The Impact of P/E Ratio and Price Return on the Stock Market Bohmian Quantum Potential Approach

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ABSTRACT

Price return and P/E are two important factors for a lot of investors based on the latest studies by researchers in Tehran Stock market; however, it is expected that the price and the variation of that affect the return and the P/E of any given market as a complicated system. The Bohmian quantum mechanics used referring to the time correlation of return and P/E of the stock market under consideration. In this study, we extend the quantum potential concept to determine the behavior of P/E and also price return. The obtained results show that the quantum potential behaves in the same manner for P/E and price return, also confines the variations of the P/E and price return into a specific domain. Furthermore, a joint quantum potential as a function of return and P/E is derived by the probability distribution function (PDF) constructed by the real data of a given market. It serves as a suitable instrument to investigate the relationship between these variables. The resultant PDF and the corresponding joint quantum potential illustrate that where we have light points in joint quantum potential chart, the probability of those amount of P/E and price return are more than other point.

Keywords:

Joint quantum potential. Price return. P/E ratio. Bohmian quantum mechanics.

1. Introduction

Predicting the trend and the variation of P/E ratio and stock return has attracted the attention of many finance and economics researchers. nowadays evidence shows that some stock market studies have focused on stock price and its behavior over the time. However, due to the variability and non-stationary trend of stock price, most researchers mainly focus on stock return, defined as the logarithm of the relative change of price rather than stock price (Cambel et al.,1993).

There are several reasons for the importance of discussing the relationship between P/E ratio and stock return as follows. First, the existing models in the financial that

or raw price return. When the P/E of a stock market is concerned, different definitions are proposed by the relevant literature, including the earning of per share in each day and daily price return as well and the turnover ratio (Lo and Wang, 2000).

use a combination of P/E ratio and stock return data, it is important to know how these two are interrelated. Third, the mechanism and modality of determining P/E ratio and return have important implications for future market (Todorova et al., 2014).

markets can predict the P/E and price return trend in the market .Thus, exploring the amount of P/E ratio and stock return may help distinguish and decide between different hypotheses proposed about the market structure. Second, for those studies

studies; where the price changes have a considerable impact on the P/E ratio of futures contracts or not.

2. Literature Review

The correlation between P/E ratio and price return and predicting these variables by bohemian quantum potential model has been never studied and discussed by any authors, but there are different studies using above equation for analyzing other variables in stock markets. For example, conducting an empirical study and using the data from the New York Stock Exchange was found that daily price changes has no relation with trading volume for both in absolute terms (Ward and Volkmer, 2019).

Uusing OLS and GARCH models was concluded that there exists no casual relation between volume and return for the Egyptian market (Habib, 2011).

Mantegna and Stanley gained new ideas about financial markets behavior by implementing statistical and physical methods (Mantegna, 2000). The chaos theory was applied to study the dynamics of a financial system by Chakraborti and his associates (Chakraborti et al., 2011) and Chen (Chen, 2014). Moreover, Baaquie studied the basic concepts of economics based on the statistical mechanics (Baaquie, 2013). Other study by using classical potential and Hamiltonian dynamics obtained option pricing (Baaquie et al., 2014).

During the last years, the correlation between the stock markets and their corresponding variables has increased to be inevitably tangled. This behavior of the financial assets has pushed researchers to use the quantum potential model taken from Bohmian quantum mechanics. employed the principles of quantum mechanics to describe the stochastic processes inherent in the financial markets. Similarly, Choustova employed Bohmian quantum mechanics as a theoretical framework to implement a model for describing the dynamics of the financial systems (Choustova, 2008).

Tahmasebi et al. (2015), did an empirical study that implemented Bohmian quantum mechanics in financial markets that presented the entanglement between today’s and yesterday’s prices of stock markets implies the existence of quantum potential which limits the price return changes into a specific domain (Tahmasebi et al., 2015). Shen and Haven (2017), followed the same method by employed both classical and quantum potentials and finalized that, in addition to stock markets, there create potential walls for commodity markets as well (Shen et al., 2017). The same technique to study the collective behavior of some targeted emerging and developed markets was used by Nasiri et al. (2018). Using the empirical data of the market indices, they expressed that the quantum potential walls limit the variations of the price return into a definite interval where the distance between the walls can be a representative for the risk of the respective stock index.

In this study, we follow the logic adopted by Tahmasebi et al. (2015) also Shen and Haven (2017), by using the data extracted from top 10 Tehran stock market companies, from April. of 2008 to March. of 2019, to investigate the collective behavior of joint P/E ratio and price return.

Focusing on pricing of options, using the formalization of random walk to obtain an appropriate differential equation was studied for the probability function of price changing. This innovative statistical approach recognizes as the starting point for alternative models such as the Mandelbrot hypothesis and the Black and Scholes (Black et al., 1973). Furthermore, using the chaos theory to analyze the state of a financial system was studied by Chakraborti et al. (2009) and after that by Chen (2014). In these days, due to the strong correlations and subsequent entanglement of the markets, quantum mechanics can be applied as a suitable toolkit for studying the evolution of these entangled systems. A pioneer researcher in this area, was applied Quantum Mechanics into modeling some financial systems (Khrennikov, 1999). In a series of papers, were introduced a mathematical modeling based on Classical and Quantum Mechanics to investigate the dynamics of the financial systems by Choustova (2004), Choustova (2009), Choustova (2002). They argued that the real financial conditions are include of hard as well as soft components. The previous ingredient may be governed by the classical Hamiltonian mechanics, while the recent is described by Bohmian quantum mechanics.

Using empirical data, was employed the quantum potential method to describe the mechanism of the fluctuations of price returns by Tahmasebi et al. (2015). They found that creation the vertical potential walls could be responsible for this issue through the time entanglement of the price return. In addition, their findings expressed that the probability distribution function of the price return of the markets obeys a power law behavior indicating a scale invariance of the price return, which, helps us to get information about the behavior of the emerging and mature markets. Very recently, the classical as well as the quantum potential function, was estimated by Shen and Haven (2017) Using the empirical data for the commodity markets. They could confirm the creation of the potential walls and the scaling behavior of the return variations. According to different information contents of Risk Information of Stock Market Using Quantum Potential Constraints and the classical quantum potentials, which show the hard and soft market conditions respectively, they pointed out the correlation between these two potentials. Osborne modeled the stock price trend using an issuance process and showed theoretically that the volume could affect the price variance.

3. Methodology

In this step, we try to describe how Bohmian quantum mechanics helps us to understand the impact of different variables in the stock market. It is obvious that modeling a real stock market as a complex system, may not be performed by considering only a single variable of price return or P/E ratio. In addition, the existing evidence shows that different factors have their impacts on the behavior of the (PDF) (Black and Scholes, 1973). Given this, one may like to generalize the method adopted by Nasiri et al. (2018) to a system of more than one variable.

Two central equations of Bohmian quantum mechanics showing the impacts of the n dimensional systems are as follows:

$$(1)\ \frac{\partial R^2}{\partial t}+\frac{1}{m}\sum_{i=1}^{n}\frac{\partial}{\partial qi}\left(R^2\frac{\partial S}{\partial q_i}\right)=0$$

$$(2)\ \frac{\partial S}{\partial t}+\frac{1}{2m}\sum_{i=1}^{n}\left(\frac{\partial S}{\partial qi}\right)^2+\left(v-\frac{\hbar^2}{2mR}\sum_{i=1}^{n}\frac{\partial^2 R}{\partial {q_i}^2}\right)=0$$

Which are gained by inserting the time dependent wave function of n-independent variables$(q_1.q_2.\dots q_n.)$, i.e., $\psi(q_1.q_2.\dots q_n.t)$ = $R(q_1.q_2.\dots q_n.t)$ exp (i$\frac{S(q_1.q_2.\dots q_n.t)}{\partial t}$), in the Schrodinger equation$i\hbar\frac{\partial\psi(q_1.q_2.\dots q_n.t)}{\partial t}=-\frac{\hbar^2}{2m}\sum_{i=1}^{n}\frac{\partial^2\psi(q_1.q_2.\dots q_n.t)}{\partial q_i^2}+V(q_1.q_2.\dots q_n)\psi(q_1.q_2.\dots q_n.t)$.

$R(q_1.q_2.\dots q_n.t)$ and $S(q_1.q_2.\dots q_n.t)$ are the amplitude and the phase of the wave function, and $\hbar$,q_i and m are the Planck constant, the ith component of the position, and the mass of the particle, respectively (for more details see the [35] reference below). In Eq. (2) in addition to the classical potential, $V(q_1.q_2.\dots q_n)$, there is another potential:

3) $U(q_1.q_2.\dots q_n.t)=\frac{\hbar^2}{2mr}\sum_{i=1}^{n}\frac{\partial^2 R(q_1.q_2.\dots q_n.t)}{\partial q_i^2}=\sum_{i}^{n}U_i(q_1.q_2.\dots q_n.t)$.

Which is recognized as the quantum potential for an n-dimensional system. Note that, if R in Eq. (3) is a separate function of n-independent variables, the corresponding quantum potential reduces to the sum of n one-dimensional quantum potentials. In this special case, as is shown in Fig. 1,2, the domains of the variables are fixed and confined by the corresponding separable quantum potentials. However, as will be shown later, at least in our data this is not the case and the evidence does not always allow for the separation of the variable technique to solve the problem. This means that R, in general, is not a separable function of n-independent variables$(q_1.q_2.\dots q_n)$.Nevertheless,one may still express the total quantum potential as the summation of n quantum potentialsU_i,i = 1,2,...,n as a function of $(q_1.q_2.\dots q_n)$ family, governing q_i coupled with the remaining dependent group of variables of the family. Even, one may consider various cases intermediating the above extreme limits, where the group of n variables could be divided into independent subgroups of dependent variables. Corresponding to each independent variable in a given subgroup, one may define a quantum potential of partially coupled dependent variables. The selection of the best kernel function and bandwidth will enhance the results. However, considering the complexity of such a selection, we do not test all of the possible functions, but simply use the Gaussian density as the kernel function. were calculated and we pointed out that the quantum potential causes restrictions in amplitude changes with respect to the time scales of the data, which is consistent with the results from other researchers (Tahmasebi et al., 2015). we emphasized that the quantum potential can be a measure of the amplitude changes for return (Tahmasebi et al., 2015). Therefore, there should be a very close link between the quantum potential and the volatility (that is, the financial risk) and we will discuss this further in the following part. In detail, it can be seen that the distance between the quantum potential walls shows that the risk of those stocks with shorter distance are less than others. On the other hand, different companies may face different situations due to their economic conditions and the globalization of economic activities, such as industrial services. Therefore, the different distances between the potential walls, which are also a kind of measure of the amplitude variations of the price returns may not be completely explained by those "hard" economic conditions. In fact, the real financial market may be considered a complex cognitive system, which includes conditions regarding the behavior of traders. In the quantum-like model, Choustova (2004) described such conditions as "soft" or mental market conditions, which are included in the quantum potentials (Choustova, 2008).

We realized that we would have less risk when bound of volatility is smaller and then the amplitude of the quantum potential reduces, on the contrary increasing in bound of volatility and expand the distance between the two potential walls will cause increasing in risk of stocks.

4. Results

As we mentioned in the previous section, the practical behavior of real markets, recognized as the complicated dynamical systems, is expected to be affected by several variables. In other words, examining the evolution and outcomes of a market by a single variable model, may be an unreasonable/unreal approach to the problem and far from the reality. To answer the questions 'why the price return and/or the P/E variations have never been experienced', 'What the joint PDF of these variables is' and 'whether these variables are inherently independent', one needs to have information about the functional behavior of the PDF in its general form.

let us first consider the case of markets with a PDF as a function of a single variable, i.e., either the price return r, represented by R(r) obtained through integrating on all variables and the time except r, or the P/E, represented by R(P/E) obtained through integrating on all variables and the time except P/E. In Fig. 1, R(r) for all possible values of returns during a time interval of April. 2008 to march. 2019 is plotted for the top 10 Tehran exchange companies market. It seems that R(r) of the Market is more localized and peaked around the zero return values in Fig. 1(red chart as our PDF), We extracted density function for daily returns of stocks by applying the kernel density estimation (KDE), the extracted density distribution by the KDE method is a fat-tailed distribution with a lot of finance research on the time series in stock market.

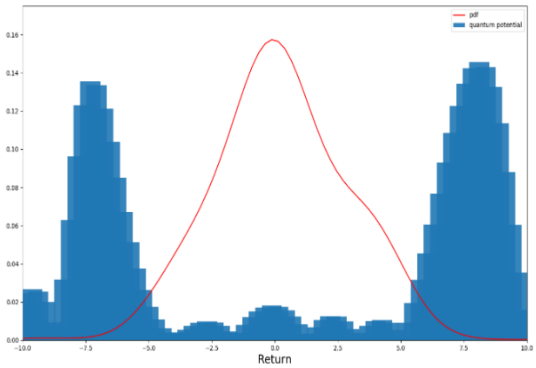

Fig.1.The plot of the PDF and quantum potential for price returns from April. of 2008 to April. of 2019 for Tehran exchange market.

See Fig.1 and its caption, the quantum potentials of return are illustrated in respectively Figs. 1 with h and m being equal to 1.

We observe that there are a pair of potential walls which prevent the returns from deviating too far away from the mean values.

For the return variable, it can change within the range from the value around −5 and +5, and breaking these walls is so hard and the resistances which we can see in potential wells are maximum in these points.

but it is possible by some events such as presenting financial statement for a fiscal year and having net income in it or announce that the company wants to pay profit to shareholders and… so, companies can cross from that.

For example, we saw that we had a big decrease in price of stocks and therefore the return after announcing that the company do not increase the capital so far.

We have some peaks in -2.5 ، +2.5 and +4 as return but cutting these walls are more possible.

We point out that the quantum potential causes restrictions for amplitude changes with respect to time scales of data. Therefore, we can say that those companies which have longer amplitude between their potential walls have higher risk than those companies with shorter amplitude, because different return amount in those companies are more possible.

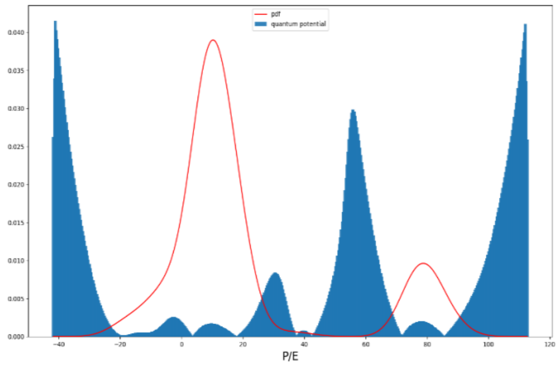

Fig. 2. The plot of the PDF and quantum potential for P/E from April. of 2008 to April. of 2019 for Tehran exchange market

See Fig.2 and its caption, there exists a threshold value of P/E in around -20 and + 20 also in 40 and 85 amount as P/E. In other words, the market will crash below the threshold volume.

We extracted density function for daily P/E of stocks by applying the kernel density estimation (KDE), the extracted density distribution by the KDE method which is consistent with a lot of finance research on the time series in stock market.

The quantum potentials of P/E are illustrated in respectively Figs. 2 with h and m being equal to 1.

We observe that there are a pair of potential walls which prevent the P/E from deviating too far away from -20 and 85 values.

For the P/E variable, it can change within the range from the value around -20 to +20 also in 40 and 85 P/E we have potential walls, the walls in -20 and +85 are stronger than other walls.

breaking these walls is so hard but it is possible and needs some different events. For example, we saw that we had a big decrease in P/E of stocks whenever the companies announcing loss in their annual reports and also they have a big increasing in their P/E after announcing that they want to pay profit of their shares.

In addition, we saw that after stopping trading shares of companies they have decreasing in their P/Because when the Market start to trade again the prices are less than usual.

All in all, these variations are short term and after few days' companies returns or P/E back to normal.

We think that we should pay attention to this trend and pattern, so try to buy or sell in these picks or try to buy the shares of some companies which have less risk by comparing the amplitude of their potential walls.

See Fig.3 and its caption, the trace of intersections of a plane perpendicular to the vertical axis for different values of the PDF is shown in (r,v) plane to obtain is probability contours. According to Figs. 3, it is obvious that the absolute value of price return and the P/E doesn't have any interaction with each other and no one cause any changing on another one.

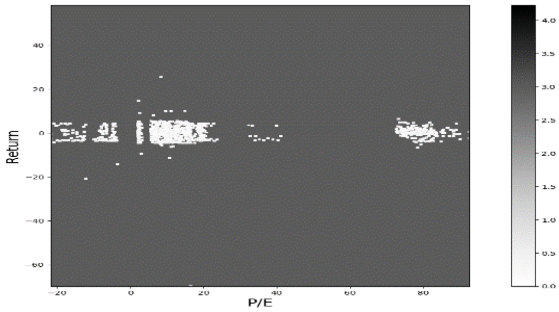

Fig. 3. The joint PDF from April. of 2008 to March. of 2019 for Tehran exchange market.

An interesting finding in Figs. 3, is that r and P/E behave as two independent variables. If they were, the traces shown in these figures would have rectangular shapes rather than irregular ones as it is. In other words, the two-dimensional PDF surface would become the surface of a pyramid with rectangular cross section. The independence of r and P/E means that the P/E has not any impact on price return and vice versa.
We can see some light points in fig.3 which show the points that we have more probable amount of price return and P/E ratio.

5. Discussion and Conclusions

It is obvious that the exact modeling for evolution of a market, being considered as an extremely complicated dynamical system, could not be solely determined by some of variables. A lot of soft (behavioral and psychological) and hard (economical) factors are present and have their own impact on the markets returns. The mentioned express is the main reason for generalizing the methodology as adopted by Ohwadua et al. (2018) for those multi-variable system. However, researchers should not disappoint from trying to model the issue by a simplistic as well as scientific point of view. Based on the fact that such modeling, with presumably maximum number of simplifications, does not consider all relevant ingredients, but can still detect the essential identity of the real problem without worrying about its full complexity. As we mentioned before, some authors have investigated the effect of the price return together with the trading volume, most of the researchers have assumed the price return as a single variable describing the evolution of the markets which have been amassed in the Econophysics literature.

In this paper, the behavior of price return in the presence of P/E is investigated. The approach is an extension of the method used in another study by Nasiri et al. (2018) who were applied by two other prior studies (Tahmasebi et al.2015) The present results, based on what were previously reported for price return (Dayaga and Trinidad, 2019), showed that there exists a quantum potential controlling the dynamics of the real market P/E which confines its variations into a certain domain walls.

In addition, the joint probability distribution of return and P/E introduced here shows that these two variables are not independent from each other but have their own mutual impacts. Due to the localized nature of the probability distribution function around the lower returns, further evidence can be provided by the probability contours.

Another important finding express that behind the observed behavior of the joint probability distribution function and the corresponding is probability contours, there exists a joint quantum potential due to the correlation between a price and a P/E and their prior-day price and P/E, respectively. Therefore, one answer to the question of 'why it is not possible to have higher absolute returns in higher P/E' can be the constraints embedded in such a joint quantum potential function. In fact, the credibility could be interpreted and understood better in terms of the joint quantum potential which governs the variations of price return and P/E together.

As explained in Section 2, with the use of the quantum potential method in studying different markets, one may distinguish between four distinct clauses. The first clause deals with representing the markets by means of the quantum potential as a function of single independent variable, ignoring the impact of all other possible variables. In this clause, the interval of variations of the variable is fixed and confined by the corresponding quantum potential. This method has been adopted and discussed for instance by Chen (2015), Shen and Haven (2017) and very recently by Lee Reimond (2019) expressing that the quantum potential is a function of price return as a single variable with a fixed variation interval. In the second clause, that is mentioned here, the markets are represented by the quantum potential as a function of two joint variables leading to a bidirectional causality relation between return and P/E ratio. Thirdly, the quantum potential of the markets is taken as a function of more than two variables without any subgroup structures and is expressed to govern the fluctuations of each variable through the impact of all remaining groups of variables. Finally, the quantum potential is again taken as a function of more than two variables; however, in contrast to the former case, here the variables could be categorized into different subgroup. In this clause, the quantum potential, which obtained, could shed light on deeper layers of the corresponding markets.

Further, in this study we considered an individual market as an isolated dynamical system without thinking of other existing markets.

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