400/0 (513/2)	**Book value To Market value**
*86/789 (-857/4)	*5/673 (-313/4)	*–13/699 (-464/4)	**347/0 (309/2)	*–45/741 (-693/4)	*–1/803 (-939/4)	**Liquidity**
			*–13/718 (-575/4)		**003/0 (764/1)	**SD**
				**003/0 (002/2)		**Semi SD**
			***032/0 (825/1)			**VaR Parametric**
		***035/0 (936/1)				**HR Parametric**
	*497/1 (945/4)					**Hist. Parametric**
**729/0 (857/4)						**HR Hist**.
059/0	093/0	086/0	086/0	087/0	059/0	**R(Adjusted)**

*, ** and *** indicate significance levels at 90, 95, and 99 percent, respectively, and the numbers in parentheses are t-statistics.

Amihud's (2002) illiquidity has a negative and significant relationship with expected return, which can be concluded that there is a positive relationship between liquidity and expected return. By adding the above variables to model (1), it can be seen that the positive and significant relationship between traditional and asymmetric measures of risk and expected return remains and the t-statistics of these variables are 1.647, 2.002, 1.825, and 1.936, respectively., 4/945, 4/875. In Table (5), the effect of momentum and reversal on the relationship between risk metrics and expected return is examined.

Table 5. The relationship between risk measures and expected returns based on the Fama and Macbeth model after taking into account the momentum and reverse effects

Model.20	Model.19	Model. 18	Model. 17	Model.16	Model. 15	Model. 14	Model. 13	Variables
–047/0 (-649/0)	–050/0 (-719/0)	**–238/0 (-217/2)	**–202/0 (-966/1)	**–210/0 (-237/2)	**–228/0 (-153/2)	**–304/0 (-166/2)	**–314/0 (-189/2)	**C (Constant)**
*–519/26 (-543/9)	*–097/26 (-655/2)	*–619/26 (-599/2)	*–602/26 (-598/2)	*–617/26 (-601/2)	*–607/26 (-598/2)	**–428/0 (-374/2)	–**435/0 (-358/2)	**Leverage**
*–433/20 (-757/15)	*–937/20 (-047/3)	*–926/19 (-689/2	*–933/19 (-678/2)	*–928/19 (-690/2)	*–926/19 (-688/2)	*–55/12 (-237/12)	*–015/13 (-447/12)	**Size**
**365/0 (502/2)	*370/0 (655/2)	*363/0 (-499/3)	**331/0 (367/2)	**308/0 (155/2)	**343/0 (473/2)	*413/0 (669/2)	*429/0 (713/2)	**Book value To Market value**
*18/689–)492/4(–	*32/675–)396/3(–	*31/697–)499/3(–	*69/716–)605/3(–	*38/741–)739/3(–	*19/709–)568/3(–	*21/795–)994/4(–	*26/799–)914/4(–	**Liquidity**
*377/0)860/2(	*369/0)985/3(	*367/0)972/3(	*367/0)973/3(	*368/0)991/3(	*368/0)974/3(	*347/0)594/2(		**Momentum**
*428/0–)315/3(–	*418/0–)475/4(–	*438/0–)576/4(–	*436/0–)571/4(–	*437/0–)578/4(–	*438/0–)572/4(–	*468/0–)575/3(–		**reverse**
					**003/0 (040/2)			**SD**

Asymmetric risk and expected return

MODEL. 20	MODEL. 19	MODEL. 18	MODEL. 17	MODEL. 16	MODEL. 15	MODEL. 14	MODEL. 13	Variables
				**004/0 (324/2)				**Semi SD**
			**0325/0 (954/1)					**VaR Parametric**
		**036/0 (148/2)						**HR Parametric**
	*311/1 (889/2)							**Hist. Parametric**
**655/0 (901/1)								**HR Hist**.
125/0	129/0	125/0	126/0	127/0	125/0	098/0	058/0	**R(Adjusted)**

,** ,*and *** indicate significance levels at 90, 95, and 99 percent, respectively, and the numbers in parentheses are t-statistics.

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In table (5), model 13 shows the relationship between variables of financial leverage, company size, book value to market value, liquidity and expected return. Adjusted R2 of model (13) is equal to 0.058. With the addition of momentum and inverse in model (14), the explanatory power of the model increases. Also, with the addition of momentum and reverse variables, it can be seen that the positive relationship between risk metrics and expected return is still maintained.

In order to better understand the relationship between volatility and return, as well as neutralizing the effect of each of the variables of financial leverage, company size, book value to the market value of equity and liquidity, the companies in the sample based on each of the variables of financial leverage, company size, B/ M, liquidity is assigned to 5 equal portfolios, such that the first portfolio (P0) includes the smallest variable and the fifth portfolio (P5) includes the largest. Then, in each portfolio, the effect of momentum and reverse on the relationship between risk measures and expected return is tested.

Results and Recommendations

In this realization, we sought to test the relationship between symmetric and asymmetric risk criteria on the expected rate of return of knowledge-based companies active in the stock market based on the Fama-McBeth model. Therefore, traditional risk measures such as standard deviation and half standard deviation and asymmetric risk measures such as parametric and historical HR and parametric and historical value at risk have been used. The results show that the use of different risk measures does not cause volatility to break the rule. The positive and significant relationship between standard deviation, half standard deviation, historical and parametric exposed value, parametric and historical HR of risk with the findings of Goyal et al. Is. Also, adding control variables of financial leverage, company size, book value to the market value of equity and liquidity, and virtual variables of momentum and reverse, which have a significant relationship with expected return, do not change the positive relationship between risk measures and expected return. In addition, with the formation of portfolios based on financial leverage, company size, book value to the market value of equity and liquidity, there is a positive relationship between risk metrics and expected returns.

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