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Measurement and assessment of systematic risk of selected industries in stock exchange using wavelet approach

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Abstract

Investment is an essential factor in a country's economic development. Meanwhile, return and risk have been effective factors in investment. Today, many financial economists have accepted Risk or Beta as a standard tool for assessing the risk involved in certain actions. This paper has been conducted to find a way to obtain the risk of industries in different timescales included in the short-term and long-term. The statistical population includes a daily index of selected industries (including banks and the food, and car industries) from 2009 to 2014. The present study has measured the risk in different timescales using the wavelet analysis, and consequently, the risk time series have been expressed using a State- Space model. The direct relation between the risk of the selected industries and the market have been eventuated in which, an increase in return of the market would lead to an increase in return of industries and this has also been proven when there is a reduction in return.

JEL classification: C22, G11

Keywords: Systematic Risk, Stat Space Model, Beta Coefficient, Wavelet.

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Introduction

Allocating financial resources, efficiently and correctly, has an important role in a country's economic growth and development. Stock Exchange is a sample of economic development of every country with a key role in corporates' financing, instructing small capitals of investors in the course of production, preventing small and unexploited assets from stagnation, public revenue, etc. On the other hand, investors consider the return of investment when purchasing, selling and keeping stock. If investors are able to predict the future return rate of a considered stock and rank the mentioned return rates, it will be easy for them to decide about the investment. Hence, risk and return are effective and crucial factors that are considered by investors. Investors try to invest their financial sources in an investment process with a high return and less risk. Risk is a mental and non-quantitative concept contrary to the concept of return. Hence, most of the economic and financial experts have been concentrating on the recognition and measurement of risk.

According to the theory of portfolio, risk has been divided into two parts: the systematic risk that is related to the whole market and the non-systematic risk that is related to the specific condition of any stock. Therefore, Beta has been one of the most common and accepted tools used by financial economists and market experts in order to manage and assess risk. In spite of considerable empirical research in terms of recognition of factors and extensive use of the risk and return model, the capital asset pricing model (CAPM) has been a standard model in global analyses. In fact, investment institutes have considered the mentioned model for more than four decades after the introduction of this model. The mentioned model includes some unique capabilities. However, this model has some shortcomings.

For instance, CAPM can present a fixed amount of risk (Beta) while it is not able to measure risk in short-term (short scale) and long-term periods (general trend regardless of minor fluctuations) (Zolfaghari et al, 2012). Accordingly, this study is aimed at obtaining and investigating the risk of industries in different timescales including short-term (fluctuations in short scale) and long-term (general trend regardless of minor fluctuations). The following hypothesis has been considered in this study based on the mentioned issue:

- The systematic risk of the selected industries is different in the considered timescales, short-term and long-term.

Theoretical literature

CAPM has been considered by investment institutes for more than four decades following the introduction of this model. The mentioned model includes some unique capabilities. However, this model has some shortcomings. For instance, CAPM can present a fixed amount of risk (Beta) while it is not able to measure risk in short-term (short scale) and long-term ranges (general trend regardless of minor fluctuations). In other words, a firm might have a risk (Beta) in short-term fluctuations that are different from the general trend without short-term fluctuations (Zolfaghari et al, 2012). Accordingly, the present study has been conducted to obtain the risk of industries in different timescales including short-term (fluctuations in short scale) and long-term (general trend regardless of minor fluctuations).

In the past four decades, the fiscal discipline has improved many risk measurement theories and their use in return estimation. Two key factors in this theory are Beta or risk and CAPM. Beta is a tool to estimate the return and the CAPM is the first Equilibrium Asset Pricing Model that is related to the selection of the Mean-Variance Portfolio under uncertainty (Darabi & Saeedi, 2009). According to the CAPM, rational and risk-averse investors would tend to maximize their utilities. They would maximize their utilities through return and would measure the risk by the standard deviation of return.

The rational and risk-averse investors have the same expeditions and time horizons for investment. The capital market would assume a complete market without any cost of tax and exchange. In this market, all investors can lend and borrow without any risk rate of return (Cirter and Ozun, 2007).

Beta is assumed as an unchangeable risk of an asset toward the stock market. The required return for investment has been defined by CAPM in the following equation:

$$\mathbf{C(s,\tau)} = \int_{-\infty}^{\infty} \mathbf{f(t).\psi_{s,\tau}(t)dt} \qquad (1)$$

In this equation, $E(R_i)$ is related to the expected return of asset i, r_f is the Risk free interest rate, $E(R_m)$ is the expected return of the stock market and is the risk of asset i β_i.

CAPM is divided into two parts, the risk-free interest rate (r_f) and the

risk premium$\beta_i[E(R_m) - r_f]$. Risk premium of stock is the amount of returns an investor demands in addition to the risk-free interest rate in order to compensate the unchangeable risk of investment, and this is calculated for Beta in following equation:

$$\beta_i = \frac{Cov(R_i,R_m)}{Var(R_m)} = \frac{\sigma_{im}}{\sigma_{mm}} \quad (2)$$

The main model of a portfolio has been designed and developed by Harry Markowitz. He obtained the expected return rate and risk for a portfolio of assets for the first time. Markowitz showed that standard deviation of return rate is suitable for measuring the risk of the portfolio and specified a methodology for calculating portfolio risk under a set of logical assumptions.

Many foreign studies have been conducted regarding the mentioned issue. Black & Shools have eventuated, in a study done in 1972, that during 1931-1965 higher Beta has been correlated with higher return. Another study conducted by Fama and Mac Beth in 1973 in which, it was proven that there is a positive and direct relationship between Beta and return. In addition, the mentioned relationship has been linear while non-systematic risk has no effect on returns. Kothari, Shanken and Sloan conducted a study in 1995. They have shown that there would be a stronger relationship between Beta and return if annual returns were applied instead of monthly returns during 1927-1990. Handa et al conducted a study in 1993 in which, it has been proven that Beta would change as a coefficient of systematic risk and based on the time scale. Another study conducted by Lynch and Zumbach in 2003. They have approved the importance of a multi-scale framework in the analysis of price changes with combination of daily, monthly and annual data. The mentioned studies have shown that Beta is sensitive to time duration.

Many studies have also been conducted in Iran and some of them are mentioned in this paper. Raee and Khosravi conducted a study in 2007 in which, three criteria of undesirable risks have been assessed. They also evaluated the performance of CAPM in the specification of the behavior of capital markets based on the four types of Beta including traditional Beta and three types of undesirable Betas. According to the obtained results of mentioned study, if undesirable is an alternative to traditional Beta in specification of expected return using CAPM, the results will be different in spite of its high accuracy in specification. Samadi et al assessed the existence of a Price Bubble and efficiency in the Tehran Stock Exchange using the filter rule in 2007. Another study conducted by Mohammadi et al in 2007, estimates Beta and assessment of return durations using different specification models in

econometrics. The obtained results show that monthly returns and nonparametric regression model would help managers to estimate Beta. Hejazi and Gholamhosseini assessed the usage of CAPM in Tehran Stock Exchange in 2010. According to the obtained results from this study, CAPM would be able to specify the behavior of return in short-time sections in stock exchange. The obtained relationship between risk and return in Tehran Stock Exchange under the circumstances of using weekly data would prove the main claim of CAPM in terms of linearity of return function.

Methodology

The method of this study is applied in terms of objective and is descriptive-analytical in terms of nature. An Econometric approach and the wavelet method have been applied to model and estimate the relationship between variables.

According to conducted studies, it could be said that CAPM is considered as an important model by financial and economic researchers, mainly because it is able to specify the systematic risk in different stock exchanges in the world. However, there are some shortcomings of CAPM. For instance, this model can only present a fixed coefficient of risk for long-term that the present study has tried to resolve this problem by using State-Space model in order to present a time-series of Beta instead of one digit. Another shortcoming of CAPM is the lack of awareness regarding short-term and long-term Betas (long-term and short-term fluctuations). This paper has divided fluctuations into large and small fluctuations with different Betas using the Wavelet approach.

According to CAPM, the return rate of a portfolio is an independent variable and the return rate of asset (stock) i has been the dependent variable and the following regression equation has been estimated:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + e_{i,t} \quad (3)$$

$R_{i,t}$, is equals to return of asset i in t time, β_i is Beta of asset i, $R_{m,t}$ is return of portfolio of market in t time, $e_{i,t}$ is residual sentence in time of t and β_i is the slope of calculated regression.

Beta is an indicator of systematic risk. This indicator shows the fluctuations of the return of an asset towards fluctuations of the return of a market index.

$$\beta_i = \frac{COV(R_{m,t}, R_{i,t})}{\delta^{2}_{R_{m,t}}} = \rho_{i,m}\frac{\delta_i}{\delta_m} \quad (4)$$

The Beta coefficient can be assessed in the three following aspects:

- If Beta coefficient is equal to one, the risk of financial asset will be equal to market risk and investment will be neutral.
- If Beta coefficient is more than one, the risk of Stock or financial asset will be more than market risk and the stock will be referred to as an aggressive stock.
- If Beta coefficient is less than one, the risk of considered stock will be less than market risk and the stock referred to as a defensive stock.

Wavelet transform

Wavelet is a small wave. Wavelets are functions with limited quantities and their average quantity is equal to zero. Wavelets have various types.

Continuous wavelet transforms can be shown as sum of multiplications of original signal to scale and transfer wavelets in time.

$$\mathbf{C(s,\tau) = \int_{-\infty}^{\infty} f(t).\psi_{s,\tau}(t)dt} \quad (5)$$

In this equation, $\psi_{s,\tau}(t)$ is called the mother wavelet that is changed at scale of S and transferred in time of τ . The results of continuous wavelet transforms are wavelet coefficients of C that are functions to scale and transferred coefficients. With multiplying each of these coefficients in transferred mother wavelets, the constituent wavelets of original signal would be obtained. Using continuous wavelet transforms would lead to the large size of data due to the required integration of original signal and wavelet function in different scales and time durations. Therefore, there would be a large size of data and calculations because S is continuously changing and, in some cases, there is a Non-analytic function, which cannot be integrated. Hence, it would be better to use a discrete wavelet transform (Sadeghi & Zolfaghari, 2010). The mentioned transformation includes specific features as follows:

- Presenting required information to analyze original signal
- Reducing required calculations to a suitable amount
- Possibility of analyzing original signal in different scales.

- Analyzing original signal to some signals with not very good approximation but very good and beneficial information.

For most signals, the components of low frequency are extremely important. These components would determine the general features of the signal. On the other hand, components of high frequencies would express the small details of the signal (Conlon & Crane, 2008). The present study has applied the wavelet approach in order to obtain time series of return of industries and index of whole market based on the different time scales. Then, the State-Space model has been applied to extract time series of Betas, to expand results in time duration and to consider some unobservable factors.

State-Space Model

The State-Space model would specify a model by entering unobservable variables (state variables) into the model. This model can be specified by a recursive algorithm called the Kalman filter. The mentioned model includes two equations of state equation or transfer equation and observed equations or measurement equations. There are some considered applications of State-Space Model including the ability of predict and change parameters during a specific time, and modeling and specifying time series.

State-Space Model formulation:

Observation equation;

$$y_t = \mu_t + e_t \qquad e_t \sim (0, \sigma_e^2) \tag{6}$$

State or system equation;

$$\mu_{t+1} = \mu_t + \eta_t \qquad \eta_t \sim (0, \sigma_\eta^2) \tag{7}$$

Observation equation and state or system equation for CAPM:

$$R_{it} - R_{ft} = \alpha_i + \beta_{imt}(R_{mt} - R_{ft}) + \omega_t \tag{8}$$

$$\beta_{imt} = \beta_{imt-1} + \varepsilon_t$$

Statistical population of this study includes the daily index of three selected industries, including banks and the food and car industries, from 2009 to 2015. Data of the present study have been extracted from articles, books and theses using survey methods and required statistics (daily indices of three industries) for specifying the model have been extracted from the website of Tehran Stock Exchange. In addition to daily indices of the three selected

industries, the total return index of market has been extracted from the Tehran Stock Exchange's website. The mentioned data have been tested through unit root test to determine stationary. The obtained results have shown stationary data. It should be mentioned that total return index of market has obeyed normal distribution.

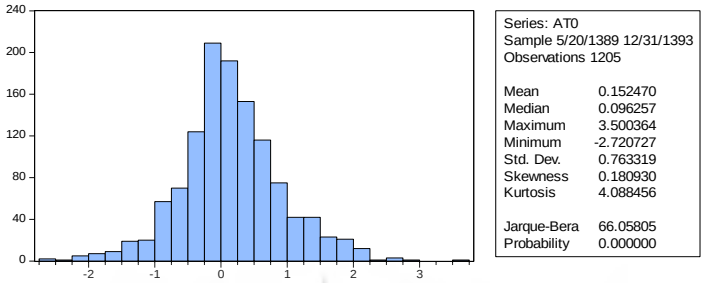

Figure 1. Normal distribution of total return index of Tehran Stock Market

This paper has specified the model and estimated the Beta coefficient after assessing the trends of the three studied indices. The return indices of the selected industries and the general trend of the return index have been filtered in five levels using the wavelet transformation. The mentioned steps have been conducted towards total index. Then, the time series of risks (Betas) of the industries have been extracted and modeled using a State-Space and based on short-term and long-term fluctuation.

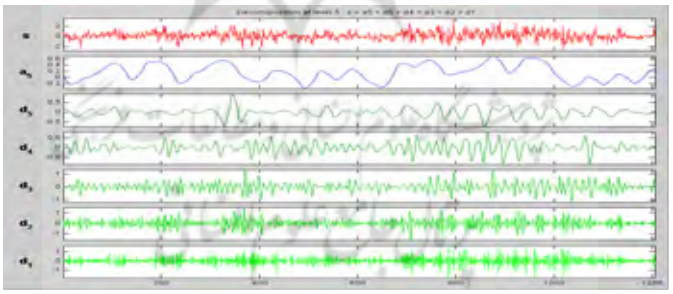

Figure 2. Original and filtered quantities of total return index of Tehran Stock Exchange for 2009-2014

According to figure 2, the S series is related to the real and raw returns of time series of total index of Stock Exchange for 2009-2014. In this figure, d1 is related to very small fluctuations; d2 is related to small fluctuations of time series that are bigger than d1. d3 is expressing medium small fluctuations of time series that are bigger than d2, d4 is related to medium fluctuations of time series that are bigger than d3. d5 is related to medium large fluctuations of time

series that are bigger than d4. Series of a5 is related to the large and long-term fluctuations of time series that are bigger than d5. In fact, the last series of a5 is filtered from fluctuations of d1-d5. This series is related to general trend of total return index of stock exchange. Accordingly, the scale of fluctuations would be increase from d1 to a5 and this scale is moving from short-term to long-term.

In this step, the mentioned method has been applied to extract return time series of three industries. After filtering and extracting series in different scales, the second step is related to the extracting the Beats of different industries matched with total return index of stock exchange in different time scales. The following results have been obtained from the mentioned process conducted in three mentioned industries.

Food industry

Table 1. Extracted coefficients from State-Space Model for food industry

Food industry	Coefficient of total index & Prob	State coefficient SV & Prob
Original series	-6.436030 0.0000	0.544273 0.0000
D1	-0.328596 0,0000	0,438879 0,0000
D2	-0,948787 0,0000	0,390916 0,0000
D3	-1,246735 0,0000	0,507318 0,0000
D4	-1,963790 0,0000	0,350831 0,0000
D5	-2,046758 0,0000	1.034448 0,0000
A5	-1,903151 0,0000	0,969425 0,0000

According to table 1 (Coefficients and Prob<0/05), it could be found that the return index of the food industry is affected by the total index of the market during all time scales. According to the obtained coefficient of SV and Prob<0/05, the existence of state changes between Betas has been be proven.

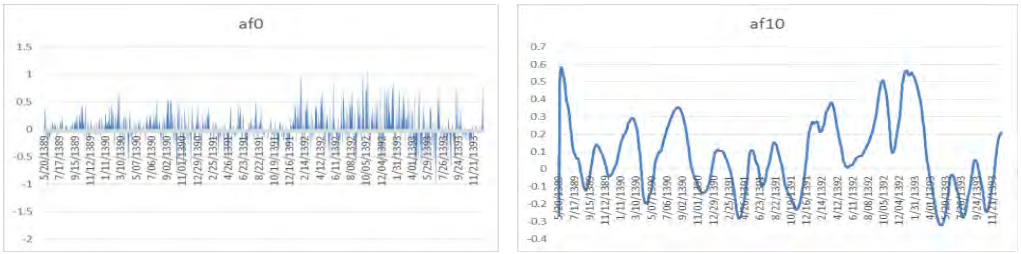

Figure 3. original series and long-term series of Beta of food industry

According to figure3, Beta's time series of the food industry have been less than one in original and long-term time series. Hence, the stock of food industry has been defensive stock towards the occurred fluctuations in market and total index of stock exchange. According to the original series of the food industry's Betas, this stock has been aggressive in 2013 (1392) due to the increase in index of this industry and omission of subsidies of food items. The risk of stock of food industry has been more than total risk based on the mentioned reasons in 2013.

Banks

Table 2. Extracted coefficients from State-Space Model for banks

banks	Coefficient of total index & Prob	State coefficient SV & Prob
Original series	-۲ ۰۱۲۵۳۴ 0.0000	۰ ۱۱۹۹۹۴ 0.0000
D1	۰ ۶۹۹۷۱۶ 0,0000	۰ ۲۴۹۴۳۳ ۰ ۰۱۴۳
D2	-۰ ۵۷۳۵۱۵ 0,0000	-۰ ۱۸۰۴۸۹ ۰ ۰۰۱۱
D3	۰ ۶۱۶۱۵۸ 0,0000	-۰ ۲۲۸۲۲۶ ۰ ۰۶۷۲
D4	-۰ ۶۱۰۸۸۳ 0,0000	۰ ۳۲۴۲۸۱ ۰ ۰۰۰۳
D5	-۲ ۰۱۲۶۳۸ 0,0000	۰ ۲۴۹۷۴۲ 0,0000
A5	-۰ ۹۰۶۸۱۱ 0,0000	۰ ۶۶۱۷۰۳ 0,0000

According to table 2 (Coefficients and Prob<0/05), the return index of banks are affected by the total index of the market during all time scales. According to the obtained coefficient of SV and Prob<0/05, the existence of state changes between the Betas has been be proven except d3.

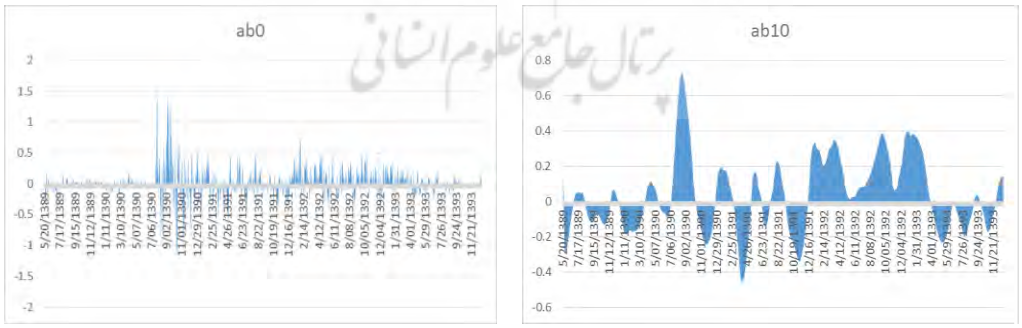

Figure 4. original series and long-term series of Beta of banks

According to figure3, the time series of the banks' Betas have been less than one in original and long-term time series except some cases. Hence, the banks' stocks have been a defensive stock towards the occurred fluctuations in market and total index of stock exchange. According to the time series of beta of banks, it could be found that systematic risk of banks would be less from short-term to long-term.

Car industry

Table 3. Extracted coefficients from State-Space Model for car industry

Car industry	Coefficient of total index & Prob	State coefficient SV & Prob
Original series	۰ ۸۲۴۰۵۹ 0.0000	۱ ۱۲۰۱۸۱ 0.0000
D1	-۰ ۲۵۵۲۳۶ 0,0000	۰ ۹۶۷۴۰۸ 0,0000
D2	-۰ ۴۱۰۲۲۵ 0,0000	۱ ۱۹۰۲۸۲ 0,0000
D3	-۰ ۸۱۴۹۶۲ 0,0000	۱ ۰۵۴۷۴۰ 0,0000
D4	-۱ ۷۴۳۴۷۰ 0,0000	۱ ۳۸۱۸۵۸ 0,0000
D5	-۲ ۲۱۱۹۹۷ 0,0000	۱ ۱۴۹۵۱۱ 0,0000
A5	-۲ ۲۱۰۵۱۱ 0,0000	۱ ۱۴۹۸۲۳ 0,0000

According to table 3 (Coefficients and Prob<0/05), the return index of the car industry is affected by total index of market during all time scales. According to the obtained coefficient of SV and Prob<0/05, the existence of state changes between Betas has been be accepted.

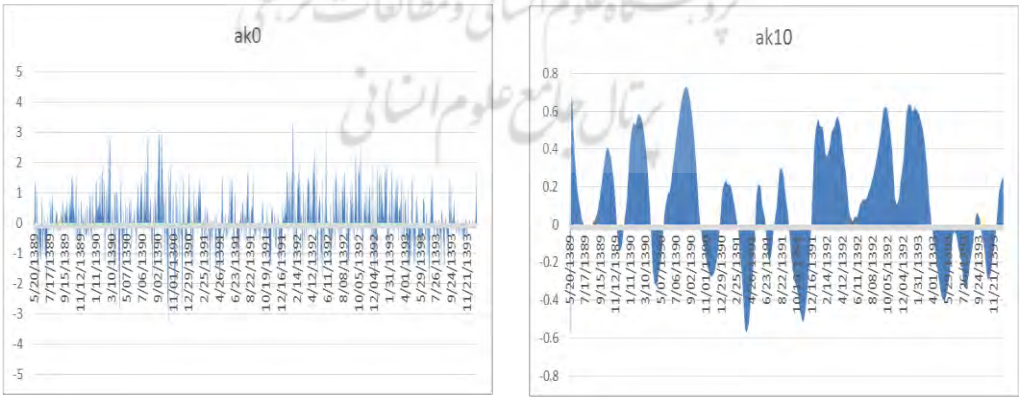

Figure 5. Original series and long-term series of Beta of car industry

According to figure4, the time series of the car industry's Betas are more than one in original and long-term time series. Hence, the stock of banks has been an aggressive stock towards the occurred fluctuations in the market and the total index of stock exchange. According to the long-term time series the car industry's Betas, the systematic risk of the industry would be less in long-term.

According to the obtained results of study, systematic risks in different time scales (short-term and long-term) would be different. Therefore, the hypothesis of study is accepted.

Conclusion

As the study shows, investment is essential for economic growth and development hence; financial assets are crucial to make a profitable investment possible. The best source for investment is the people's saved capital. Financial managers should consider financial sources, risk and return of firm, and their impact on the risk and return of common stock of firm in stock exchange. Risk and return are two key factors considered by financial experts.

The present study has been conducted to extract betas (systematic risks) of selected industries in Stock Exchange using non-linear methods in different time scales. This paper has assessed short-term and long-term Betas in order to obtain the best interpretation of systematic risk.

According to the extracted tables from State-Space model, it could be observed that all impact coefficients have been significant. Therefore, there has been a direct relationship between the risk of the selected industries and the market risk. In other words, the return of the selected industries will increase if there is an increase in market return. The mentioned relationship would also occur in terms of decrease in returns. Beta coefficients of the industries have been less than one in long-term; therefore the systematic risks of industries is less than market risk on long-term. In other words, the return of stocks of selected industries will increase less than the increase in market return. The mentioned relationship would also occur in terms of a decrease. Finally, it is suggested that investors invest in banks if they are risk averse and invest in car industries if they are risk takers.

According to the obtained results of this study, the following suggestions are proposed:

- Using the other non-linear methods such as neural network and fuzzy logic to measure systematic risk.
- Assessment and comparison of internal and external stock exchanges.
- Simultaneous measurement of systematic and non-systematic risks of industries.

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