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Providing a Hybrid Strategy Based on the Theory of Turbulence and Price Acceleration in the Iranian Stock Market

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ABSTRACT

Stock prices are influenced by economic, technological, psychological, and geopolitical factors. A literature review in this field reveals that stochastic approaches, trend analysis, and econometrics have been employed to examine stock market dynamics and forecast prices. However, these techniques fail to provide a comprehensive understanding of market dynamics. They disregard the temporal relationship between these factors and are unable to capture their cumulative effects on prices. In order to bridge these gaps, this study integrates chaos theory and continuous data mining based on price acceleration, resulting in the development of a new price forecasting method called the Dynamic Stock Market Recognition Simulator. This method combines two approaches: one involves incorporating delay structures or time intervals into the dataset, while the other entails selecting new variables to account for the market environment. The results demonstrate that the proposed method can effectively forecast long-term stock prices using a small dataset with limited dimensions.

1 Introduction

Technical analysis is a method used to predict market prices by examining past market conditions. By analyzing price changes, fluctuations, transaction volumes, and supply and demand, future price movements can be anticipated. This approach is widely employed in foreign exchange markets, stock markets, and the market for precious metals such as gold. Unlike fundamental analysis, which focuses on intrinsic value, technical analysts utilize charts and other tools to identify patterns that can forecast future stock behavior. This analysis involves studying past price movements and stock volumes to determine future price trends. Technical analysis is primarily employed by speculators seeking to increase their desired returns when stock prices rise. It is a short-term perspective used by investors. The technique relies on testing past prices and futures exchange volumes to predict prices. The analysis relies on the use of graphs and mathematical and geometric relationships to identify both minor and major trends, ultimately enabling the estimation of market fluctuations and identification of buying or selling opportunities [1]. The

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application of chaos theory demonstrates that chaotic time series often exhibit intermittent cycles and strong trend behavior. These cyclical patterns can be identified, but their start and end times are unpredictable. Positive returns follow positive returns, and the same is true for reverse returns, but the transition from one stage to another is sudden and unpredictable. Chaos and fractal theory aim to study the nonlinear periodic behavior of a system's sensitivity to initial conditions, resulting in strange attractors. While chaotic behavior is inherent in a system, if the market exhibits clear and predictable patterns with constant periodicity, these patterns are responsible for long-term memory and the absence of chaotic behavior [9].

One particular analysis based on chaos theory that has not been extensively studied in Iran is Bill Williams' analysis. Bill Williams developed his own trading method to gain a better understanding of market psychology [13]. His approach is based on logically analyzing the market while acknowledging the irrationality of chaos. Williams does not deny the science of turbulence; rather, he views chaos as a higher level of order in which organization arises from random and disordered events. Williams argues that price movements are accidental and unpredictable, causing turbulence in financial markets. He rejects linear trading methods that rely on predicting future prices based on past analyses. Through his research, Williams concluded that standard indicators have limited capabilities due to their linearity. This leads us to the question of whether it is possible to predict key indicators in the Tehran securities market using chaos theory and applying Bill Williams' approach.

2 Theoretical Foundations and Review of the Literature on the Subject

2.1 Chaos Theory

In 1898, Hamard published his valuable studies on the motion of a free particle sliding on a fixed surface without friction and negative curvature. He was able to show that all particle paths are unstable and diverge exponentially from each other. In fact, the divergence of paths from each other is one of the main characteristics of chaotic systems, which is called "sensitive dependence on initial conditions" [6]. Later, other scientists were involved in advancing the theory of chaos. Initially, much of the work done and theorizing was done under the name of orgadic theory. Subsequent studies were conducted under the subject of nonlinear differential equations. Chaos theory has seen rapid progress since the mid-twentieth century, when it became clear that linear theory, which at the time was the dominant theory in the field of system theory, could not explain many of the behaviors observed in practice. In addition, the invention of the computer also played the role of catalyst in the development of chaos theory.

Because many mathematical calculations of chaos theory require a lot of repetition in the calculations, which is practically impossible by hand. One of the pioneers of turbulence theory was Edward Lorenz, who, while conducting his study of weather forecasting in 1961, stumbled upon the phenomenon of turbulence and aroused the scientist's interest in this subject. Currently, chaos theory, which describes, examines, and identifies systems that exhibit complex behavior, is used in many disciplines such as mechanics, cosmology, biology, telecommunications, computer science, meteorology, economics, and science. Finance has a wide application and some consider it as one of the important phenomena of the twentieth century, along with important theories such as relativity and quantum theory. As today, some common tests in chaos theory have evolved from the field of financial research. Also, scientists of other sciences, especially physics, by using the concepts of chaos theory and other concepts used in physics, have created a new branch of interdisciplinary science called physics economics, which discusses the application of chaos theory and analysis. Covers fractal aspects of economic and financial phenomena [15].

2.2 Stock Price Acceleration

In economics, the stock market is a market in which the pricing and buying and selling of goods and securities takes place and in a general classification includes the stock exchange of goods and securities. An exchange or stock market is an organized market that is formed for the purpose of buying and selling stocks or any other type of securities. The stock market is subject to regulations set by the legislature, and in order to prevent disorder and respect the rights of supply and demand parties, it is necessary to comply with them. Today, stock exchanges and securities are the highway of investment and trading in the field of commodity and securities exchanges in the world. The stock market, in the term of economics, is a place where the work of pricing and buying and selling goods and securities is done and is divided into two types of commodity exchanges and stock exchanges [20]. The stock price is the ratio of the total income (loss) from investing in a given period to the capital that was used to obtain this income at the beginning of the period. The stock price includes the change in the principal of the capital (change in the stock price) and the cash dividend receivable. Stock price refers to the set of benefits that accrues to common stock during a period and includes the difference between the stock price at the beginning and end of the period in question, as well as other benefits such as dividends and capital gains. Changes in stock prices and dividends per share over the period have been used to obtain stock returns [13].

Price-to-income ratio, which is the price-to-earnings-per-share ratio, is one of the most important tools for valuing corporate stocks. This ratio is obtained as the market price ratio in terms of the share divided by the annual earnings per share. The price-to-earnings-to-earnings ratio indicates that the company's stock price is many times the amount of cash dividends that the company allocates per share. In other words, this ratio indicates whether the stock price is worth the ratio of the profits it distributes to its shareholders. Capital market investors often refer to stock prices as a means of showing the value of the company. This ratio is the most common ratio in the capital market, which is very important for far-sighted investors. The reason for the popularity of this ratio is its ability to express the market value and earnings per share in the language of a mathematical number. The purpose of this ratio is to express the price relationship that an investor, based on the company's future outlook, pays for the projected earnings per share and expects to return to profitability [10]. Stock price behavior follows two factors: market movement and company-specific information. Market movement, which will be affected by various factors including domestic, foreign, political, etc., and company-specific information that is related to the company's own factors. The firm's profit depends more on company-specific information. The more investor confidence in the firm's profit is more dependent on company-specific information.

In making investment decisions in the stock market, the first and most important factor facing the investor is the price, and examining the trend of stock changes is the most common starting point when buying stocks. Therefore, it is very important to be aware of the factors affecting the stock price. Since the stock price changes under the influence of different factors and each of these factors somehow reduces or increases the stock price, study and analyze each of the factors. It is necessary. Changes in stock prices of companies are affected by various factors, including political and economic factors. One of the factors influencing the stock price trend of a company is the signs and symbols that are reflected in the form of various information from within that company and are available to investors. The major part of a company's stock return is the change in the price of that market share, which is called the change in value. While many factors such as economic and political changes in society, exchange rate fluctuations, shareholder expectations and economic changes and the company's financial situation affect the stock price fluctuations in the market, but it seems that the most important factors are economic changes and the company's financial situation. Financial reflections are reflected [12].

2.3 Presenting the Hybrid Strategy

In this section, a new hybrid strategy based on the theory of turbulence and price acceleration in the Iranian stock market is presented. Following the formation of chaos theory and its ability to explain price behavior in the stock market, the efficient market hypothesis, proposed by researchers such as Fama [5], was challenged. The efficient market assumption is based on the fact that prices react quickly to new information. In other words, stock price changes are random and independent of changes made in the past and based on information from that time. Numerous researches have been conducted in different stock exchanges of the world in relation to market efficiency. The results of most of these researches indicated the inefficiency of the studied stock exchanges. Some of these researches have also shown that there is no specific trend in the studied market and social and economic information quickly affects the prices in the stock market. Research on the efficiency of the Tehran Stock Exchange has not confirmed the hypothesis of market efficiency on the Tehran Stock Exchange. According to some of these results, the Tehran Stock Exchange in a weak form lacks the necessary efficiency, and prices in the stock market do not follow the hypothesis of random patrol, but a traceable trend is seen in prices.

The use of artificial neural networks can predict the price series better than statistical methods, which in itself can be a sign of chaos in this series of wasted data. Despite such evidence, it can be argued that applying chaos theory and dynamic systems theory to explain price changes in stock markets is much more logical than accepting the efficient market hypothesis and the unpredictability of price changes in the stock market. Investment markets include alpha and beta groups. In these markets, there are two groups of analyst investors known as Alpha Group and traders known as Beta Group. The ideological basis of these two groups for buying and selling orders is different. Hence, it is quite obvious that the behavior of both groups in the positive and negative feedback loops affects the market, which can be explained using the theory of turmoil. Securities analysts see stock value as a function of discounted value and their future income stream or price-to-earnings ratio. In this way, they determine the intrinsic stock price for the current period by determining the rate of income growth and forecasting next year's income, and by comparing it with the real prices in the market, they make trades. There are capital markets, speculators or speculators who, unlike analysts and investors who think about future and long-term profits, think about short-term and immediate profits and tend to take advantage of short-term stock price changes. The basis of this group's demand is previous changes in stock prices; Thus, with the initial increase (decrease) in stock prices, this group predicts a further increase (decrease) in stock prices and based on that, they determine their demand (supply) [9].

3 Research methodology

This research, in terms of correlation and research methodology, is of quasi-experimental and post-event type in the field of positive accounting research that is done using real information and because it can be used in the process of using information, therefore, It is a kind of applied research (this research is applied in terms of nature and goals).

3.1 Evaluate systems dynamics and price acceleration

Dynamic systems include the characteristics of evolution and interdependence between variables over time, and to understand and conceptualize it, systems under the control of drastic changes at the organization level and time scales have been used. Dynamic systems are mathematically represented by a basic equation that describes the evolution of variables over time. This equation is in the direction of converting the initial

state in which the variable x in time (t) to a new state x in time (1 + t) which depends on the previous states x (t) and this relationship in the form of relation (1) Has been defined [3].

$$x(t+1) = f(x(t))$$
$$\pi = \left\{q, p | \pi C\mu;\ \Theta;\ \xi = \begin{pmatrix} 0 & -E \\ E & 0 \end{pmatrix}\right\} \quad (1)$$

Where Θ is the acceleration potential, matrix ξ is an alternating metric matrix, E is a unit diameter matrix. As can be seen, conventional equations of acceleration potential are defined as multiples of the acceleration potential:

$$\frac{\partial q}{\partial t} = -\frac{\partial \Theta}{\partial p};$$
$$\frac{\partial p}{\partial t} = -\frac{\partial \Theta}{\partial q}; \quad ;\{q, p\} \in \pi$$

4 Research Findings

Dynamic evaluation of stock price behavior in the Iranian capital market can be in different dimensions, which has been studied as follows:

Stability test: Stagnation is a common trend for many economic and financial data such as asset prices, exchange rates, GDP or gross domestic product, coin and precious metal prices, and stock prices. However, these time series may be fixed by calculating the difference between consecutive observations. Based on previous studies [6], the first method is differentialization to evaluate mana and staticity in fixed series or time mana, based on the assumption that distant observations should not be correlated. Correlation Performance Test (ACF) is the most common method of assessing the correlation between data [14]. When there is stagnation in the process of change, the ACF values quickly increase to zero with a slight increase or decrease to be unstable. A slow decrease in ACF values may indicate that the data are not meaningful and that differentiation is needed to establish meaning. The ACF test shows that when there is no static surface, the static properties are displayed after a differentiation process. The first-order ACF differentiation helps confirm the presence of a white noise (WN) process. White noise occurs when at least 95% of abrupt changes in boundary distance are observed (√2%), while N is the length of the time series [16]. In this study, after first-order differentiation, the results of ACF test showed that the data are within acceptable limits and have a good significance. The time interval shows 1 = k, it is unlikely that the negative changes have a random source. It is difficult to verify that the time series behaves completely randomly. In addition, since most time series in economics cannot be associated with a white noise process [17], this study also hypothesizes that the lack of white noise process in the time series is established.

In this study, three other unit root tests were performed to determine the type of static process. The mentioned tests are: 1) Dickey-Fuller unit (ADF) root test, 2) Phillips-Prone (PP) unit root test and 3) Kwiatkowski-Phillips-Schmidt-Shin unit (KPSS) root test. Tests that have been selected in previous research as appropriate methods for assessing time series stock prices [12]. In order to evaluate the significance of the data in time series analysis, the ADF test uses a regression model based on a distinct first series ($\boldsymbol{y}'_t$= yt – yt-1) $\boldsymbol{y}'_t$, which includes several structures. A delay or interruption is when denoted by (k) and expressed as Equation (2). The main drawback of the test is its low ability to reject the unit root, which is mainly objectified when delay differences are added [11].

$$y'_t = \emptyset y_{t-1} + \beta_1 y'_{t-1} + \beta_2 y'_{t-2} + \cdots + \beta_k y'_{t-k} \quad (2)$$

PP unit root test is popular in the field of mana analysis of financial time series. The regression structures of the PP test are shown in Equation (3) while u_t is the null hypothesis versus the H1 hypothesis and may

be inconsistent [20]. The main advantage of PP test over ADF test is better robustness in defining errors for forms of heterogeneity and heterogeneity among errors.

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \quad (3)$$

The KPSS unit root test is a similar inverse test whose null hypothesis confirms static versus the unit root hypothesis. The KPSS test breaks down time series into static or mania components during Equation (4) and the random patrol test during Equation (4). The KPSS test is a determinant of the Lagrangian coefficient (LM) for the relation test (4), which is defined as follows:

$$\begin{aligned} & y_t = \beta' D_t + \mu_t + u_t \\ & \mu_t = \mu_{t-1} + \varepsilon_t, \varepsilon_t \sim WN(0, \sigma_\varepsilon^2) \\ & KPSS = \frac{(T^{-2} \sum_{t=1}^{T} \hat{S}_t^2)}{\hat{\lambda}^2} \end{aligned} \quad (4)$$

Definitive components in D_t: μ_t are defined as H0, and μ_t is a patrol process with a variance of σ_ε^2 . Therefore, if $0 = \sigma_\varepsilon^2$: H0, this means that μ_t is constant and the null hypothesis is formulated for y_t.
As a reverse test, a large value of p indicates static or non-static data, and a small value confirms the null hypothesis of non-static or non-static [20]. The results of the study during the ADF test rejected the null hypothesis at a level of less than 5% error of the first type and 95% confidence and showed that the data are not consistent. After the first-time differentiation, the test was repeated, the null hypothesis was rejected again, but the accuracy of the data was better than before the differentiation, and the possibility of rejection was at the level of 99% confidence. Admission was accepted. PP unit root test at 90% confidence level and KPPS unit root test at 95% level rejected the null hypothesis before first-time differentiation. The results of the unit root tests mentioned in this research are summarized in Table 1 as follows:

Table 1: Results of single unit root tests

Test	Data	Significant Level	Statistics	Critical Value		
				٪ **1**	٪ **5**	٪ **10**
ADF	**(1)(3)	0/009	-3/06	-3/51	-2/89	-2/58
ADF	***(2)(3)(4)	0/000	-8/48	-3/51	-2/89	-2/58
PP	*(5)	0/000	-2/70	-3/51	-2/90	-2/59
KPSS	**(6)	0/091	0/17	0/12	0/15	0/22

* H0 is rejected at 90% confidence level, ** H0 is rejected at 95% confidence level, *** H0 is rejected at 99% confidence level
(1) interrupt (1), (2) interrupt 1, 3, 9 and 11, (3) intercept added, (4) intercept and trend added, (5) constant deterministic component, (6) constant deterministic component with trend
Therefore, the null hypothesis was rejected and it was concluded that this time series is meaningful and the results obtained support the findings of previous research [6].

4.1 Stability or Randomness Test of Effects

A stable process (with non-random effects) can be described by a set of first-order differential equations that have a unique solution. Therefore, in order to evaluate the non-randomness of the effects of a vector space, it is made directly from the time series and then the uniqueness of the reconstructed vector solution in the phase space is evaluated to distinguish between deterministic and irregular features of random behavior. Oprean [15] presented an experiment that detects definite properties and fixed effects even in very small data sets. The test was evaluated based on a simple question: "If the two points zj and zk are very

close to each other, are their images also close to each other at the points zj + 1 and zk + 1?". These tests are defined mathematically in the form of relations (5) and are as follows:

$$\begin{aligned} &\boldsymbol{\delta_{j,k}} = \left|\boldsymbol{z_j} - \boldsymbol{z_k}\right| \\ &\in_{j,k} = \left|\boldsymbol{z_{j+k}} - \boldsymbol{z_{k+k}}\right| \\ &\boldsymbol{e_{j,k}} = \overline{\in_{j,k}} \qquad for\ j,k,s,t,r \le r + \Delta r \end{aligned} \tag{5}$$

During Equation (5), ($\delta_{j,k}$) is the Euclidean distance between the points of fuzzy space ($z_j - z_k$), (k) is the general orbital delay interval, ($\in_{j,k}$) is the distance between (k) The next point is that along a measured circuit, (Δr) increases the width of the Euclidean size and finally e(r) is the average storage capacity.
Thus, the statistic E, which analyzes the definite structure and fixed effects of a time series, is generated by calculating the cumulative sum greater than e(r), which is measured based on Equation (6) as follows:

$$E(r) \equiv \sum \overline{e(r)} \tag{6}$$

This test examines the possible interconnectedness of the circuits in the reconstructed phase space (with the time series of the main series) and is performed in three steps: 1) First, a set of alternative data is generated. 2) In the second step, an appropriate E statistic is calculated for the main time series with delays in various embedded delays (1 to 8) and alternative data. 3) Finally, the comparative statistic E and the values added to the cumulative statistic of Equation (10) determine whether the time series contains fixed and definite effects. The noticeable separation of the E statistic between the original time series and the alternative data set is a sign of definite behavior or fixed effects. In this study, based on the test results, the definite or fixed effects were accepted at 95% confidence level.

4.2 Alternative Analysis Test

The substitution analysis test is an important method for determining the nonlinearity of time series that can differentiate between a linear random process and a non-Gaussian nonlinear process by evaluating the nature of the fluctuations. Substitution analysis requires the creation of a random data set, called substitution, which preserves the statistical properties of the original data set. In examining the data set during this test, the null hypothesis is that in the time series, "uniform nonlinear evolution has a Gaussian linear trend". The AAFT algorithm is often used to generate random substitutes that have almost the same power spectrum and amplitude distribution as the original data set. A review of the research literature shows that the AAFT substitution analysis algorithm is a powerful method for detecting nonlinear data series. However, bias over a slightly flat spectrum can be created in a completely closed small data set [6].
In this study, to evaluate the dynamic properties of time series, the method introduced by Moffitt [13] was used to overcome the sensitivity of the AAFT algorithm to small data sets. This test calculates the probability of rejecting the false residue at the desired level of significance and determines the production of alternative M sequences in a one-way test based on relation (7) and a two-way test based on relation (7). In this test, K is a positive integer that determines the number of substitutes and at least 19 or 39 items are required in one-way and two-way tests to reach the 95% significance level, respectively:

$$\begin{aligned} &\mathrm{M} = \mathrm{K}/(\alpha - 1) \\ &\mathrm{M} = 2\mathrm{K}/(\alpha - 1) \end{aligned} \tag{7}$$

By estimating the level of statistical significance of the experimental data and comparing it with the successors, the method of evaluating the reliability of the results of experiments related to dynamic changes such as Nigbor's nearest pseudo-representative Lyapunov (λ) and entropy is calculated. The statistical probability that the observed data are obtained from a linear random process modeled by the successors can

be evaluated by rejecting the assumption of the normal distribution of the successors [11]. This level of significance is determined based on Equation (8) as follows:

$$\delta = \frac{|Q_D - \nu_H|}{\sigma_H} \quad (8)$$

Significance level of "sigma" (δ) in substitution analysis tests, which is a dimensionless value, by measuring the difference between the original time series statistics (Q_D) and the mean of the successors (ν_H) divided by their standard deviation (σ_H) It is as a random quantity that the normal distribution of the standard is determined. Then, significant level values are calculated using the complement error function (erfc) for δ by dividing by a fixed value based on Equation (9) as follows:

$$\rho - \text{value} = \text{erfc}(\delta/\sqrt{2}) \quad (9)$$

In this test, the null hypothesis is rejected for values less than 5% of the significance level and $2 \leq \delta$.
An additional test was performed and it was shown that at a significant level of 2% Q_D which indicates that if the statistical values are calculated in a low statistical percentile of at least 100 substitutes so that these substitutes are equal to $(v_1, v_2, \dots, v_n)$, can be used to judge the placement of data at 95% confidence [8].
In this study, based on the above-mentioned test, alternative analysis for the main time series as well as for dynamic changes was performed, and in addition, entropy and the nearest false proximity were investigated. To test the null hypothesis for the original time series, the Boeing [3] method using 19 to 199 alternatives was used. Then, AAFT algorithm was used to generate 199 additional alternatives to investigate the nonlinearity of the change process, using the value of δ and the significance level. The same method was used to test the null hypothesis of no dynamic change by examining 19 alternatives. In both cases, δ ۹ and a significance level of less than 5% were obtained and as a result, the interchangeability of the data series with the alternatives was accepted at the 95% confidence level.
In the one-way test, the null hypothesis that the time series results from a linear random process was rejected at the 95% and 99% statistical confidence levels. In addition, based on the two-way test, hypothesis zero was rejected with 95% statistical confidence but could not be rejected at 99% confidence level. From the obtained results, δ and significance level are summarized in Table 2 and the results show that the null hypothesis with statistical certainty higher than 95% based on these results has a significance level equal to 0.016 and 2 δ 2. As a result, the null hypothesis is rejected at the 95% confidence level and Q_D is in the first percentile of the substitute degree.

Table 2: Substitution analysis of values and significance level

Significant level		Original data		Alternative data			
percent	**erfc(δ/√2)**	**δ**	**Q_D**	**First q**	**First quartile**	**ν_H**	**number**
0/02	0/016	2/4086	-0/06675	-0/0629	0/0274	-0/0007	108

In both experiments, the results showed that the behavior of the original time series is significantly different compared to their substitutes. Therefore, it can be concluded that the long-term series of stock prices does not belong to the Gaussian family of random linear signals and the possibility of using the turbulence process to simulate its behavior can be used.

4.3 The Nearest False Proximity

Dynamic instabilities such as false nearest neighbors (FNN) and entropy can provide valuable information about time series features that determine the structure that governs system dynamics. Two close points of

real neighbors in a reconstructed space are n-dimensional if they are adjacent to each other in n-n and n + 1 dimensional space, otherwise they are false neighbors [13]. The FNN method, first developed by Kaur [10], tests the definite properties of a system and distinguishes between definite and random signals using the E2 (d) function in Equations (15) and (16). While in these relationships, d represents the system dimension, N represents the time series length and $x_{n(i,d)+d\pi}$ represents the reconstructed time interval vectors.

$$E^*(d) = \frac{1}{N-d\tau}\sum_{i=1}^{N-d_\tau}\left|x_{i+d\tau} - x_{n(i,d)+d\tau}\right|$$
$$E_2(d) = \frac{E^*(d+1)}{E^*(d)} \quad (10)$$

For definite signals, the values of E2 (d) fluctuate and fluctuate from one distance. In addition, for some values of dimension d, $1 \neq E2$ (d), while fixed values of E2 (d) are approximately equal to one, indicating definite signals. The results obtained in this study during the above test for stock price acceleration in Tehran capital market showed that the fixed values of E2 (d) are approximately equal to one and as a result of the research findings the definite nature of the time series of stock price acceleration in the period Shows the survey. Table 3 summarizes the sequence of experiments related to flow and group learning and the rules related to them based on what has been said so far:

Table 3: A summary of the simulation settings in the continuous and batch pattern

Template components	**Examples**	
	Batch pattern	**Continuous pattern**
Model	Increasing learning under conceptual drive	Batch learning
Data	DB01_Nt	DB01_Nt
	DB03_Nt	DB03_Nt
	DB01_t	DB01_t
	DB03_Nt	DB03_Nt
Variable refinement techniques	-----	Full dataset
	FIL	FIL
	WRP	WRP
	PCA	PCA
	CTC	CTC
Data processing algorithm	FITMDD	MLP
	AM rules	SMO regeression
	Prospetron	Linear regeression
	------	M5P
	-------	M5 rules
Evaluate model performance	Introductory	Complete data training
Forgetting strategy	ν = 10	-----
Frequency of sampling	Cross-sectional	------

5 Experimental Findings

In this part of the research findings, the performance of adaptive supervised learning algorithms on sliding windows under different data set settings is measured and expressed. The period under review in this valuation is in a period of 10 years in which the stock index is shown in the form of diagram (1) as follows:

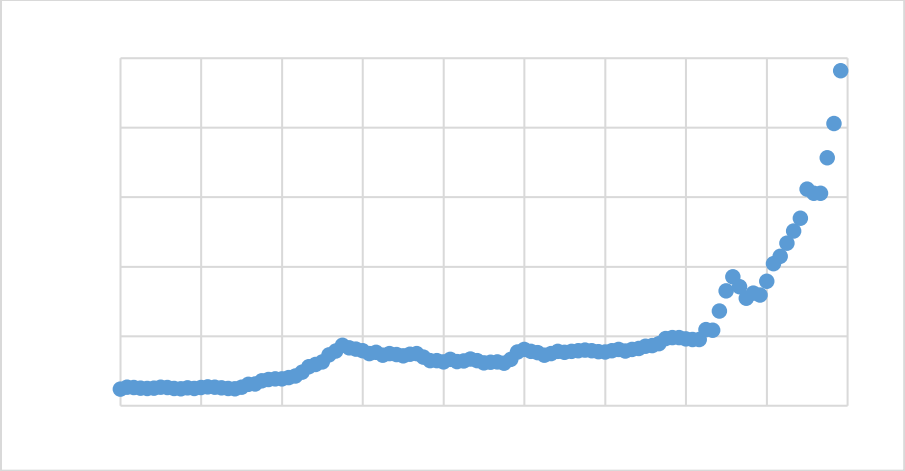

Fig. 1: The general trend of monthly acceleration of stock prices in the period under review (researcher findings)

5.1 Evaluate the Performance of Algorithms

The performance of the algorithms used in the simulation and forecasting of stock prices in the long run based on the combination of chaos theory and price acceleration in each generated data set was analyzed experimentally. The performance of the models was estimated using the preliminary error, which is the most appropriate method in conceptual drift scenarios, and in addition, the RMSE and MAE error measurement criteria were used to evaluate the performance [9]. In this regard, it is assumed that in the analysis of the findings, the lower the RMSE and MAE values, the lower the mean squares and absolute magnitude of errors and, consequently, the better the performance of algorithms and models.

RMSE and MAE criteria: RMSE and MAE values were used as an analysis criterion to compare and determine the predictive performance rating of the 48 experiments performed in this study. Due to the nature of the problem concept drift and the models made, performance evaluation was performed not only for the whole time period but also in the concept drifts. In addition to using these criteria in performance appraisal, this evaluation is also intended to measure the adaptive capacity of models and the effect that changes in ten concepts have for predicting accuracy. Details on concept drift detection and boundary determination are given below.

5.2 Prediction Chart

As mentioned earlier, due to the continuous and increasing learning of the capital market in the real world, the knowledge of experts is important in answering the question of whether the design, configuration and results of predictive models reflect the true evolution of the system [13]. Therefore, in addition to statistical analysis of errors, visual analysis of the evolution of the predicted models in this research is included as "prediction diagrams". Image analysis of forecast charts not only helps to evaluate the performance of models and rank them, but also helps in a special way because of the performance of algorithms. This information provides in-depth insight into the dynamics and learning process of regression algorithms when using small-sized stream data in a market environment due to human behavior. Forecast charts show the evolution of stock price forecasts obtained from each model. Due to conceptual drift, forecast charts were also measured for the entire time period and changes in system concept. This assessment is to assess the ability of the proposed DynamtS Dynamic Stock Market Recognition Simulator (DyMStS) model to predict long-term stock prices based on a combination of chaos theory and price acceleration, as well as support for model performance rating to determine the best Model setting used.

5.3 Evaluation Limits - Drift Detection

Based on the theoretical foundations of statistics and probability, if the distribution is constant, the error decreases but increases as the distribution changes. In the field of regression, the mean of statistical squares is the standard that is used to determine the error. Thus, changes in the RMSE can provide a reasonable understanding of changes in the continuous data distribution and thus concept changes. In this study, these changes were identified using two criteria of RMSE variance and RMSE evaluation.

A) RMSE variance

RMSE diffraction or variance is a statistical test that has been measured in this dissertation to measure the sequence scattering of RMSE values during the incremental learning process. This test involves measuring the absolute percentage of the RMSE difference between two consecutive predictions. According to the two predicted values yt and yt + 1 and their corresponding initial error RMSE t and RMSE t + 1, the diffraction or variance of RMSE is calculated based on equation (17) and as follows:

$$\mathrm{RMSE}_{\mathrm{Disp}} = \left|(\mathrm{RMSE}_{(\mathrm{t})} - \mathrm{RMSE}_{(\mathrm{t}-1)}/\mathrm{RMSE}_{(\mathrm{t}-1)}\right| \quad (11)$$

$RMSE_{Disp}$ values were calculated for all sections of the 16 datasets evaluated in each of the three algorithms. Then, the standard deviation $RMSE_{Disp}$ was calculated for each period and each algorithm. Possible changes to the concept are determined in periods where the standard deviation $RMSE_{Disp}$ is greater than 0.25. This deviation error threshold was determined based on the degree of accuracy required in the feasibility studies for economic investments, which is at the level of plus or minus 25% [6]. Fig. 2 shows the values obtained for $RMSE_{Disp}$ per algorithm. Examination of the results obtained in diffraction analysis shows that, in addition to large values at the beginning of the time series, which is normal in the preliminary error, three drifts have been identified. The first case is identified by three algorithms. The second case is identified by Perceptron algorithm and the last case in the year is identified by Perceptron algorithms and AM rules:

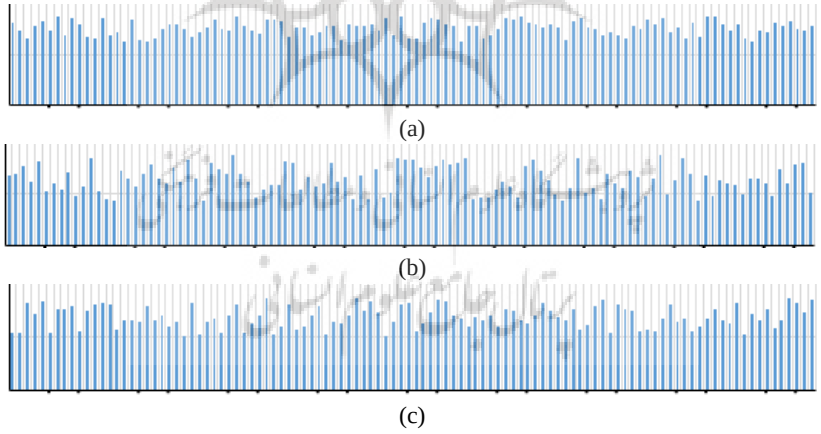

Fig. 2: Algorithm error analysis: a) Prospectron, b) FITMDD and c) AM rules

B) RMSE evaluation

This test includes a visual analysis of the RMSE evolution to detect changes in the concept taught. The initial RMSE values obtained for the incremental learning process are plotted from year to year and show sudden changes in the RMSE of possible drifts. Fig. 3 presents the RMSE variations of the nine models that are evaluated according to the best three RMSEs obtained from each algorithm. All models show a sudden drop in RMSE in the beginning and then a sudden drop in perceptron-based models (Part A). Most models have shown a sudden increase in RMSE in 2014 (paragraph b).

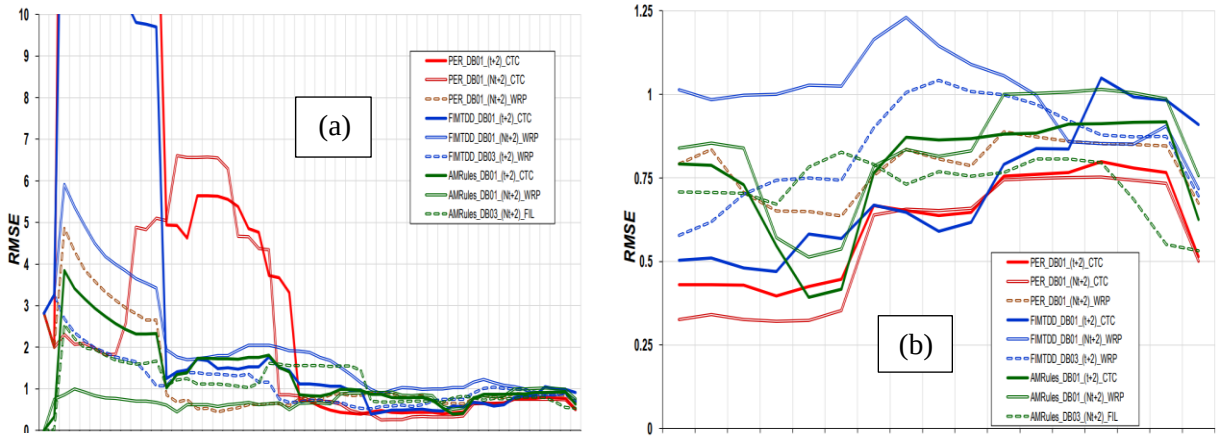

Fig. 3: Preliminary evaluation test in the evaluation of continuous algorithms a) 2011-2019, b) 2015-2019

Visual assessment confirms the drifts detected in the previous test. Therefore, these three periods are considered as boundaries to evaluate the performance of models over time. Therefore, the performance of algorithms and models was measured in four periods: 1) all data (2010-2011), 2) Drift_01 (2010-2011), 3) Drift_02 (2014-2015) and 4) Drift_03 (2014–2020)

6 Conclusions and Suggestions

Capital market growth has been crucial for the economic, technological and social development of human society because capital market activities in attracting and directing capital provide for all market factors, including governments, companies and society. Given the impact of stock prices and its trend on the attractiveness and prosperity of this market, understanding the long-term dynamics of stock prices to predict price behavior for all market factors is very important. However, the economic problem is characterized by a continuous learning process that gains experience over time. Therefore, forecasting stock prices in the long run is a complex task due to the widespread influence of economic, financial, political and psychological factors that are inherently evolving and time-related.

Economic theory provides meaningful guidelines for understanding the long-term behavior of markets by stating that market prices are essentially determined by the balance between supply and demand. However, the supply side can be predicted through legal constraints and corporate conditions, but it is difficult to predict the demand for stocks because it is mainly influenced by psychological factors that take the form of preferences, demands and expectations on political decisions. Affect financial strategies and investor preferences. Psychological factors are the results of a unique human cognitive process that, for adaptation and problem solving, can collect, record, classify, process, and store information for decision making over time. The results of data mining and simulation indicate that the application of turbulence theory may be further explored and used to find stock price prediction models. Based on these results, we can make two main recommendations in the field: a) performing numerical and visual analysis of the results and b) monitoring of experts in this field, including in selecting the initial variables or validating the final results. Therefore, it is recommended to capital market analysts and at least legal investors:

Evaluating the dynamics of a small yet large-sized data set based on a combination of numerical and visual analysis is needed to identify the patterns that govern the system and its descriptive parameters. Therefore, a common numerical and visual analysis is critical to discarding any conclusions that seem theoretically consistent but are in practice incorrect. Given the temporal nature of the increasingly adaptive learning

process that takes place in markets, the experience of experts has helped to reconstruct the dilemma of stability-resilience that exists for humans and the market, and a good balance between learning new knowledge and retaining or forgetting old knowledge. The results obtained from each research can be interpreted and applied in the context of limitations related to data type, data collection pattern, assumptions and inference method. The most important limitations that the users of this research should pay attention to in using or applying the obtained results are:

In this study, on the one hand, the studied data in relation to variables were selected non-randomly and random sampling was not objectified. Chaos has been exploited. Based on this, the inference in the research is descriptive, the design and testing of the hypothesis and the application of hypothesis testing methods such as hypothesis testing have not been used, which generalizes the findings to a level beyond which it is meaningless. However, in similar studies, the proposed model can be used as a predictive tool and the validation of the model in this field can be examined.

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