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Research Paper

The Improved Semi-Parametric Markov Switching Models for Predicting Stocks Prices

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ABSTRACT

The modeling of strategies for buying and selling in Stock Market Investment have been the object of numerous advances and uses in economic studies, both theoretically and empirically. One of the popular models in economic studies is applying the Semi-parametric Markov Switching models for forecasting the time series observations based on stock prices. The Semi-parametric Markov Switching models for these models are a class of popular methods that have been used extensively by researchers to increase the accuracy of fitting processes. The main part of these models is based on kernel and core functions. Despite of existence of many kernel and core functions that are capable in applications for forecasting the stock prices, there is a widely use of Gaussian kernel and exponential core function in these models. But there is a question if other types of kernel and core functions can be used in these models. This paper tries to introduce the other kernel and core functions can be offered for good fitting of the financial data. We first test three popular kernel and four core functions to find the best one and then offer the new strategy of buying and selling stocks by the best selection on these functions for real data.

1 Introduction

The index of the stock exchange and its subsets in the financial markets, as one of the most important benchmarks of the movement of stock prices of stock companies, is of particular importance. The Stock Exchange Index is derived from the stock price movements of all companies in the market, and thus enables the analysis of the price movement in the stock market. Understanding and examining the behavior of this index and its subsidiaries has always been the focus of researchers, economists and capital market activists since the formation of capital markets. Nowadays, there is a lot of research on stock indexes in financial markets of different countries to scientifically model the movement of stock price information. In addition, accurate forecasting of the stock price trends of companies in the form of

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modeling that is relevant to the overall index process and its subsidiaries is very important in providing useful trading strategies.

Predicting stock prices is one of the most complex issues because the stock market is essentially non-linear and influenced by probabilistic issues. In addition, the stock market is affected by a variety of factors including political and social crises, economic performance, investor behavior, global prices and more. Following the efforts of economic and statistical scientists, new methods have been developed to predict prices in the stock market. Nowadays, nonlinear models of Markov switching, as well as non-parametric and semi-parametric estimation methods, are among these methods. Recent research into the prediction of stock price trends suggests that these models outperform traditional methods such as the ARIMA, GARCH, and Regression models. (See Nademi and Nademi [16], Chang et al. [4], Von Ganske [22], Billio et al. [2], Doaei et al. [11], Davoodi et al. [8], Aghaeefaret al. [1]).

The many investigations in economic and financial mathematics focused on what makes an investor profitable in the stock market. These studies can aid the researchers to decrease the investment risks and increase opportunities for high return of gaining. One of the important questions in the stock market is when the investors can buy the stocks and when they can sell their stocks. In research economic papers, there are two aspects of analysis: fundamental and technical analysis. In fundamental aspects, the researchers find the reasons of changing stock prices, in response to reasons of changing prices that caused from exogenous geopolitical events, supply disruptions or financial operation of the companies and etc. But technical analysis noted more the statistical and probabilities rules governed by processes of the data. In aspect of technical analysis, there are a lot of models in time series to capture the stock prices.

The Semi-parametric Markov switching models are the popular models in time series that are applied most widely in financial and economic data. These models exhibit abrupt changes in behavior of time series data, called switches of regimes, where the switching between the regimes is controlled by a hidden Markov Chain process. In semi-parametric class of algorithms, a special function, called kernel function and core functions, are used. The selection of proper kernel and core function is important item for estimating the parameters. Such that, if we apply the proper types, we can have a fast and unbiased estimating process. So, offering the best kernel and core functions for estimation algorithms can be essential for modelling process. In this paper, we first focus on selecting the best kernel and core functions in a special class of Markov switching models called semi-parametric Markov switching offered by Nademi and Farnoosh [15] for modeling the time series data and then offer the new strategy of buying and selling stocks by the best selected kernel and core function of this model on real data.

In the next section, the theoretical fundamentals and research background of this field will be introduced. Section 3 discuss on the offered kernel and core functions. Finally, section 4 probe the best selection of these functions and offer the new buying and selling strategy for stock markets.

2 Theoretical Fundamentals and Research Background

2.1 Research Background

The forecasting and offering strategies of stock buying and selling has been the object of plentiful expansions and applications over the past two decades, both theoretically and empirically. There are several attempts in this field. Pourzamani et al. [19] Compared stock buying and selling strategies in long-term investment using filtering, buying and holding methods and the moving average of the market. They showed the moving average of the market and the return of the buying and holding method is higher than the moving average method. Rastegar and Dastpak [20] offered a model entitled" Developing a High-Frequency Trading system with Dynamic Portfolio Management using Reinforcement Learning in Iran Stock Market". Results showed that, the proposed model outperformed the Buy and Hold strategy in Normal and Descending markets. Davallou and Meskinimood [7] examinated of trading strategy based on Stochastic Dominance. They showed the pricing of the random dominance factor in the Tehran Stock Exchange is approved. Sharif-far et al. [21] applied the assessment of the optimal Deep Learning Algorithm on Stock Price Prediction (Long Short-Term Memory Approach). The results showed better performance of LSTM architecture with Drop Out layer than RNN model. Pashaei and Dehkharghani [18] examined stock market modeling using Artificial Neural Network and compared with classical linear models

In the other hand, the most widely applied type of models is AR-ARCH models. The combination of autoregressive (AR) processes and autoregressive conditionally heteroscedastic (ARCH) processes, the so-called AR-ARCH process, are well created and very general models.

These findings clearly show a potential source of unknown structure, to explain that the form of the variance is relatively inflexible and held fixed throughout the entire sample period. Hence the estimates of an AR-ARCH model may suffer from a substantial bias in the persistence parameter. So, models in which the parameters are allowed to change over time may be more feasible for modeling processes. Recently, The Markov Switching models have repeatedly applied for making switching regimes processes which allow for more flexibility in modeling data which only show locally a homogeneous behavior. The Markov Switching models are the popular models in time series that are applied most widely in financial and economic data. These models exhibit abrupt changes in behavior of time series data, called switches of regimes, where the switching between the regimes is controlled by a hidden Markov Chain process. (See Chang et al. [4], Von Ganske [22], Billio et al. [2], Di Persio and Frigo [9-10], Neale et al. [17]).

Recently, Semi-parametric Markov switching models have repeatedly applied for making switching regimes processes and every of them offer an algorithm for estimating the parameters. In this respect, the combination of parametric and nonparametric methods, called semi-parametric algorithms, are popular and most broadly applied. (See Chan and Wang [3], Chang et al. [5], Chen et al. [6], Gupta et al. [14], Gu and Balasubramanian [13], Nademi and Farnoosh [15]). In the next subsection, the theory of these models will be explained.

2.2 Theoretical Fundamentals

This section consists of two subsections. In the first subsection, we introduce the Markov switching model introduced by Nademi and Farnoosh [15] and in the second subsection, their algorithm for estimating the parameters will be reviewed. Note that, their semi-parametric algorithm is a part of more general algorithm as EM algorithm that apply for class of Markov switching models.

2.2.1. The Model

Suppose $Y_1, \dots, Y_N$ are part of a strictly stationary time series that are generated by the following semi-parametric switching model

$$Y_t = \sum_{k=1}^{M} Z_{tk}\big(\mu(Y_{t-1}, Y_{t-2}; \rho_k) + \sigma(Y_{t-1}, Y_{t-2}; \omega_k, \alpha_k, \beta_k) u_{t,k}\big), \tag{1}$$

such that,

$$\mu(Y_{t-1}, Y_{t-2}; \theta_k, \rho_k) = g(Y_{t-1}, \theta_k)\xi_k(Y_{t-1}) + \rho_k\big(Y_{t-1} - g(Y_{t-2}, \theta_k)\xi_k(Y_{t-2})\big), \quad (2)$$

and

$$\sigma^2(Y_{t-1}, Y_{t-2}; \omega_k, \alpha_k, \beta_k) = \omega_k + \alpha_k Y_{t-1}^2 + \beta_k Y_{t-2}^2,$$

with

$$Z_{tk} = \begin{cases} 1 & Q_t = k \\ 0 & otherwise, \end{cases}$$

where switching between the regimes is controlled by a hidden Markov chain Q_t, with values in $\{1, \dots, M\}$, and the residuals $u_{t,k}, t = 1, \dots, N, k = 1, \dots, M$ are i.i.d. random variables with mean 0 and variance 1. $Z_t = (Z_{t1}, Z_{t2}, \dots, Z_{tM})^T$ are random variables which assume as values of the unit vectors $e_1, e_2, \dots, e_M \in R^M$, i.e. exactly one of the Z_{tk} is 1, and the others are 0. The stationary distribution of the hidden regime process is given by the $M \times M$ transition probability matrix A, i.e, $A_{jk} = pr(Q_t = k|Q_{t-1} = j)$. $\xi_k(x)$ is a nonparametric adjustment factor and $g(x, \theta_k)$ is a known function of x and θ_k , called the core function.

2.2.2. The EM Algorithm Based on Semi-Parametric Method

Supposing the definition of $Y^{(N)} = (Y_1, Y_2, \dots, Y_N)$ and $Z^{(N)} = (Z_1, Z_2, \dots, Z_N)$, Nademi and Farnoosh [15] applied a special class of log likelihood function, called "complete" log likelihood function, by the following form

$$l_c\big(v, A|Y^{(N)}, Z^{(N)}\big) = log\pi_{q_1} \sum_{t=2}^{N} logA_{q_{t-1},q_t} + \sum_{t=2}^{N}\sum_{k=1}^{M} Z_{tk} log \frac{1}{\sigma(Y_{t-1}, Y_{t-2}; \omega_k, \alpha_k, \beta_k)} \varphi\left(\frac{Y_t - \mu(Y_{t-1}, Y_{t-2}; \theta_k, \rho_k)}{\sigma(Y_{t-1}, Y_{t-2}; \omega_k, \alpha_k, \beta_k)}\right)$$

Where $v = (\theta_1, \dots, \theta_M, \rho_1, \dots, \rho_M, \omega_1, \dots, \omega_M, \alpha_1, \dots, \alpha_M, \beta_1, \dots, \beta_M)^T \in V$ and $\varphi(.)$ is the normal density with mean $\mu(.)$ and standard deviation $\sigma(.)$. The word "complete" refer to this definition that if we would have observed the complete data $\big(Y^{(N)}, Z^{(N)}\big)$, instead of just $Y^{(N)}$, we could maximize the complete data log likelihood (see Franke et al. [9]), instead of ordinary log likelihood.
Applying this method led to use of Expectation and Maximization algorithm known as EM algorithm. The EM algorithm repeats between drawing the unseen variables Z_{tk} by conditional expectations Z_{tk} given the seen data $Y^{(N)}$ and using a elementary estimate of the parameters on the one phase (E-step), and by maximizing $l_c\big(v, A|Y^{(N)}, Z^{(N)}\big)$ to get an update of approximations of A or v on the other phase (M-step). These two phases until assuring certain stopping criteria are iterated. The algorithm offered with the EM algorithm can be summarized to the following steps.

E-step: Suppose $\hat{\pi}_1, \dots, \hat{\pi}_M, \hat{\rho}_1, \dots, \hat{\rho}_M, \hat{\theta}_1, \dots, \hat{\theta}_M, \hat{\omega}_1, \dots, \hat{\omega}_M, \hat{\alpha}_1, \dots, \hat{\alpha}_M$ and $, \hat{\beta}_1, \dots, \hat{\beta}_M$ are given. S0, the conditional expectation of the unseen variables Z_{tk} given $Y^{(N)}$are calculated by

$$C_{tk} = E[Z_{tk}|Y^{(N)}] = \frac{\alpha_k^t \beta_k^t}{\sum_{i=1}^{M} \alpha_i^t \beta_i^t} \quad k = 1, \dots, M \quad t = 1, \dots, N,$$

where α_i^t and β_i^t are estimated by following recursive relations

$$\alpha_j^{t+1} = \varphi\left(Y_{t+1}; \mu\big(Y_t, Y_{t-1}; \theta_j, \rho_j\big), \sigma\big(Y_t, Y_{t-1}; \omega_j, \alpha_j, \beta_j\big)\right) \sum_{k=1}^{M} A_{kj} \alpha_k^t,$$

and

$$\beta_j^t = \sum_{k=1}^{M} \beta_k^{t+1} \varphi\big(Y_{t+1}; \mu(Y_t, Y_{t-1}; \theta_k, \rho_k), \sigma(Y_t, Y_{t-1}; \omega_k, \alpha_k, \beta_k)\big) A_{jk},$$

where $\varphi\big(Y_{t+1}; \mu(Y_t, Y_{t-1}; \theta_k, \rho_k), \sigma(Y_t, Y_{t-1}; \omega_k, \alpha_k, \beta_k)\big)$ is the normal density with mean $\mu(.)$ and standard deviation $\sigma(.)$.

M-step: Suppose the approximations C_{tk} for the unseen variables Z_{tk} are given. Then, the transition probabilities are calculated by

$$\hat{A}_{ij} = \frac{\sum_{t=1}^{N} \delta_{ij}^{t,t+1}}{\sum_{t=1}^{N} C_{ti}},$$

where $\delta_{ij}^{t,t+1}$ are the joint conditional probability of $Q_t = i$ and $Q_{t+1} = j$ given the entire sequence of observations ($Y^{(N)}$) estimated by

$$\delta_{ij}^{t,t+1} = p\big(Q_t = i, Q_{t+1} = j \big| Y^{(N)}\big) = \frac{\beta_j^{t+1} \varphi\left(Y_{t+1}; \mu\big(Y_t, Y_{t-1}; \theta_j, \rho_j\big), \sigma\big(Y_t, Y_{t-1}; \omega_j, \alpha_j, \beta_j\big)\right) A_{ij} \alpha_i^t}{\sum_{k=1}^{M} \alpha_k^t \beta_k^t}.$$

The probabilities $\pi_1, \dots, \pi_M$ are approximated by

$$\widehat{\pi}_k = \frac{1}{N} \sum_{t=1}^{N} C_{tk}, \quad k = 1, \dots, M,$$

and the functions $\mu(x, y; \theta_k, \rho_k)$ are estimated by

$$\mu\big(x, y; \hat{\theta}_k, \hat{\rho}_k\big) = g\big(x, \hat{\theta}_k\big) \hat{\xi}_k(x) + \hat{\rho}_k \left(x - g\big(y, \hat{\theta}_k\big) \hat{\xi}_k(y)\right),$$

such that, $(\hat{\theta}_k, \hat{\rho}_k)$ gets from $\big(\hat{\theta}_k, \hat{\rho}_k\big) = argmin Q_n(\theta_k, \rho_k), \theta_k, \rho_k \in \mathrm{V}, |\rho_k| < 1$ for $k = 1, \dots, M$, where $Q_n(\theta_k, \rho_k)$ is

$$Q_n(\theta_k, \rho_k) = \sum_{t=2}^{N} C_{tk} (Y_t - g(Y_{t-1}, \theta_k) - \rho_k (Y_{t-1} - g(Y_{t-2}, \theta_k)))^2,$$

and $\hat{\xi}_k(x)$ is

$$\hat{\xi}_k(x) = \frac{\sum_{t=2}^{N} C_{tk}\left[k\left(\frac{Y_{t-1}-x}{h_k}\right)g\left(Y_{t-1},\hat{\theta}_k\right)Y_t + k\left(\frac{Y_{t-2}-x}{h_k}\right)g\left(Y_{t-2},\hat{\theta}_k\right)Y_{t-1}\right]}{\sum_{t=2}^{N} C_{tk}\left[k\left(\frac{Y_{t-1}-x}{h_k}\right)g^2\left(Y_{t-1},\hat{\theta}_k\right) + k\left(\frac{Y_{t-2}-x}{h_k}\right)g^2\left(Y_{t-2},\hat{\theta}_k\right)\right]}, \tag{3}$$

where $k(.)$ is a Gaussian Kernel function and $(\omega_k, \alpha_k, \beta_k)$ are estimated by

$$\left(\hat{\omega}_k, \hat{\alpha}_k, \hat{\beta}_k\right) = Arg\ max \sum_{t=2}^{N} C_{tk}\ log \frac{1}{\sigma(Y_{t-1}, Y_{t-2}; \omega_k, \alpha_k, \beta_k)} \varphi\left(\frac{\hat{e}_{tk}}{\sigma(Y_{t-1}, Y_{t-2}; \omega_k, \alpha_k, \beta_k)}\right),$$

for $k = 1, \ldots, M$, where $\hat{e}_{tk} = Y_t - \mu\left(x, y; \hat{\theta}_k, \hat{\rho}_k\right)$ denotes the sample residuals. The optimal selection of the bandwidth h_k are also estimated by

$$\hat{h}_k = \arg\max_{h_k} \sum_{t=2}^{N} C_{tk}\left[Y_t - g\left(Y_{t-1},\hat{\theta}_k\right)\hat{\xi}_k(Y_{t-1}) - \hat{\rho}_k\left(Y_{t-1} - g\left(Y_{t-2},\hat{\theta}_k\right)\hat{\xi}_k(Y_{t-2})\right)\right]^2.$$

The estimate of the parameters are obtained by iterating these two steps (E-step and M-step) until convergence.

In estimating the functions $\hat{\xi}_k(x)$ and core function, they applied the Gaussian Kernel function and exponential core function. But there is a question that if other types of kernel function and core function can improve performance of the semi-parametric algorithm. We want to trial some other types of kernel and core functions that are popular in mathematics field. These functions consist of: Uniform and Triangle. We also apply the Gaussian kernel to compare this function with the candidate kernel functions. We also test some core functions to compare the ability of them in improvement of the EM algorithm.

3 Materials and Methods

The type of study used in this study is correlational studies. The statistical population of this study includes all indices as well as stock prices of companies listed on the Tehran Stock market. The sample data consist of financial observations, including of Bank's index (industry group) of Tehran Stock market the period March 25, 2018 to March 19, 2019, downloaded from "http://tse.ir/archive.html", where the sample size is 243. So, the variable of our study is Bank's index which is presented by Y_t (Bank's index in time t).

In the first step, we must determine the number of regimes in observations. This can demonstrate by drawing the sample path of data and observing changes trends as increasing and decreasing function. Figure 1 (blue line) shows the sample path the data. Applying this plot, we applied the step function (red line), the down step (regime=1) and upper step (regime=2), to indicate the regimes such that we named increasing trends and decreasing trends by regimes =1 and regimes=2, respectively.

In the second step, we apply the semiparametric model (1) to fit the observations and then, we use of EM algorithm to estimate the parameters of the model. Note that, in one part of M-step, we must select a kernel function ($k\left(\frac{Y_{t-1}-x}{h_k}\right)$) and core function ($g\left(x, \hat{\theta}_k\right)$) .So, In the third step, the selected core functions are as follows

$$g_1(x,\theta) = \exp(x\theta),\ g_2(x,\theta) = \exp\left(\sqrt{x}\theta\right),\ g_3(x,\theta) = \frac{\exp(x\theta)}{1+\exp(x\theta)},\ g_4(x,\theta) = \theta\sin(x).$$

The kernel functions are selected by

$$k_1(u) = \frac{1}{2}I_{[-1,1]}(u),\ k_2(u) = (1-|u|)I_{[-1,1]}(u),\ k_3(u) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}u^2\right),$$

where $k_1(u), k_2(u)$ and $k_3(u)$ are called Uniform, Triangle and Gaussian kernel functions, respectively. For the sake of simplicity in definition of the models, we will call the semi-parametric Markov switching models by MS-SEMI-k(i)-G(i) based on $k_i(u)$ and $g_i(x,\theta)$.
For comparing the models, we apply two indices the square Root of Mean Squared Error (RMSE) and classifying index "Max$C_{tk}, k=1,\dots,M$". The square Root of Mean Squared Error (RMSE) is defined by the following form:

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(Y_t - \hat{Y}_t\right)^2},$$

and the classifying index "Max$C_{tk}, k=1,\dots,M$" is defined by: "Y_t is belonging to regime k if and only if $C_{tk} = \underset{i=1,\dots,M}{\text{Max}}\ C_{ti}$". This index is suitable in evaluation of the models, such that high amounts of this index show the correction classifying of the best model in categorizing the observations in the right regimes. We also apply a step function to show the regimes based on behavior the observations (see Nademi and Farnoosh [15] and Nademi and Nademi [16]).

4 Results

In the first step, we focus on the plot of the data. Figure 1 (blue line) shows the sample path the data. Based on to this plot, we applied the step function (red line), the down step (regime=1) and upper step (regime=2), to indicate the regimes such that we named increasing trends and decreasing trends by regimes =1 and regimes=2, So, we considered Twelve Semi-parametric Markov Switching models (MS-SEMI-K(i)-G(j), i=1,2,3, j=1,2,3,4) based on three kernel functions and four core functions with two regimes (M=2).

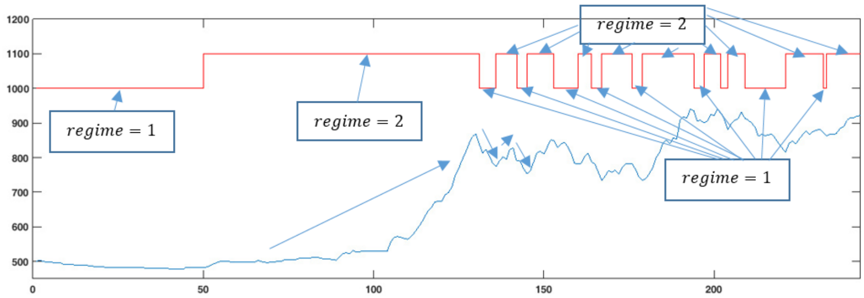

Fig.1. Bank's index data (blue line) and Step function (red line).

In the second and third steps, we apply the semiparametric model (1) and focus on selecting the core function for every kernel function and then compare the best models based on the best kernel function. Table 1 lists the estimated parameters for kernel function Uniform where we have the semi-parametric Markov switching models MS-SEMI-K(1)-G(1), MS-SEMI-K(1)-G(2), MS-SEMI-K(1)-G(3) and MS-SEMI-K(1)-G(4). The results of RMSE criteria for these models show the model MS-SEMI-K(1)-G(4) has the minimum RMSE (0.0725) among the other models. So, we can say that the core function $g_4(x,\theta) = \theta\sin(x)$ is proper for capturing the data. After this core function, the model MS-SEMI-K(1)-G(1) with RMSE, 0.0731 can be selected for observations with the structure with Uniform kernel function. Figure 2 shows the classification of the data based on index $Max(C_{tk})$ where the values of

$Max(C_{t1}, C_{t2})$ for four models, which are all greater than 0.5, show the ability of semi-parametric models in classifying the data. On the other hand, in the MS-SEMI-K(1)-G(4) model the belonging probabilities greater than 0.85 indicate that this model is more powerful than the other models in classifying the observations.

Table 1. The Estimated Parameters Based on Uniform Kernel Function

The Parameters	MS-SEMI-K(1)-G(1)	MS-SEMI-K(1)-G(2)	MS-SEMI-K(1)-G(3)	MS-SEMI-K(1)-G(4)
θ_1	-1.1501	-3.3104	-1.3116	-1.1032
θ_2	-6.4251	-4.3148	-3.2190	-6.2163
ρ_1	0.4216	0.3148	0.5184	0.4084
ρ_2	0.6218	0.7315	0.4023	0.5032
ω_1	0.0015	0.0051	0.0010	0.0021
ω_2	0.0001	0.0016	0.0003	0.0013
α_1	0.0037	0.0204	0.0216	0.0001
α_2	0.0028	0.0381	0.0203	0.0061
β_1	0.0104	0.0204	0.0016	0.0053
β_2	0.0265	0.0110	0.0367	0.0011
π_1	0.3401	0.3721	0.5169	0.3606
π_2	0.6599	0.6279	0.4831	0.6394
A_{12}	0.6112	0.5143	0.4035	0.6203
A_{21}	0.3150	0.3048	0.4318	0.3498
h_1	0.0012	0.0102	0.0122	0.0016
h_2	0.0034	0.0131	0.0351	0.0010
$RMSE$	0.0731	0.0945	0.0871	0.0725

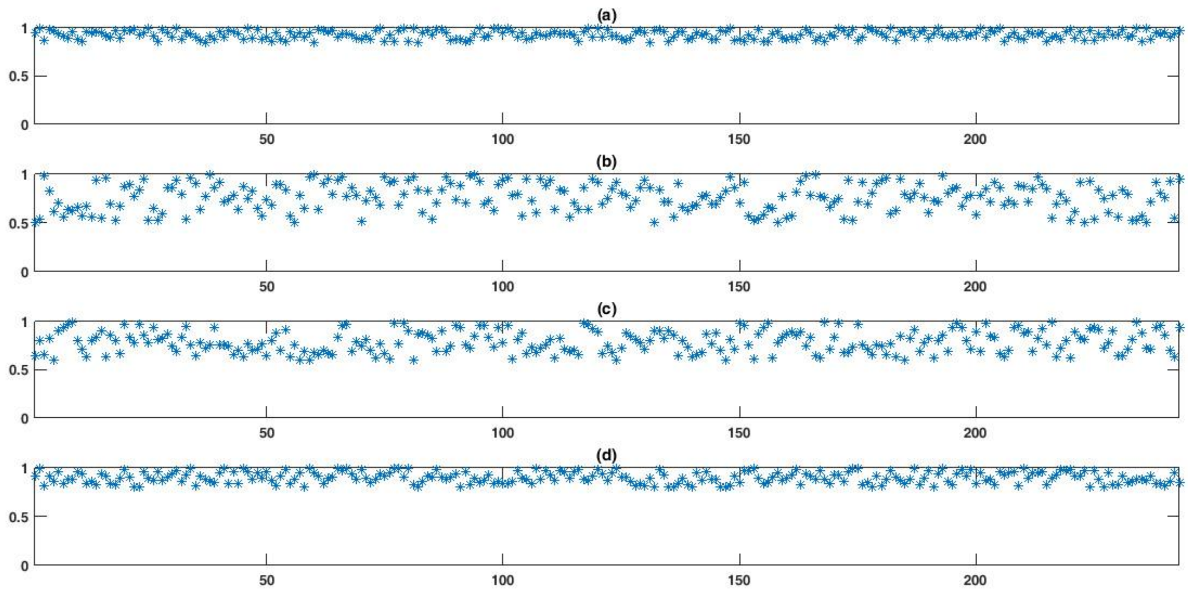

Fig.2. Max(C_{t1}, C_{t2}) for models: (a). MS-SEMI-K(1)-G(1), (b). MS-SEMI-K(1)-G(2), (c). MS-SEMI-K(1)-G(3), (d). MS-SEMI-K(1)-G(4).

Table 2 consists of the estimated parameters based on Triangle kernel function. This table indicate the RMSE for models MS-SEMI-K(2)-G(1), MS-SEMI-K(2)-G(2), MS-SEMI-K(2)-G(3) and MS-SEMI-K(2)-G(4). According to the results, we can find that the model MS-SEMI-K(2)-G(1), with RMSE 0.0945, has the minimum amount of RMSE, comparing the other models. So, the best core function, for Triangle kernel function, is $g_1(x,\theta)=\exp(x\theta)$. After this core function, the model MS-SEMI-K(2)-G(2), with RMSE 0.1134, has the minimum RMSE among the other models. Figure 3 shows the classification of the data based on index $Max(C_{tk})$ for Triangle kernel function where the values of $Max(C_{t1},C_{t2})$ for four models, which are all greater than 0.5, show the ability of semi-parametric models in classifying the data. On the other hand, in the MS-SEMI-K(2)-G(1) model the belonging probabilities greater than 0.70 indicate that this model is more powerful than the other models in classifying the observations based on Triangle kernel function.

Table 2. The Estimated Parameters Based on Triangle Kernel Function

The Parameters	MS-SEMI-K(2)-G(1)	MS-SEMI-K(2)-G(2)	MS-SEMI-K(2)-G(3)	MS-SEMI-K(2)-G(4)
θ_1	-1.2510	-1.1024	-2.0012	-3.1004
θ_2	-3.5462	-3.6412	-2.1640	-2.3145
ρ_1	0.4325	0.5148	0.2489	0.1624
ρ_2	0.6245	0.6489	0.4327	0.2031
ω_1	0.0026	0.0514	0.0031	0.0321
ω_2	0.0010	0.0379	0.0049	0.1202
α_1	0.0311	0.0302	0.0319	0.1304
α_2	0.0051	0.0942	0.0402	0.0181
β_1	0.0645	0.0234	0.0521	0.0094
β_2	0.0713	0.0824	0.0601	0.0081
π_1	0.5732	0.2859	0.3289	0.3186
π_2	0.4268	0.7141	0.6711	0.6814
A_{12}	0.3489	0.6150	0.6502	0.4316
A_{21}	0.4685	0.2462	0.3186	0.2018
h_1	0.0013	0.0046	0.0027	0.0003
h_2	0.0048	0.0487	0.0062	0.0042
$RMSE$	0.0945	0.1134	0.1246	0.1215

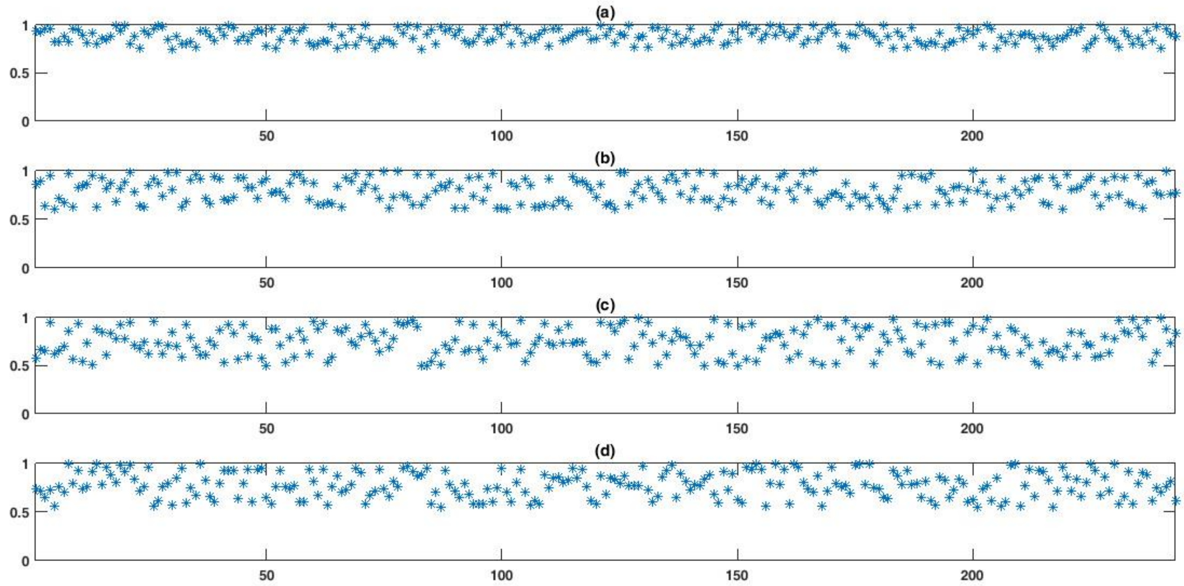

Fig. 3. $\mathrm{Max}(C_{t1},C_{t2})$ for models: (a). MS-SEMI-K(2)-G(1), (b). MS-SEMI-K(2)-G(2), (c). MS-SEMI-K(2)-G(3), (d). MS-SEMI-K(2)-G(4).

Table 3 shows the estimated parameters based on Gaussian kernel function. Comparing the amounts of RMSE for the models MS-SEMI-K(3)-G(1), MS-SEMI-K(3)-G(2), MS-SEMI-K(3)-G(3) and MS-SEMI-K(3)-G(4), we can see the best model is the model MS-SEMI-K(3)-G(1) in which RMSE is 0.0703. Therefore, we can find that the best core function for Gaussian kernel function is $g_1(x,\theta) = \exp(x\theta)$. After this model, the core function $g_4(x,\theta) = \theta \sin(x)$ of the model MS-SEMI-K(3)-G(4) can be offer as the proper core function based on Gaussian kernel function. Figure 4 shows the classification of the data based on index $Max(C_{tk})$ for Gaussian kernel function where the values of $Max(C_{t1}, C_{t2})$ for four models, which are all greater than 0.6, show the ability of semi-parametric models in classifying the data. On the other hand, in the MS-SEMI-K(3)-G(1) model the belonging probabilities greater than 0.87 indicate that this model is more powerful than the other models in classifying the observations based on Gaussian kernel function.

Table 3. The Estimated Parameters Based on Gaussian Kernel Function

The Parameters	MS-SEMI-K(3)-G(1)	MS-SEMI-K(3)-G(2)	MS-SEMI-K(3)-G(3)	MS-SEMI-K(3)-G(4)
θ_1	-1.0162	-3.0510	-1.4692	-0.8472
θ_2	-2.3201	-2.4210	-4.3150	-1.3496
ρ_1	0.1240	0.3160	0.4682	0.4081
ρ_2	0.4201	0.5015	0.4182	0.2486
ω_1	0.0213	0.0105	0.0013	0.0003
ω_2	0.0010	0.0315	0.0041	0.0008
α_1	0.0114	0.0021	0.0203	0.0214
α_2	0.0315	0.0184	0.0344	0.0804
β_1	0.0243	0.0648	0.0510	0.0034
β_2	0.0152	0.0921	0.0025	0.0107
π_1	0.3812	0.5501	0.3091	0.3329
π_2	0.6188	0.4499	0.6809	0.6671
A_{12}	0.5142	0.4210	0.3162	0.4316
A_{21}	0.3168	0.5147	0.1482	0.2154
h_1	0.0032	0.0032	0.0018	0.0002
h_2	0.0102	0.0012	0.0054	0.0011
$RMSE$	0.0703	0.0791	0.0849	0.0748

Comparing the RMSE of the models, we can find that the MS-SEMI-K(3)-G(1) has the least amount of RMSE among the others. So, the selected kernel function and core function for the data are Gaussian kernel and $g_1(x,\theta) = \exp(x\theta)$, respectively. But, with a closer look, one see that the Uniform kernel can be a strongly rival for selecting the kernel function. Because some RMSE's for this kernel, regardless in selecting the core function $g_1(x,\theta)$, is better than the Gaussian kernel. This indicate that in modeling data, the researchers should not focus on just one kernel or core function.

After estimating the models for the data, we forecasted future of the data for four lags of time. Figures 5, 6 and 7 consist of the estimated joint conditional probabilities for twelve the models. The estimated joint conditional probabilities were defined by $\delta_{ij}^{t,t+1} = p(Q_t = i, Q_{t+1} = j|Y^{(N)})$, such that we can write the joint conditional probability matrix

$$\delta_{ij}^{T} = \begin{pmatrix} p(Q_t = 1, Q_{t+1} = 1|Y^{(N)}) & p(Q_t = 1, Q_{t+1} = 2|Y^{(N)}) \\ p(Q_t = 2, Q_{t+1} = 1|Y^{(N)}) & p(Q_t = 2, Q_{t+1} = 2|Y^{(N)}) \end{pmatrix},$$

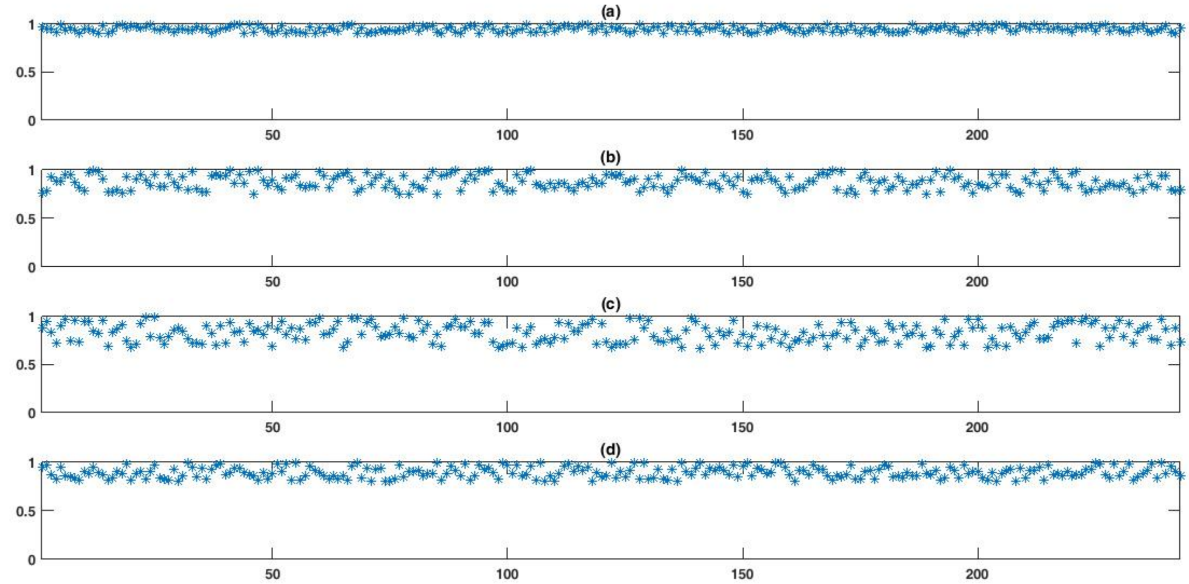

Fig. 4. Max(C_{t1}, C_{t2}) for models: (a). MS-SEMI-K(3)-G(1), (b). MS-SEMI-K(3)-G(2), (c). MS-SEMI-K(3)-G(3), (d). MS-SEMI-K(3)-G(4).

for the models. This matrix can offer the strategy of buying and selling stock in financial markets. Such that, the probability elements of the matrix indicate the behavior of the data in passing time "t" to "t+1". According to structure of the Semi-parametric model (1) and dependency degree of observation Y_t that is degree of 2, based on dependency of observation Y_t on Y_{t-1} and Y_{t-2}, we can see that the plots can predict strongly the behavior of observations just for two lags of future time and after that there is not a certain decision for behavior the observations for future lags. Such that, these figures show that after the lag 4 the joint conditional probabilities almost converge to the same amount.

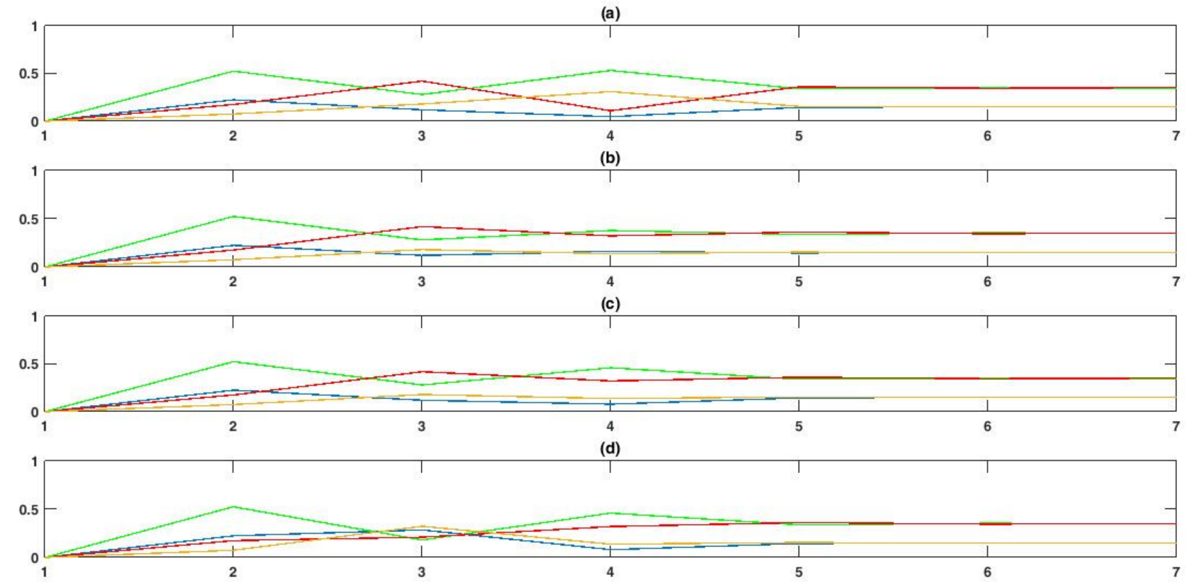

Fig. 5. (a). MS-SEMI-K(1)-G(1), (b). MS-SEMI-K(1)-G(2), (c). MS-SEMI-K(1)-G(3), (d). MS-SEMI-K(1)-G(4), the colors of green, brown, red and blue are the joint conditional probability of $(Q_t = 1, Q_{t+1} = 2)$, $(Q_t = 1, Q_{t+1} = 1)$, $(Q_t = 2, Q_{t+1} = 1)$ and $(Q_t = 2, Q_{t+1} = 2)$, respectively.

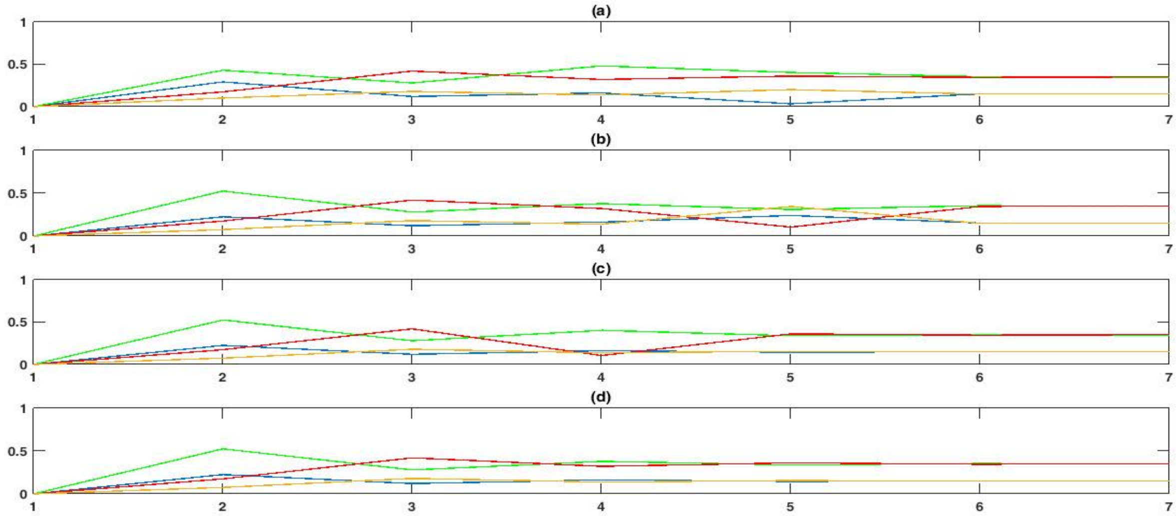

Fig. 6. (a). MS-SEMI-K(2)-G(1), (b). MS-SEMI-K(2)-G(2), (c). MS-SEMI-K(2)-G(3), (d). MS-SEMI-K(2)-G(4), the colors of green, brown, red and blue are the joint conditional probability of $(Q_t = 1, Q_{t+1} = 2)$, $(Q_t = 1, Q_{t+1} = 1)$, $(Q_t = 2, Q_{t+1} = 1)$ and $(Q_t = 2, Q_{t+1} = 2)$, respectively.

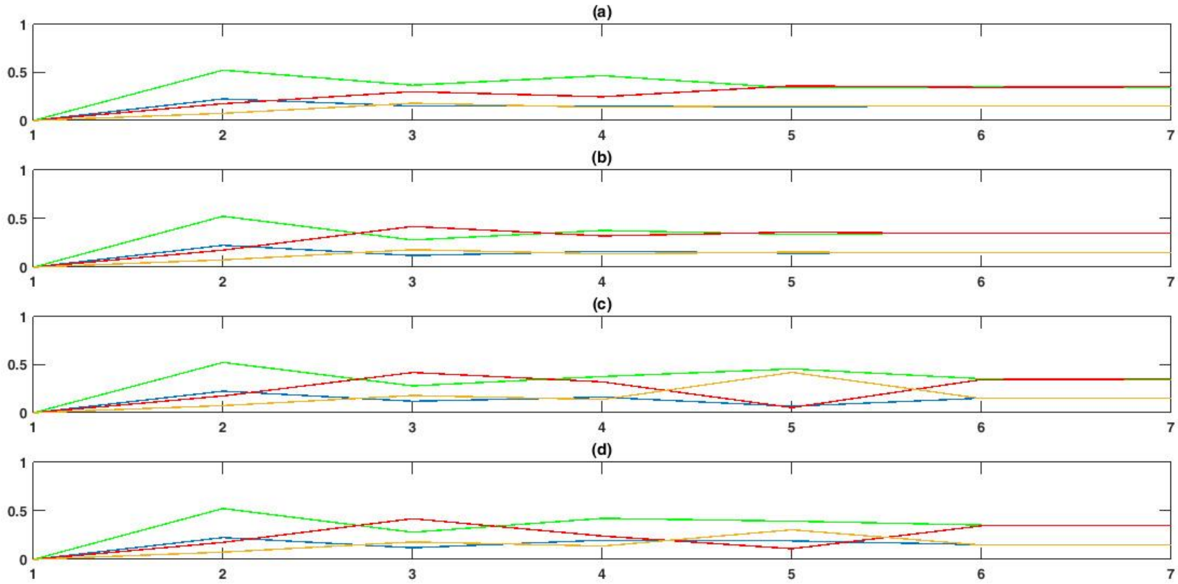

Fig. 7. (a). MS-SEMI-K(3)-G(1), (b). MS-SEMI-K(3)-G(2), (c). MS-SEMI-K(3)-G(3), (d). MS-SEMI-K(3)-G(4), the colors of green, brown, red and blue are the joint conditional probability of $(Q_t = 1, Q_{t+1} = 2)$, $(Q_t = 1, Q_{t+1} = 1)$, $(Q_t = 2, Q_{t+1} = 1)$ and $(Q_t = 2, Q_{t+1} = 2)$, respectively.

Table 5 shows the estimated joint conditional probability matrix for the observations of the Banks index (industry group) for the selected time period based on the twelve models.

According to the result of this Table for the best selected model (MS-SEMI-K(3)-G(1)), we can see the most probabilities among the elements of the matrices $\delta_{ij}^{t,t+1}$for period (t=243, t+1=244), (t=244, t+1=245) and (t=245, t+1=246) are 0.5247, 0.3680 and 0.4670, respectively, that are belong to the switching between the regimes from 1 to 2 ($Q_t = 1, Q_{t+1} = 2$). This offers that the strategy of buying the stocks in period of time t=243 to t= 245. In the other hand, the results indicate that the most probabilities among the element of the matrices $\delta_{ij}^{t,t+1}$for period (t=246, t+1=247) is 0.3610. This shows the switching between the regimes is from 2 to 1 ($Q_t = 2, Q_{t+1} = 1$) that offers the strategy of selling the stocks in period of time t=246. On the other hand, if we select the second proper model (MS-SEMI-K(1)-G(4)), the most probabilities among the elements of the matrices $\delta_{ij}^{t,t+1}$for period (t=243, t+1=244) and (t=245, t+1=246) are 0.5256 and 0.4602, respectively, that are belong to the switching between the regimes from 1 to 2 ($Q_t = 1, Q_{t+1} = 2$). This offers that the strategy of buying the stocks in period of time t=243 and t= 245. But, the most probabilities among the elements of the matrices $\delta_{ij}^{t,t+1}$for period (t=244, t+1=245) is 0.3234 that is belong to the switching between the regimes from 2 to 2 ($Q_t = 2, Q_{t+1} = 2$) that show the trend of the data will stay in increasing trend. This state indicate that the strategy of buying for traders in time of t=244. Although, the probability of the switching between the regimes from 1 to 2 ($Q_t = 1, Q_{t+1} = 2$) (0.1810) is weak, comparing the other probabilities.

Table 5. The Estimated Joint Conditional Probability for the Models

The model	Time period			
	t=243, t+1=244	t=244, t+1=245	t=245, t+1=246	t=246, t+1=247
MS-SEMI-K(1)-G(1)	$\begin{pmatrix}0.2243 & 0.5252\\ 0.1751 & 0.0753\end{pmatrix}$	$\begin{pmatrix}0.1198 & 0.2797\\ 0.4203 & 0.1802\end{pmatrix}$	$\begin{pmatrix}0.0475 & 0.5321\\ 0.1102 & 0.3102\end{pmatrix}$	$\begin{pmatrix}0.1451 & 0.3395\\ 0.3605 & 0.1550\end{pmatrix}$
MS-SEMI-K(1)-G(2)	$\begin{pmatrix}0.2249 & 0.5243\\ 0.1757 & 0.0752\end{pmatrix}$	$\begin{pmatrix}0.1200 & 0.2806\\ 0.4193 & 0.1801\end{pmatrix}$	$\begin{pmatrix}0.1619 & 0.3775\\ 0.3225 & 0.1381\end{pmatrix}$	$\begin{pmatrix}0.1457 & 0.3387\\ 0.3613 & 0.1543\end{pmatrix}$
MS-SEMI-K(1)-G(3)	$\begin{pmatrix}0.2253 & 0.5242\\ 0.1755 & 0.0750\end{pmatrix}$	$\begin{pmatrix}0.1201 & 0.2807\\ 0.4193 & 0.1800\end{pmatrix}$	$\begin{pmatrix}0.0792 & 0.4602\\ 0.3225 & 0.1382\end{pmatrix}$	$\begin{pmatrix}0.1452 & 0.3391\\ 0.3609 & 0.1548\end{pmatrix}$
MS-SEMI-K(1)-G(4)	$\begin{pmatrix}0.2247 & 0.5256\\ 0.1746 & 0.0750\end{pmatrix}$	$\begin{pmatrix}0.2854 & 0.1810\\ 0.2102 & 0.3234\end{pmatrix}$	$\begin{pmatrix}0.0810 & 0.4602\\ 0.3209 & 0.1379\end{pmatrix}$	$\begin{pmatrix}0.1449 & 0.3381\\ 0.3619 & 0.1551\end{pmatrix}$
MS-SEMI-K(2)-G(1)	$\begin{pmatrix}0.2923 & 0.4310\\ 0.1747 & 0.1020\end{pmatrix}$	$\begin{pmatrix}0.1201 & 0.2796\\ 0.4205 & 0.1798\end{pmatrix}$	$\begin{pmatrix}0.1598 & 0.4811\\ 0.3214 & 0.0377\end{pmatrix}$	$\begin{pmatrix}0.0331 & 0.4041\\ 0.3613 & 0.2015\end{pmatrix}$
MS-SEMI-K(2)-G(2)	$\begin{pmatrix}0.2010 & 0.4903\\ 0.1416 & 0.1671\end{pmatrix}$	$\begin{pmatrix}0.1246 & 0.2591\\ 0.4128 & 0.2035\end{pmatrix}$	$\begin{pmatrix}0.1633 & 0.3785\\ 0.3215 & 0.1367\end{pmatrix}$	$\begin{pmatrix}0.2402 & 0.3105\\ 0.1042 & 0.3451\end{pmatrix}$
MS-SEMI-K(2)-G(3)	$\begin{pmatrix}0.2250 & 0.5254\\ 0.1747 & 0.0749\end{pmatrix}$	$\begin{pmatrix}0.1224 & 0.2910\\ 0.4175 & 0.1691\end{pmatrix}$	$\begin{pmatrix}0.1548 & 0.4030\\ 0.1054 & 0.3368\end{pmatrix}$	$\begin{pmatrix}0.1449 & 0.3387\\ 0.3613 & 0.1551\end{pmatrix}$
MS-SEMI-K(2)-G(4)	$\begin{pmatrix}0.2437 & 0.5349\\ 0.2134 & 0.0080\end{pmatrix}$	$\begin{pmatrix}0.1181 & 0.2471\\ 0.5118 & 0.1230\end{pmatrix}$	$\begin{pmatrix}0.1502 & 0.3584\\ 0.3413 & 0.1501\end{pmatrix}$	$\begin{pmatrix}0.1449 & 0.3387\\ 0.3613 & 0.1551\end{pmatrix}$
MS-SEMI-K(3)-G(1)	$\begin{pmatrix}0.2253 & 0.5247\\ 0.1751 & 0.0749\end{pmatrix}$	$\begin{pmatrix}0.1512 & 0.3680\\ 0.3010 & 0.1798\end{pmatrix}$	$\begin{pmatrix}0.1471 & 0.4670\\ 0.2480 & 0.1379\end{pmatrix}$	$\begin{pmatrix}0.1451 & 0.3390\\ 0.3610 & 0.1549\end{pmatrix}$
MS-SEMI-K(3)-G(2)	$\begin{pmatrix}0.2317 & 0.4902\\ 0.1564 & 0.1217\end{pmatrix}$	$\begin{pmatrix}0.1202 & 0.2802\\ 0.4198 & 0.1798\end{pmatrix}$	$\begin{pmatrix}0.1531 & 0.33694\\ 0.3108 & 0.1667\end{pmatrix}$	$\begin{pmatrix}0.1451 & 0.3390\\ 0.3610 & 0.1549\end{pmatrix}$
MS-SEMI-K(3)-G(3)	$\begin{pmatrix}0.2038 & 0.5011\\ 0.1698 & 0.1253\end{pmatrix}$	$\begin{pmatrix}0.1227 & 0.2712\\ 0.4037 & 0.2024\end{pmatrix}$	$\begin{pmatrix}0.1584 & 0.3698\\ 0.3157 & 0.1561\end{pmatrix}$	$\begin{pmatrix}0.0679 & 0.4570\\ 0.0541 & 0.4210\end{pmatrix}$
MS-SEMI-K(3)-G(4)	$\begin{pmatrix}0.2102 & 0.5063\\ 0.1502 & 0.1333\end{pmatrix}$	$\begin{pmatrix}0.1215 & 0.2641\\ 0.4005 & 0.2139\end{pmatrix}$	$\begin{pmatrix}0.1981 & 0.4230\\ 0.2410 & 0.1379\end{pmatrix}$	$\begin{pmatrix}0.1906 & 0.3940\\ 0.1104 & 0.3050\end{pmatrix}$

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Research Paper

Moderating Role of Managerial Entrenchment to Effect of Technology-Based Capabilities on Product Market Competition: Resource-Based View by Data Envelopment Analysis (DEA)

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ABSTRACT

The development of knowledge and advancement in technology has created a wide-ranging transformation in societies and has led to changes in the performance of companies in order to respond to environmental turmoil and social expectations. In this way, they tried to gain a significant competitive advantage over other competitors. The purpose of this study was to investigate the moderating role of managerial fortification in relation to the impact of technology-based capabilities on the product market competition of knowledge-based companies in the capital market: a source-based capabilities (DEA). This research is applied in terms of purpose and in terms of data envelopment analysis is a quasi-experimental and post-event research in the field of positive accounting research. Then, based on multivariate regression, the research hypothesis was tested using Eviews software. The statistical population studied in this study consisted of knowledge-based companies listed on the Tehran Stock Exchange during the years 2015 to 2019 and 79 companies were selected and reviewed based on systematic screening. The result of testing the research hypothesis is that the technological capabilities have a positive and significant effect on the product market competition of knowledge-based companies in the capital market. This result demonstrates that the resource-based technology capability based on the source-based capabilities is seen as a resource against stagnation in a competitive environment and helps the company, to maintain flexibility in the face of environmental change in order to respond faster, at the same time to develop the company's competitive capacity to create new resources or new and innovative products, and to make the company's future more attractive to stakeholders with greater returns and potential risk control.

1 Introduction

The basic concept of governance is defined in a wide range, as a network of relationships that includes not only a company and its owners, but also all stakeholders including employees, customers, people, society, etc [1]. The most important element of this system are managers, whose decisions can

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be influential in a wide range and for which they must be accounTable to a wide range of stakeholders [2]. But in unsTable and complex environmental conditions; increasing competition; with the increasing development of communications and technological advances, company managers are facing new conditions in terms of competition, and what determines the success of firms in the survival and advancement of their goals, these are the strategies that they should choose based on their decision-making approaches based on the turbulent environment [3]. These strategies today are different from the past, more than anything else, depending on the level of technology-based capabilities, because the growth and development of technologies has caused drastic changes in the competitive processes of companies. As the environment and market space changes due to the multiplicity of competitors and the intensity of competition, companies also have to use technology-based capabilities based on resource-based view to grow and achieve their goals [4]. The resource-based view is one of the foundations of technological capabilities in the field of knowledge-based companies, which has greatly helped to maintain the superiority of companies over competitors. Because the resource-based view, due to the internal characteristics of companies in a competitive market, evaluates the level of capabilities and capacities that can be developed in various dimensions such as technology core and provides the possibility of sustainable development for companies [5]. In other words, this approach considers the reason for the different competitive power of companies operating in this field, in their unique resources and assets, assets that, while practical, must be innovative and based on competitive values. It is noteworthy that these unique assets and resources are not necessarily purchasable and need to be created based on strategic mechanisms based on technological costs [6]. For example, although technological development is an asset based on capital and cash resources, the value and level of knowledge that is generated from it is based on learning approaches at the competitive level of capital market companies [7]. In other words, this approach has features such as valuable, rare, imitability and in-substituTable for resources [8]. In fact, according to the resource-based view (RBV), companies always try to strengthen various infrastructures such as technological development by focusing on technological capabilities such as research and development, so that information feedback is more dynamically reflected to stakeholders to increase the effectiveness of the company's interaction with stakeholders. This form of capital market interaction will be possible through the disclosure of transparent financial reporting to shareholders and investors [9, 10]. Technology-based capabilities also help knowledge-based companies to be more successful in product market competition. Carayannis & Sagi [11] using case studies of successful companies, identify key components of product competitiveness in capital market-active industries at three national levels; Industry and companies were identified. They examine the interrelationships between product market competitiveness based on productivity (profitability) and innovation and developed their observations and conclusions by creating the CPI model which is the basis for gaining a competitive advantage, while creating a dynamic interaction between the government; Industry and companies are the development of technology-centric competitive capabilities. On the other hand, Li et al [12] by examining the level of technological capabilities stated, lack of technology-based capabilities can reduce the quality of information and information asymmetry due to the company's inability to compete with other companies with a competitive advantage, because the lack of these capabilities is considered a kind of non-response to market changes and shareholders, realizing this, may lose confidence in the company's competitiveness for greater returns, and the company faces the risk of a financial crisis under these circumstances. Fang [11] also cited the existence of technology-based capabilities based on the dynamics of competitive capabilities as a reason for companies to differ in profitability and gain a competitive advantage in the product market. They described the existence of these capabilities as a factor in information transparency as a basis for competitiveness in the product market. In fact, technology-based capabilities are a set of capabilities; Skills and infrastructure knowledge in knowledge-based companies to gain a competitive advantage in the product market which help companies in choosing the most appropriate technologies to maximize productivity to reduce their costs and create a favorable environment for sustainable development [13]. According to the descriptions given, this study seeks to investigate the moderating role of managerial entrenchment on the impact of technology-based capabilities on the product market competition of knowledge-based companies in the capital market based on data envelopment analysis (DEA) to create a technical efficiency of a company compared to competitors in the field of turning research and development resources into an innovative product.

2 Literature Review

2.1 Technological Capabilities

Technological capability, or IT, is the ability to control IT-related costs, deliver systems on time, and influence business goals through IT implementation [14]. This capability has been studied from several perspectives; How it relates to work design, process change, power relations and collaboration [15] and a number of studies have examined it from a resource-based perspective [16, 17]. From the point of view of a resource-based approach to diversification, valuable, scarce, inimiTable and irreplaceable resources create a competitive advantage. Therefore, information technology should be considered as an organizational capability that leads to competitive advantage by leading the company to superior performance [18]. In addition, Madhavaram and Hunt [19] based on resource advantage theory, organizational resources in a hierarchy of basic resources (such as information resources, relationships and human resources), combined (eg, A + B = C) and interconnected (for example, a × b) are categorized, because organizational capabilities and / or competencies are formed through a bowl of basic resources [20]. It can be said that IT capability is a source of mixed factor. Mixed sources can be measured through their constituent components, which can be tangible or intangible [19]. Therefore, IT capability can have different dimensions depending on the number of separate IT-based resources. IT capabilities can be divided into 4 sections and several components: [21].

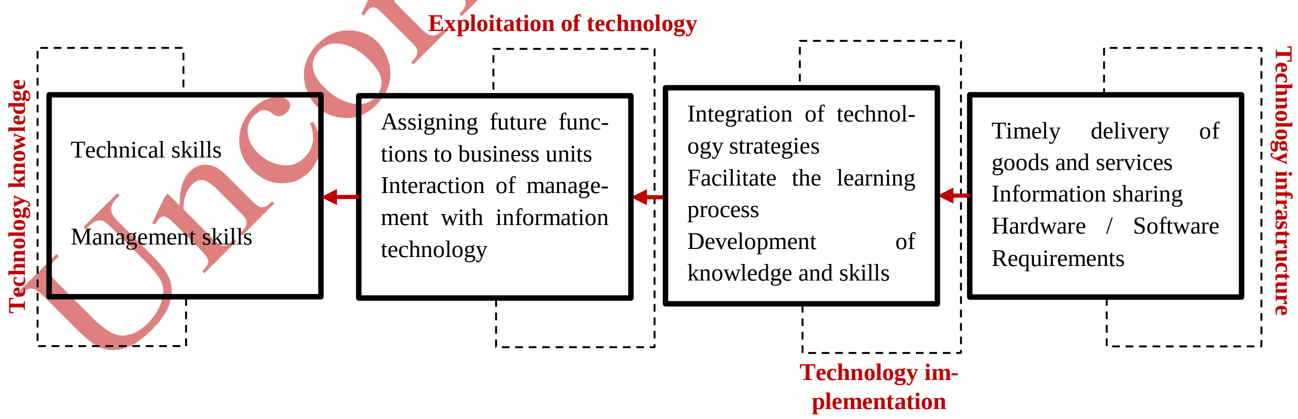

Fig.1: Multidimensional Figure of Technological Capabilities

2.2 Resource-Based View in the Development of Technological Capabilities

The resource-based view is a competitive performance model that focuses on resources and capabilities controlled by the firm as a source of competitive advantage, one of the dimensions of which is technology-based capability. Empirical evidence consistently states that industry structure or external factors cannot be the sole determinants of competitive strategy and competitive performance [22]. For this reason, a group of theorists in this field such as Maiti et al [23]; Andersen [24] and Fahy [25] stated that having the distinct gifts of strategic resources is the ultimate determinant of strategy and performance. This attitude is exactly in line with the phenomenon of knowledge-based competition. Such competition causes the long-term success of a company to depend on what it knows and understands, and therefore competitors look at capabilities and competencies as the key to success against their competitors [26]. Resource-based view was introduced by Barney [27], and the key to success is focusing on intangible assets such as knowledge. In fact, these resources can act as barriers to copying and imitating other assets, so they are imiTable, irreplaceable, valuable, and scarce. Other capabilities include team knowledge, organizational culture, organizational history, learning, management skills and the like. Technological capabilities help the company to achieve a competitive advantage and create more value for stakeholders than other competitors in the competitive market. In fact, competitive advantage includes a set of technological factors or capabilities of the company that always enable the company to show better performance than competitors [28].

2.3 A Resource-Based View to Developing a Competitive Advantage

Maintaining the survival of companies in today's competitive environment leaves them with no choice but to gain a competitive advantage. Management theorists have proposed two approaches to competitive advantage, one that is based on environmental opportunities and one that is based on the internal capabilities of the company [23]. Numerous studies by researchers in the last two decades, such as Wernerfelt [29]; Barney [27]; Byrd [30] showed that competitive advantage based on the company's internal capabilities is the best source for competitive advantage and was the basis for strengthening the resource-based view. According to this approach, both the external environment and the internal characteristics of companies will have a significant impact on the success of companies [31]. The resource-based approach pays attention to the internal characteristics of companies and is considered as a basis for creating value for the use of tangible and intangible assets within the company's structures. In fact, according to this approach, the company's strategies are based on internal resources and the development of capacities to exploit intangible assets through which companies in a competitive environment can achieve a competitive advantage. In other words, when the market is constantly changing and the competition in it is increasing, going back and looking back for guidance and guidance in making strategic decisions will face many problems. For example, Porter's Competitive Forces model [32] used five external factors that underlie strategic decision-making. These factors include the bargaining power of resource suppliers, the bargaining power of customers, the threat of new companies entering the market, the threat of the presence of alternative goods, and the competition of companies with each other in the field of industry. Unfortunately, in a dynamic environment, paying attention to these factors cannot provide the necessary guidance for making strategic decisions, in a reasonable way, or even be useful in the allocation of resources of these companies [33]. But in line with the resource-based view, focusing on resources within the company and identifying its strengths, especially the irreplaceable set of resources such as knowledge enhancement; Innovators and human resource capabilities of decision makers can be strategic options based on resource allocation and distribution to gain a competitive advantage in a changing market and competitors.

2.4 Product Market Competition

The concept of competition should include all forms of competition (including market transactions, auctions, etc.), competitive instruments (including price; commercials; research and development; mergers and acquisitions) and competitive objectives (including interests, market share, control). Company, advertising and survival) [34]. The competitiveness of the product market means that different companies are in close competition in the production and sale of goods and its goods are not much superior to each other, because if not, the market tends to monopoly or multilateral monopoly [2]. Market competition can also be considered as market power. Accordingly, market power means the monopoly power, the multilateral or competitive monopoly of a company [35]. Also, competitiveness can be defined as the possibility of achieving a good position and stability in global markets, which shows the ability to gain a competitive advantage in the market. Previous studies over the past few years such as Singla and Singh [36]; Iqbal et al [36] and Laksmana and Yang [37] have shown that competition in the product market is considered as a kind of extra-organizational governance mechanism and an important and vital factor in the decisions of information disclosure by companies. Competition in the product market, on the one hand, forces companies in similar industries to seek information from competitors and, on the other hand, to hide their information in order to have a competitive advantage. Competition in the product market not only makes companies extensively dependent on external competitive advantage, it also encourages owners to strengthen internal corporate governance mechanisms and reduces the opportunistic behaviors of managers. Thus, competition in the product market is a substitute for internal governance that reduces agency costs [38]. Hart [39] argues that competition in the product market can be used as an effective regulatory and regulatory mechanism to control agency problems. The reason for this is that competition in the product market increases the likelihood that companies with high costs will go bankrupt [40].

2.5 Development of Theoretical and Experimental Research Hypothesis

The competitiveness of companies has been introduced by many researchers as a multidimensional concept [41]. Booth and Philip [42] divide the factors affecting competitiveness at the enterprise level into two categories in the form of technology-based approaches and approaches based on competencies and capabilities. They see technology on the one hand as improving efficiency and on the other as a capacity to develop strategic capabilities for companies. Liu and Jiang [43] stated that by combining capabilities and technology, a resource-based view will be able to help increase competitive advantage. In fact, technological capabilities based on the resource-based view were proposed by Teece et al [44]. This capability includes strategic areas of companies' competitive functions, which help to create and develop valuable resources. On the other hand, technological capability based on the resource-based view, also to participate in the integration; Creating and reshaping internal and external competencies to respond and respond quickly to the environment and enables companies that have such capabilities to reflect their ability to enter the market in order to gain a competitive advantage [45]. In order to expand the relationship between technology capability and product market competition based on a resource-based perspective, it should be stated that creating coherence in the development of internal resources and alignment with external resources puts the company in a position to gain a competitive advantage. As stated by Wernerfelt [29] and Barney [46], each company is a collection of resources and capabilities; Resources are input factors that are used to achieve business goals and the capabilities of the company, that is, the company's ability to use resources, it can enhance a company's competitive performance, both in terms of innovation and in terms of product effectiveness. In this regard, Grant [47] and Makadok [48] point out that while sources are the main units of analysis, but in fact, companies have a competitive advantage by integrating them to create technological capabilities, because technological capabilities enable the creation of knowledge and innovation to achieve greater productivity, and having such capacities can help to make the company more competitive in the competitive market. It should be noted that the main advantage of focusing on resource-oriented in developing the relationship between technological capability and the effectiveness of the product market competition of knowledge-based companies is the non-transferability of knowledge or the so-called localization of knowledge that he company is based on investing in its technology infrastructure and enables the company to gain a competitive advantage [10]. Studies such as Dotta et al [49] and [50] and Li et al [51] based on a resource-based view focusing on advanced technology at the heart of technology capabilities with the aim of enhancing competitive advantage, relative to the company's technology characteristics as its technical efficiency. They have conceptualized other companies in turning R&D resources into innovative products. These researchers realized that without sufficient technological capabilities, investing in R&D resources alone could not create a sustainable competitive advantage because this investment could be replicated by competitors [10]. In fact, technological capabilities in the form of technical efficiency over competitors meet the requirement of a resource-based view to a source of sustainable competitive advantage, because the existence of such capabilities in a company's internal processes usually through practical learning related to internal development path. They find that it is not possible to pass it on to companies or to be imitated by competitors [52]. Through hands-on learning, a company's unique understanding of successful development processes emerging through prior knowledge leads to a competitive advantage in creating new knowledge in the same research direction [53]. Given the distinctive market and technological characteristics of knowledge-based companies operating at the capital market level, the unparalleled and non-transferable technological capability of a company at the capital market level is certainly the main source of its competitive advantage. The advantage of sustainable competition will not affect the manager's decision to disclose information in the form of financial reporting, because a company with such an advantage over competitors, firstly, by disclosing information in a timely manner, seeks to gain a competitive advantage and a greater share of the capital market, and secondly, through innovation, seeks more stability in product market competition [27]. Therefore, the existence of technological capabilities helps to raise the level of imitation and non-transferable capabilities and brings a competitive advantage to companies in the product market. Based on this, the research hypothesis states:

- **The first hypothesis of the research) Technological capabilities have a positive and significant effect on the product market competition of knowledge-based companies in the capital market.**

But if the approaches are based on the level of proprietary management thinking, the company will not show much interest in pivotal development in all matters of the company, especially information technology, because managers with managerial fortifications seek long-term tenure to maintain stability in the conditions under their management, they are in the managerial position of the company. By focusing on the goals of the board of directors and meeting the level of relative satisfaction of the shareholders, these managers try to prevent challenges and fundamental changes in the company's performance by controlling things. Shleifer and Vishny [54], while stating that managers do not want to maximize shareholder wealth, based on their theory of representation and research, stated that managers use their authority to achieve their personal goals to establish their position and value the company does not pay attention. They consolidate their position through special investments that have little risk and thus show that they play a valuable role in the interests of shareholders. The existence of these approaches indicates a superficial fortification to maintain and strengthen the managerial position. According to Marouan [55], fortification is a kind of thinking related to the strength of the manager's position and all the behaviors that lead to job retention; Increases freedom of decision-making and the preservation of personal interests. On the other hand, Lin et al [56] examined the effective role of managerial fortification on product market competition and proposed two very important reasons in this regard. First, the management entrenchment makes the disclosure of company information in the direction of corporate governance mechanisms one-sided and exclusive, and causes information to be provided to shareholders based on the amount that the company wants, and secondly, the reason for fortification and its impact on reducing product market competition is the lack of a dominant and integrated culture; Technology-based; They stated strategies appropriate to the market. In other words, Lin et al [56] analyzed the two axes of corporate representation functions and described managerial entrenchment as the result of unbalanced company structures in a competitive market. While Tyrol [57] focused on individual characteristics influencing managerial entrenchment such as narcissism and short-sightedness, managers with such characteristics sought to strengthen their position by lobbying board members and increasing their share of managerial property, by maintaining the status quo, they create a level of information monopoly to overestimate the impact of favorable events on the firm's cash flows and underestimate the likelihood of adverse events and development, They seek to improve short-term profits to increase stock prices and to lose long-term stock values, as these managers attribute the maintenance of their current position to maintaining the relative satisfaction of shareholders that capital expenditures and investment in research and development are considered to be in conflict with their managerial aspirations. Under these conditions, research and development costs are reduced, and this can reduce the level of competition in the product market, because the company, due to the loss of its competitiveness, tries to prevent the disclosure of its desired information. From exposing the bad news of their actions in the market. Therefore, based on the explanations given, the second hypothesis of the research is:

- **The second hypothesis of the research is that the entrenchment of the CEO moderates the positive effect of technology-based capabilities on the product market competition of knowledge-based companies in the capital market in a negative direction.**

2.6 Research Background

Rahman et al [58] conducted a study entitled "Investigating the effect of product market competition on companies' profitability". This research was conducted in the period of 1996 to 2016 and 107018 observations of the year of the US Stock Exchange were examined. The results of this study showed that the in-house individuals of companies in highly competitive industries earn more extraordinary profits. The results showed that the existence of mechanisms of research and development intensity and increasing training costs is the most important factor in the sustainable development of the company's competitiveness in the product market, that the future, it can help increase the company's profitability by developing financial transparency, such as the readability of financial reporting, and increase the company's share of the capital market. Jiang et al [59] conducted a study entitled "Investigating the Impact of Stakeholder Communication and Technological Capabilities". The study, conducted between 2003 and 2014, looked at a sample of 126 listed companies on the China Stock Exchange. In this study, in order to measure the research variables, partial least squares analysis (PLS) was used. Their research findings showed that it improves the ability to communicate closely with the company's innovation stakeholders. Sahi et al [60] conducted a study entitled The Study of the Moderating Role of Entrepreneurial Orientation to the Impact of Technology Capabilities and the Intensity of Product Market Competition. The study involved 164 CEOs of US capital market companies, which used partial least squares (PLS) analysis to fit the model. The results showed that the existence of entrepreneurial orientation as a managerial insight in companies, causes the positive impact of technology-based capabilities on the intensity of product market competition, intensifies in a positive direction. Fung [10] conducted a study entitled "Investigating fraudulent financial reporting on technology capabilities based on a resource-based view." In this study, 141 US stock exchange companies in the period 1998 to 2011 were examined. In this study, regression was used to measure fraudulent financial reporting and data envelopment analysis (DEA) was used for technology capabilities. The results showed that according to the source-based view, technology capabilities have a significant negative impact on fraudulent financial reporting. In addition, the likelihood of fraud is irrelevant to the scale of returns on technology activities, because investing in R&D resources is not in itself a source of sustainable competitive advantage. Ramezan Ahmadi et al [61] conducted a study entitled "Study of the effect of macroeconomic variables and product market competition on profit quality: Structural equation approach." The study period is the years 2006 to 2015 and the selected sample is 70 companies. For data analysis, structural equation modeling with partial least squares (PLS) approach and PLS software has been used. The results show that product market competition directly and indirectly (through financial performance mediator) has a significant positive effect on profit quality, but through the mediator variable of capital structure, it has a significant negative effect. Also, direct impact is stronger than indirect impact. Other research findings indicate that macroeconomic variables have a positive effect on financial performance through mediation, but a negative effect on profit quality through mediation of capital structure. Also, macroeconomic variables have a direct negative relationship with earnings quality, but this relationship is not significant. Valiyan et al [62] conducted a study entitled “Designing an Organizational Capabilities Approach Model Based on Strategic Reference Point Theory”. In fact, this study sought to design a model based on the approaches of organizational capabilities strategies with respect to the dimensions of knowledge organizations, traditional and knowledge and industrial attitudes. The approach of this research is based on the philosophy of science (Epistemology) and the philosophy of the universe (Anthropology). In other words, based on the review of the organizational capabilities strategy literature and the study of the subject libraries, it was determined that an integrated model in line with the context of organizational capabilities has not been presented and this study sought to design an organizational capabilities model using strategic reference points. Based on this, first the dimensions of this research, including knowledge organizations, traditional organizations, knowledge attitude and industrial attitude, were explained, then we tried to use a coordination model based on strategic reference points, coordinated types of each capability strategies. Therefore, following the research of Fung [10], this study has used data envelopment analysis to measure the variable of technological capability, which can be used as a basis for evaluating technical efficiency in increasing the development capabilities of companies to attract and create new resources and contribute to the stability of the capital market.

3 Methodology

The present study is an applied research in terms of purpose and quasi-experimental post-event research in the field of positive accounting research in terms of data collection method. Using data envelopment analysis method, the variable of technological capabilities was first measured. Then, based on multivariate regression based on Eviews software, the research hypothesis was tested. The statistical population studied in this study consists of knowledge-based companies listed on the Tehran Stock Exchange during the years 2015 to 2019. After applying the above restrictions, 79 companies were selected as the research sample. The data of the present study were extracted from the compact discs of the statistical and video archives of the Tehran Stock Exchange Organization, the website of the Tehran Stock Exchange and other related databases, as well as from the new Rahavard software. The final analysis of the collected data was performed using Eviews software.

3.1 Research variables

3.1.1 Independent Variable

Technology-Based Capabilities Based on a Resource-Based Approach

In his research, Makadok [48] examined the role of technological capabilities as a criterion for the development of competitive capabilities/sustainability of companies, emphasized their role in internalizing coherent competitive processes, and introduced them as a factor in promoting economic returns of the companies. Competitive processes provides the company's economic returns through more efficient resource utilization compared to the opponents. Similarly, Capabilities will lead to gaining a sustainable competitive advantage in terms of the company’s technical efficiency in converting organizational resources into product-resources because these capabilities (embodied in intra-organizational processes) cannot be transferred or imitated. Following this discussion, Dutta et al [49] measured the capabilities of a company (defined as the company’s technical efficiency in converting the input to output) over its competitors. Relying on the research by Dutta et al [50] and Li et al [51] on RBV, this study measures technological capabilities in terms of competitive capability criterion as the relative technical efficiency of a company by which it transforms R&D resources into an innovative product. Following the study by Griliches [63], the cumulative R&D resources of Company *i* in Year *t*, i.e., $RND_{i,t}$, are defined as follows:

$$RND_{i,t} = Ln\left[RDE_{i,t} + \sum_{1}^{\tau}(1-\gamma)^{\tau}\, RDE_{i,t-\tau}\right] \quad (1)$$

Where:

$RND_{i,t}$ is the R&D expenses of Company *i* in Year *t* and γ is the R&D investment rate measured using the natural logarithm of the total R&D expenses of the firms surveyed. Relying on the research by Namazi and Moghimi [1] the infrastructure of technical innovation will be employed to extract R&D investment data. The DEA will be used to measure this variable; therefore, the inputs to this analysis are the ratio of training costs to total payroll costs, the number of professional staff, and R&D expenses. This cumulative measure is shown by the symbol $RDE_{i,t}$. This study used Griliches’ [63] assumption, constant value $\gamma = 0.4$, and $\tau = 3$ in Equation (1) to measure γ and τ values. Our will use the DEA to evaluate the technological capabilities of each company in terms of its technical efficiency compared to other rivals in converting cumulative R&D resources in the form of $PAT_{i,t}$ symbol into profitability. In other words, DEA outputs mean profitability. The main idea behind the DEA is to construct a non-parametric envelopment bound (i.e., production) along with the whole sample of input-output observations such that each observation is placed over or under the bound. The reason for using data envelopment analysis as a non-parametric basis is to estimate the efficiency of the performance of the surveyed companies in terms of technical efficiency as a basis for measuring technological capabilities. The measure of “relative return” for any company is derived from the distance between the company and the bound because it is interpreted as the “best performance” among its peers. Figure 1 shows the relationship among input/output, $RDE_{i,t}$ as input, and $PAT_{i,t}$ as output, based on the “constant returns to scale (CRS)" and "variable returns to scale (VRS)" approaches in the DEA.

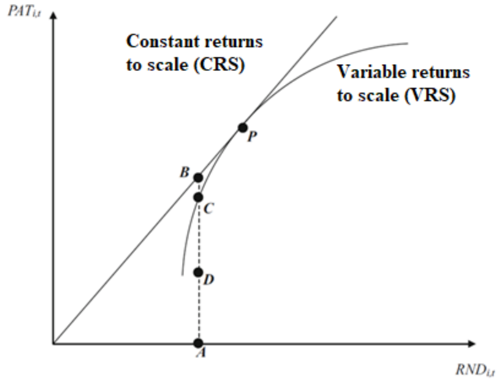

Fig. 3: DEA to Measure Technological Capabilities as a Dynamic Capability Measure

Given Company *i* active at Point *D*, its technical inefficiency in technological activities under CRS and VRS is shown by the distance between points B and D (i.e., BD) and between points C and D (i.e., CD), respectively. The difference between BD and CD, i.e., BC, indicates the scale inefficiency of the firm with respect to optimal production scale at point P. It is worth noting that Scale Inefficiency (BC) can be eliminated only by adjusting the input level to point P. On the other hand, Technical Inefficiency (CD) can be eliminated simply by improving the efficiency and utilization of existing inputs. As shown in Figure 2, the DEA efficiency measures are as follows:

$$\mathrm{TEV}_{i,t} = \mathrm{AD}/\mathrm{AC} \tag{2}$$

$$\mathrm{SE}_{i,t} = \mathrm{AC}/\mathrm{AB} \tag{3}$$

Where $\mathrm{TEV}_{i,t}$ is technical efficiency and $\mathrm{SE}_{i,t}$ is the technology-based activity scale efficiency of Company *i*. The characteristics of these efficiency metrics are as follows:

- ❖ They take values between 0 and 1.
- ❖ They measure the efficiency to the best performance among the companies surveyed.
- ❖ $\frac{1}{\mathrm{TEV}_{i,t}} - 1$ is a proportionate increase in technology-based outputs ($\mathrm{PAT}_{i,t}$) without an increase in corporate technology-based inputs ($\mathrm{RND}_{i,t}$) if the company maximizes its technical efficiency in moving from Point D to Point C in Figure 1.
- ❖ $\frac{1}{\mathrm{SE}_{i,t}} - 1$ is a disproportionate increase in technology-basedness in which there is no scale efficiency at the input level (i.e., BC = 0); in this case, it indicates the distance between the current scale of production and the optimal scale at point P.

$\mathrm{SE}_{i,t}$ is simply determined by investment in R&D resources to achieve the optimal production scale. Nevertheless, $\mathrm{TEV}_{i,t}$ is associated with the company's non-transferrable and inimiTable technological capabilities in transforming R&D resources into innovative products. The concept of "RBV" implies that $\mathrm{SE}_{i,t}$ is less likely to be considered as a source of sustainable competitive advantage because rivals can potentially invest in R&D resources. Unlike $\mathrm{SE}_{i,t}$, technological capability in the form of $\mathrm{TEV}_{i,t}$ is not transferable among companies and cannot be imitated by competitors because it involves a series of intermediate steps between input and output embedded in intra-organizational processes (Dutta et al, 2005). This "non-transferable" and "inimiTable" capability is regarded as a source of competitive advantage under RBV. Accordingly, this variable will be calculated based on $\mathrm{TEV}_{i,t}$, i.e., technical efficiency. If $\mathrm{TEV}_{i,t} \geq 0$, the technical efficiency-based technological capability would be largely inimiTable, indicating the existence of technology-based capability in the companies surveyed, which take the value 1. On the other hand, $TEV_{i,t} < 0$ indicates the low technical efficiency of the companies investigated, i.e., the surveyed companies have no technology-baseness or have low technology levels, which take the value 0.

3.1.2 Dependent variable

Product Market Competition

In this section, in order to measure the market competition of the product by following the research of Giroud and Müeller [38], the following relation is used to measure it.

$$HHI_{it} = \sum_{j=1}^{j} s_{ij}^2 \qquad (4)$$

Where s_{ij} is equal to the market share of company j in industry i. The following equation is used to calculate the company's market share:

$$s_{ij} = \left(\frac{s_i}{s}\right)^2 \qquad (5)$$

Where s_{ij} is the sales revenue of company i and s is the total sales revenue of the company in the industry in which company i operates. The HHI standard is a degree of focus on an industry and is a measure of the level of competition. To facilitate the interpretation of the results, multiply the HHI index by (-1). Therefore, a higher HHI index means a higher level of competition in the product market.

$$NegHHI = HHI \times (-1) \qquad (6)$$

3.1.3 Moderator variable

Entrenchment of CEO

Entrenchment is a concept based on possessive and entrepreneurial behavior in maintaining a job position that has been nicknamed organizational behavior in recent years. According to Marouan [55], the CEO's entrenchment refers to the strengthening of the managerial position by the individual and includes all behaviors that lead to job retention, increased freedom of decision, and personal gain. Based on this concept, to measure the strength of the CEO following the research of Di Meoa et al [64] and Bebchuk et al [65] are calculated from the virtual variables 0 and 1 and based on the three criteria of CEO tenure, managerial ownership and dual. The use of a virtual variable based on these three criteria is done because it is expected to reduce the disorders of each of these three different dimensions [66]. Now each of the three criteria of the term of office of the CEO, managerial ownership and duality of the post of CEO is explained.

- **CEO tenure**

The CEO tenure increases over time [67]. At the beginning of their tenure, CEOs prioritize the need to develop managerial skills to meet new job needs. After that, they may try to eliminate their opportunistic motives. Also. Accordingly, following the research of Di Meoa et al [64] and Bebchuk et al [65], 0 and 1 are used to measure this variable, so that if the CEO has been a CEO for 3 years or more have a company number 1 otherwise they are given the number 0.

- **Managerial ownership**

Based on previous research, Di Miguel et al [68] argue that CEOs have managerial stability with a moderate level of managerial ownership. When managerial ownership is below a certain boundary, capital markets reduce their opportunity for control by controlling managers' motivations. And in this case, agency costs will be reduced. But if managerial ownership is above a certain threshold, the interests of managers are likely to take precedence over the interests of shareholders. According to most models, the measure of managerial ownership is calculated based on the percentage of shares held by managers to the total number of ordinary shares held by shareholders. However, this study follows the model of Di Miguel et al [68] who used the firm value criterion to measure managerial ownership and determine the value of companies in the range of managerial ownership fluctuates between 18.8% and 50.06%. On this basis, if the percentage of managers' share of the total ordinary shares is in the hands of shareholders in this range, the number 1, otherwise the number 0 will be assigned to it.

- **DUAL**

According to the research of Gompers et al [69] and Bibchuk et al [65], the duality of CEO position is calculated as a two-dimensional criterion of 0 and 1. If the CEO is the chairman or vice-chairman of the board of directors, the number 1 will be assigned to him, otherwise the number 0 will be assigned to him.

Finally, to calculate the CEO's entrenchment, if there are at least two of the three factors mentioned in the company, the number 1, otherwise the number 0 is assigned to it.

3.1.4 Control variables

Based on the findings of the literature related to this research and following the research of Fung [10]; will examine the following control variables in this study:

- Growth expectation $GROW_{i,t}$ which is measured by the ratio of book value to market value, reflects investors' expectations for the company's future performance. Market-level companies may lose their capabilities because they do not have the technology capabilities and given the high expectations of investors from these companies, reduce product market competition. Therefore, product market competition is expected to increase with $GROW_{i,t}$, as companies increase investor expectations that be at a high level in terms of product market competitiveness index [10].
- Net operating assets $NOA_{i,t}$ of the ratio of the total value of shareholders' shares plus operating liabilities (accounts payable; pension and salary liabilities; realized unpaid expenses); minus cash securities are calculated on the basis of sales. Thus, product market competition is expected to be directly related to $NOA_{i,t}$ [70].
- Liquidity $LQD_{i,t}$, which is defined as cash and cash equivalents divided by current liabilities. Product market competitiveness is expected to increase with$LQD_{i,t}$, because a severe liquidity constraint weakens the firm's competitiveness by reducing the firm's ability to do so [10].

3.2 Research Models

Given the nature of the research variables and the hypothesis, Equation (7) is used to measure the model of the research hypothesis:

$$HHI_{it} = \alpha_0 + \alpha_1 TEV_{i,t} + a_2 GROW_{i,t} + \alpha_3 NOA_{i,t} + \alpha_4 LQD_{i,t} + \varepsilon_{it} \quad (7)$$

In the above relation, HHI_{it} is the market competition index of company i at time t. Also, for better regression analysis, it should be noted in the research hypothesis model that based on data envelopment analysis (DEA) if $TEV^*_{i,t}$ is the optimal scale that is, if $TEV_{i,t} \geq 0$ is (ie point P in Figure 2), according to Equation (6); Research and development costs $RND_{i,t}$ are considered desirable and effective in developing companies' technology capabilities, and this can by default lead to increased product market competition. Finally, if scale returns are potentially reproducible among firms and therefore it is not possible to distinguish between firms with product market competitiveness and product market non-competitiveness, then it is expected that where ρ_1 andρ_2 are zero. $\rho_1 \neq \rho_2$ is also possible because scale returns can be easily improved when the firm operates at a higher than optimal level instead of performing poorly.

The second model of research

$$HHI_{it} = \alpha_0 + \alpha_1 TEV_{i,t} + \alpha_2 CEO\ Entrenchment_{\,i,t} + \alpha_3 TEV_{i,t} \times CEO\ Entrenchment_{\,i,t} + a_4 GROW_{i,t} + \alpha_5 NOA_{i,t} + \alpha_6 LQD_{i,t} + \varepsilon_{it} \quad (8)$$

4 Empirical Results

In this section, first, descriptive statistics of research variables and then inferential statistics in the form of data envelopment analysis to measure technological capabilities, default models, combinations and testing of research hypotheses are presented.

Data Envelopment Analysis (DEA)

Data envelopment analysis is a kind of evaluation of the relative efficiency of decision-making units (DMUs) like the companies studied in this study. Each company performance score (DMU) is from 0 to 1. The most efficient (DMU) has an efficiency score of 1 the criterion of "best performance" (ie boundary) is considered among peers. The lower the performance score (DMU) (ie below the threshold), the more inefficient the DMU is at best performance. In this study, which is based on linear programming in technology as an exogenous variable:

$\max \theta_h$

Provided that: $Y\lambda \geq \theta_h PAT_h$

$X\lambda \leq RND_h$

$\lambda j = 0$ if $t_j > t_h$ for all $j \neq h$

$I_{\acute{N}\lambda} = 1$

$\lambda \geq 0$

That$1 \leq \theta_h \leq \infty$: $Y = (PAT_1, \dots, PAT_N)$ $X = (RND_1, \dots, RND_N)$$t_1, \dots, t_N$, is the time trend that controls external technological progress; vector λ $N \times 1$ is 1. This model, by applying the condition $\lambda j = 0$ if $t_j > t_h$ for all $j \neq h$, eliminates observations that have more advanced technology (ie have a more favorable environment) than the reference set. The condition of $I_{\acute{N}\lambda} = 1$, applies the constant return to scale variable to the solution of the problem. The interpretation of $Y\lambda \geq \theta_h PAT_h$and $X\lambda \leq RND_h$is as follows. Select the weight combination of all input observations ($X\lambda$) that uses the most input under evaluation (RND_h) to produce the largest possible multiplication of the output observations under evaluation ($\theta_h PAT_h$). Viewing Input - The output under evaluation is efficient when its output is generated with the best use of its inputs, that is, if λ cannot be found to produce $\theta_h > 1$. This efficient observation with $\theta_h = 1$ specifies a point at the boundary because its efficiency cannot be increased compared to other observations. If $\theta_h > 1$ then $\theta_h - 1$ will be a proportional increase in PAT_h with no increase in RND_h. Thus $1 / \theta_h$ defines a performance score that varies between 0 and 1. The value of θ for each input-output observation can be obtained by solving the previous linear programming problem for N times. To distinguish scale efficiency from technical efficiency, the former can be calculated from the difference between θ and θ, where θ' is the solution to the problem but with no variable return on scale (VRS). According to what has been explained, in order to measure technical efficiency, according to the period of research, which is from 2015 to 2019, research and development data and investment in it, based on the specified ratios, should be decimated in order to determine the maximum desired technical return appeared. The following Table shows the deciles of the functions calculated based on the characteristics of training costs to total salary costs; the number of professional staff and R&D costs are used as input variables and profitability as output variables to analyze performance appraisal over time. In other words, as described in the method of measuring the technology capability variable, in order to perform data envelopment analysis, for the research period, the level of inputs, training costs to total salary costs must be; Specify the number of professional staff and R&D costs and output (profitability) in the form of maximum technical efficiency.

Table 1: Calculation of Technical Efficiency

Decimation	Maximum efficiency (MAX θ)	Technical efficiency of 2015	Technical efficiency of 2016	Technical efficiency of 2017	Technical efficiency of 2018	Technical efficiency of 2019
First decile	Bad	0.794	0.2036	0.1549	0.191	0.899
Second decile	Bad	0.816	0.8187	0.6276	0.4731	0.2409
Third decile	Average	0.543	0.4635	0.7495	0.922	0.7024
Forth decile	Good	0.625	0.7918	0.9332	1	1
Fifth decile	Good	1	1	1	0.864	0.9485
Sixeth decile	Good	0.718	0.6236	0.9244	1	0.8654
Seventh decile	Perfect	0.779	0.9328	1	1	1
Eighth decile	Perfect	1	1	1	0.894	1
Ninth decile	Perfect	1	1	1	1	0.9938
Tenth decile	Perfect	1	1	1	1	1

In this analysis, the technical returns of R&D cost and investment functions were compared based on the mentioned criteria, whose returns score was obtained, then the bad and medium grade functions are evaluated together and the average grade technical return is calculated. In this model and based on the analysis of the above Table, a specific coefficient is considered for each of the input variables, because the effect of all input variables on output (profitability) is not the same. As mentioned, the calculated value for technical efficiency is in the range of zero to 1. Companies with a technical efficiency score of one are companies that are highly efficient, and companies with a technical efficiency score of less than one are below the efficiency threshold and must achieve technical efficiency or technical efficiency by reducing costs or increasing investment in research and development. The purpose of calculating technical efficiency is technology-based capabilities based on R&D functions. Because affected by these properties, more or less than the actual value is calculated. On the other hand, the good grade is compared with the bad grade and the average grade, and the technical efficiency of the good grade is calculated, and finally the technical returns of the excellent grade are evaluated with all R&D functions, and the higher and lower technical return score is calculated. Because according to the research hypothesis, determining the level of technology-based capabilities is calculated based on the technical efficiency of research and development costs and investments. Next, by comparing inefficient functions with reference units, the optimal value of each output is obtained. In this way, it is determined how much each inefficient function increases its output so that its efficiency reaches the size of its reference set. In the Table below, the inverse technical return of companies R&D in the form of specific deciles is used, so that if the inverse value of the return is more than one, it means that that decile is inefficient. Note that due to the large number of data under study, by decoding and inverting it in this section, the inefficient research and development functions of companies located in these deciles should be determined. For example, the efficiency of the second decile is 1.0818, which indicates that it is inefficient at 0.0818 and must increase the output by the same amount to improve its efficiency.

Based on the obtained results, considering the inverse of the technical efficiency of the deciles performed in terms of maximum efficiency, low performances can be identified in the Table.
Thus, as described in the measurement of technology-driven capabilities, companies that had a technical return of more than 1 in the inverse of Table (3), or in other words (TEV_{it} <1), represent the low technical returns of companies. It is examined that expresses the fact that these companies do not have core technology or at least have low technologies, based on which they are assigned the number 0. Unlike companies located in deciles that are $TEV_{i,t} \geq 1$ it means that the capability of technology-based technology based on technical efficiency is largely unmatched. And on this basis, they are assigned the number 1. In simpler terms, given that the companies in the deciles (TEV_{it} <1) have earned 0, they are assigned the number 0, which means they are not technology-oriented.

Table 2: The Optimal Output of Inefficient Deciles and the Change Values of Each in Percentage

		Training costs to the total salary		Number of professional staff and research and development costs	
deciles	Inverse returns	Change (%)	The optimal amount	Change (%)	The optimal amount
First decile	1	0%	84,038,449,555	0%	524,401,793,744
Second decile	1.0818	11%	58,256,812,531	7%	249,272,807,064
Third decile	1.06543	33%	35,388,270,376	34%	251,780,332,752
Forth decile	1	0%	24,113,028,493	0%	142,487,773,620
Fifth decile	1.0018	0%	6,320,896,701	0%	61,898,653,995
Sixth decile	1	0%	20,926,016,385	0%	120,880,663,368
Seventh decile	1	0%	13,028,773,561	0%	89,392,794,115
Eighth decile	1.0266	4%	23,548,156,580	21%	141,627,148,692
Nine decile	1	0%	25,325,894,784	0%	203,592,154,677
Tenth decile	1.0823	8%	25,327,287,614	46%	158,909,071,325

Table 3: Low Management Performance Deciles

Applied research and development deciles	Inverse technical returns
Second decile	1.0818
Third decile	1.6543
Fifth decile	1.0018
Eighth decile	1.0266
Tenth decile	1.0823

Descriptive Statistics

In order to study the general characteristics of variables, as well as to estimate the two models and their detailed analysis, it is necessary to be familiar with descriptive statistics related to variables. Table (4) shows the descriptive statistics of the tested variables, which include some central and dispersion indices.

Table 4: Descriptive Statistics of Research Variables

Variable	Number of observations	Mean	Median	Minimum	Maximum	Standard deviation
TEV	395	0.314	0	0	1	0.465
GROW	395	0.376	0.39	0.08	0.63	0.145
NOA	395	0.38	0.36	-0.02	0.81	0.23
LQD	395	1.967	1.94	1	3.01	0.566
CEO ENT	395	0.306	0	0	1	0.461
HHI	395	0.003	0.003	0.002	0.004	0.001

As can be seen in Table (4), based on descriptive statistics, it should be noted that the average technical efficiency of TEV of the surveyed companies is equal to 0.314, which indicates that the core technology capability of companies is greater than one, ie $TEV_{i,t} \geq 1$ indicates that the technologies of the knowledge-based companies under study are unimaginable; however, given that it is less than half, it should be noted that the level of knowledge-based in this area is very low and based solely on corporate investments, the main focus on the return on training has been on salaries and the number of professional staff. The average expectation of GROW growth as the first control variable of the research is 0.376, this indicates that the average stock value of companies is expected to grow below 0.5. Non-cash NOA's (Net Operating Assets) also showed that 38% of the company's sales came from net operating assets. Similarly, it was found that the average LQD (Liquidity Network) liquidity ratio of the companies under study is equal to 1.967 which shows the ability of companies to repay liquidity to current debts. Finally, the average of the CEO's fortification is calculated to be 0.306, which due to less than half of it, it can be said that the level of entrenchment of the CEO is insignificant. According to the results obtained from the descriptive statistics of research variables, which show that the mean and median in most research variables are close to each other, there is a good distribution in this area.

4.1 Results of Hypothesis Test

After reviewing some descriptive statistics related to independent and dependent variables of the research and general familiarity with the information of these variables, in the inferential statistics section using the research hypotheses test, the relationship between independent and dependent variables of the research will be examined. Before examining the results of model estimation, it is necessary to examine its assumptions. This review is performed below. Like time series data, panel data requires the meaning of model variables. In panel data, if the variables are not constant, the regression pattern is the result of a false pattern. In this study, before estimating the pattern, we examine the meaning of the variables. One of the five methods for testing unit roots in panel data is used:

- Im, Pesaran & Shin (IPS) Test
- Levin, Lin & Chui (LLC) Test
- Breitung Test
- Fisher Test
- Hadri Test

These tests are called panel unit root tests. Theoretically, root tests are units of multiple series used for panel information structures. In all these tests, the method of examining mana is such that by rejecting the null hypothesis that there is a single root, the secret mana is accepted. In this study, Hardy method (Hadri Z-stat) has been used to investigate the mean, the results of which are reported in Table (5).

Table 5: Results of Research Variability of Research Variables

Criteria	Value of test statistics	Significance level	Test result
TEV	8.195	0.001	Reject the null hypothesis
GROW	12.491	0.001	Reject the null hypothesis
NOA	12.493	0.001	Reject the null hypothesis
LQD	12.155	0.001	Reject the null hypothesis
CEO ENT	8.298	0.001	Reject the null hypothesis
HHI	8.301	0.001	Reject the null hypothesis

According to Table (5), because the significance level of the test for all variables is less than 0.05, so for all research variables, the null hypothesis that there is a single root is rejected. Therefore, at the 95% confidence level, all variables will remain the same. To check for the presence or absence of alignment between the independent variables of the model, a two-to-two correlation coefficient is used. If the correlation coefficient between the variables is less than 50% (0.5), then there is no strong correlation between the two independent variables.

Since the correlation coefficients of Table (7) are all calculated less than 0.5, the assumption of non-alignment between the independent variables will be confirmed. Of course, the VIF index is also used for this purpose. Because the data used were combined (year-company) combined data are analyzed in both panel and integrated forms, so in order to choose between panel and integrated methods in model estimation, F-Limer test is used. If the significance level of F-limer is calculated to be more than 0.05, then the combined method should be used, otherwise the panel method should be used.

Table 6: Correlation Coefficient between Independent Research Variables

Criteria	TEV	GROW	NOA	LQD	CEO ENT
TEV					
GROW	-0.004				
NOA	0.123	0.107			
LQD	0.033	-0.123	-0.110		
CEO ENT	0.284	-0.023	-0.205	0.017	

Table 7: Results of F-Limer Test for Research Model

Model	Statistics F	The first degree of freedom	The second degree of freedom	Significance level	Test result
First	0.968	78	312	0.557	Approval
Second	1.907	78	310	0.001	Reject

Because for the first model, the significance level of the F-Limer test is greater than the error of 0.05, so to estimate the first model of the research, the combined data method should be used. Therefore, in the first model, there is no need to use Hausman test to determine the type of panel data (fixed or random effects method). However, in the case of the second model, because the significance level of the F-Limer test is less than the error of 0.05, it is necessary to use the panel data method to estimate the second model of the research. However, it remains to be seen whether the fixed effects pattern is more appropriate for the data or the random effects pattern. The Hausman test is used for this purpose.

Table 8: Results of Hausman Test for the Second Model of Research

Chi-square test statistics	Degrees of freedom	Significance level	Test result
0.001	6	0.999	proving a theory

According to Table (9), because for the second model, the significance level of Hausman test is greater than the error of 0.05, so the use of random effects pattern is superior to the use of fixed effects pattern. Therefore, a random effects pattern is used to fit the second model. One of the important assumptions of the regression model is the assumption of homogeneity of the residual variance. If this condition is not met, ordinary least squares estimates do not have the characteristic of efficiency (minimum variance). To test this default, the likelihood ratio (LR) test in stata software is used. The null hypothesis in this test is the homogeneity of the residual variance that if the significance level of this test is more than 0.05, the null hypothesis is confirmed. The results of this test are presented in Table (9).

Table 9: Results of Likelihood Ratio Test to Identify Variance Homogeneity

Model	Chi-square statistics	Degrees of freedom	Significance level	Test result
First model	3658.96	78	0.001	Reject the null hypothesis
Second model	5836.44	78	0.999	Confirmation of the null hypothesis

The results of the likelihood ratio test in Table (10) show that because the significance level of the test for the first model of the research is less than 0.05 error, therefore for this model there is a problem of variance of the residual variance. Therefore, GLS (Generalized Least Squares) method is used for estimation in this model. However, in the second model of the research, the assumption of variance homogeneity with a five percent error is confirmed and as a result, there is no problem of variance inequality of the residuals for this model. Therefore, for estimation in this model, we will use the ordinary least squares method. By default, the remainder of the model is normal, the statistical distribution of the error statements should be normal. This test is performed after estimating the model using the Jarque-Bera test.

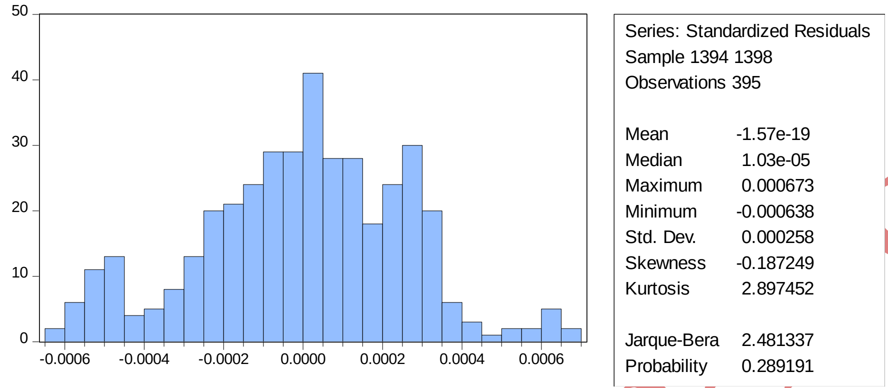

Fig. 3: Normality of Errors of First Model

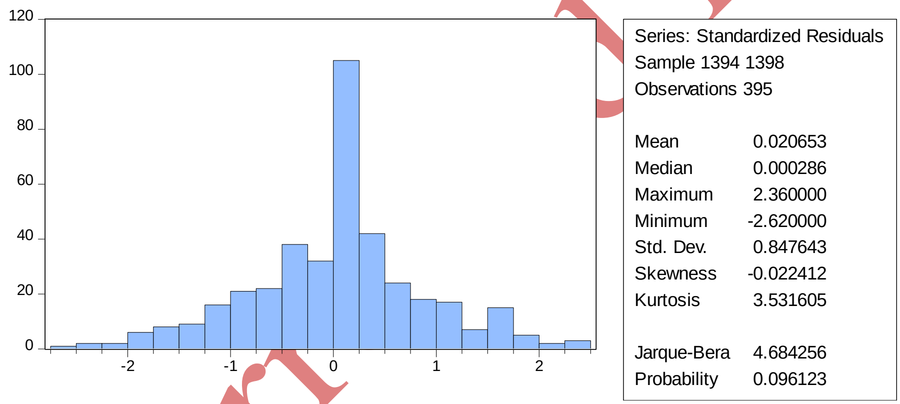

Fig. 4: Normality of Errors of Second Model

Considering the significance levels of the jb test of the model (numbers in front of the probability section in Figures 3 and 4), because these values are greater than 0.05, then at the 95% confidence level, the assumption of the remaining normality of both research models is confirmed. To ensure that there is no alignment problem between the independent variables, the alignment test using the variance inflation factor (VIF) was also examined. Since the values of this statistic are less than 10 for the explanatory variables, there is no alignment between them. Also, in order to test the correlation between the error components of the model, the camera-Watson statistic was used, the results of which are presented in Tables (10) and (11). If the value of the Watson-Camera statistic is between 1.5 and 2.5, there is no correlation. Based on this, the results of the research hypotheses test are presented in the form of Tables (10) and (11), P. Considering the value of F statistic in this figure, it indicates the general significance of the first regression model fitted at the 5% error level. The value of the Watson-Durbin statistic also indicates that there is no problem of autocorrelation between waste statements. As can be seen in this picture Estimation coefficient and t-statistic related to technical variable efficiency (TVE) at the error level of 5%, positive and significant, which indicates the positive effect of technical efficiency of technology-based capabilities on product market competition. Therefore, the first hypothesis of the research that technology-based capabilities have a positive and significant effect on the product market competition of knowledge-based companies in the capital market is confirmed.

Table 10: Estimation Results of the First Research Model

Research variables	Symbol	(- / +)	Regression coefficient	t-statistics	Significance level	VIF
Constant	C	+	0.002411	31.35625	0.0000	-
Technical efficiency	TEV	+	0.000133	4.054126	0.0000	1.018
Expect growth	GROW	+	0.000078	0.73804	0.4609	1.025
Non-cash net operating assets	NOA	+	0.000611	9.112702	0.0000	1.038
Liquidity	LQD	+	0.000107	3.96534	0.0000	1.027
The coefficient of determination	R^2	0.237				
Adjusted coefficient of determination	A_R^2	0.229				
Model estimation	F	30.262 (0.000)				
Watson-Durbin	D − W	2.161				

Table 11: Results of Estimating the Second Research Model

Research variables	Symbol	(-/+)	Regression coefficient	t-statistics	Significance level	VIF
Constant	C	+	0.002516	31.68045	0.0000	-
Technical efficiency	TEV	+	0.00072	7.712443	0.0000	1.133
Expect growth	GROW	+	0.00011	1.026246	0.3054	1.025
Non-cash net operating assets	NOA	+	0.000401	5.756147	0.0000	1.109
Liquidity	LQD	+	0.000106	3.885995	0.0001	1.028
Entrenchment of CEO	CEO ENT	-	-0.0005	- 8.909173	0.0000	1.162
The effect of adjusting the entrenchment of the CEO	TEV × CEO ENT	-	-0.000407	- 3.676984	0.0003	-
The coefficient of determination	R^2	0.549				
Adjusted coefficient of determination	A_R^2	0.427				
Model estimation	F	4.497 (0.000)				
Watson-Durbin	D − W	2.50				

Considering the value of F statistic in Table (11), it shows that the second fitted regression model is also significant at the 5% error level. The value of the Watson-Camera statistic indicates that there is no autocorrelation problem between the waste statements, also, the coefficient of estimation and t-statistic related to the variable of the effect of CEO's fortification adjustment (TE × CEO ENT) at the level of 5% error is negative and significant, which indicates the negative effect of CEO's entrenchment adjustment on product market competition. Therefore, the second research hypothesis that the CEO's fortification moderates the positive impact of technology-based capabilities on the product market competition of knowledge-based companies in the capital market in a negative direction is confirmed.

5 Conclusion

Competition and related capabilities are the main motivation for the growth and development of companies. Increasing competition and improving financial transparency have led many companies to focus their activities on resource-based view, as given the resource constraints in a competitive environment, gaining it through the firm's institutionalized capabilities can lead to a knowledge-based advantage or more productive values. To achieve these capabilities, it is necessary to increase the level of investment in research and technological innovation and strengthen the company's future returns. Companies that have a higher level of these capabilities, in terms of interaction with stakeholders and disclosure of financial information, will usually try to strengthen the level of their competitive functions by timely disclosure of information. Therefore, the purpose of this study is to investigate the impact of core technology capabilities on the market competition of knowledge-based companies in the capital market. In the analysis of the statistical result of the research, which was found, the capability of the core technology based on the resource-based view is considered as a resource against stagnation in a competitive environment and helps the company to maintain flexibility while responding to environmental changes. It is now developing the company's competitive capacity to create new resources or new and innovative products. And make the future of the company more attractive to stakeholders with greater returns and control of potential risks. In other words, companies with technology-based capabilities seek to create value and maintain the dynamism of product market competitiveness through investment in research and development. Because the capability of technology-based technology based on technical efficiency, which is done by investing in technology for the company, based on creating a fit between the company's internal processes and market needs, enables the creation of coherent knowledge based on acquired technologies for the company. Technology-driven capacities are non-transferable or imitated by competitors. Under these conditions, a kind of competitive function or advantage is created for the company, which expresses a company's unique understanding of the processes that can be developed in the market, which is the result of creating dynamism in the previous knowledge and creating new knowledge. Accordingly, according to the distinctive market and technology characteristics of knowledge-based companies active in the capital market, the technological capability will be imitated and non-transferable. And this can be the main source of competitive advantage in the product market, because such a company will be able to develop its products, gain more market share and thereby expand its territory and position in the market. On the other hand, it should be noted that companies with technology-based capabilities, by integrating, configuring and reorganizing and adapting existing resources with desirable resources in response to environmental changes, it seeks to maintain its level of competitive performance in the product market and thus, based on innovation, greater sustainability in terms of product life cycle. Create themselves in relation to competitors through the existence of irreplaceable knowledge. The result of this hypothesis with the research of Dutta et al [50]; Barney [27] and Fung [10] confirm the results of this study. The result of testing the second hypothesis of the research, however, showed that managerial fortification moderates the positive effect of technology-based capability on product market competition in a negative direction. In other words, due to the existence of strong layers of maintaining managerial ownership in the company structure, research and development is practically neglected as a costly function and management tries to maintain information in the company's performance, only information. Demonstrate that it can pursue short-term goals while maintaining relative shareholder satisfaction. In this situation, the company's competition in the product market is practically disrupted and in the long run can reduce the company's competitive position. Because the existence of management entrenchment considers any effort for research and development of the company in various fields such as core technology, as costly. And this causes the company to lose its position among other competitors in the long run due to managerial uniformity under the conditions of not gaining an advantage in a competitive market. The result obtained by the research of Lin et al (2020); Corresponding to Marouan [55] and Tirole [57]. Based on the obtained result, it is suggested that in order to strengthen the capability of technology-oriented companies in knowledge-based companies, all capacities of knowledge resources of research and development teams should be used. Because these teams, as cross-border teams, will be able to identify the changing environment and market capabilities, provide reliable information to the company based on which to develop technological infrastructure and knowledge to advance its competitive goals. It is also suggested that specific regulations and instructions on how to select and the term of office of the CEO be developed to while protecting the rights of shareholders and investors, a more coherent framework of the company's performance in reducing the agency costs gap should be created, and through this, first, more accurate evaluations of the performance of companies, especially corporate managers, should be done by organizations and regulatory bodies. And secondly, it increases the level of investment attractiveness in the capital market. Lack of specific regulations regarding the tenure of the CEO of the same tenure of auditors can reduce the level of operational transparency of companies.

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