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Modeling Stock Price Synchronization via Institutional Investor Behavior: An Evolutionary Game Theory Approach

Omid Majdabadi [1], Mehdi Zeynali [2*], Roya Alomran [3], Yones Badavar Nahandi [4]

[1] *Department of Economy, Tabriz Branch, Islamic Azad University, Tabriz, Iran*
[2] *Department of Accounting, Tabriz Branch, Islamic Azad University, Tabriz, Iran*
[3] *Department of Economy, Tabriz Branch, Islamic Azad University, Tabriz, Iran*
[4] *Department of Accounting ,Tabriz Branch, Islamic Azad University, Tabriz, Iran*

Abstract

This paper presents a stock price synchronization model based on institutional investor behavior using evolutionary game theory, with a specific focus on the Tehran Stock Exchange as a representative emerging market. Factors influencing investor decisions include potential gains or losses and the economic costs associated with their behavior. The evolutionary game model analyzes dynamic equations and simulates evolutionary equilibrium strategies under various conditions. The analysis reveals that operational costs for institutional investors, the cost of gathering information before trading, and anticipated losses are key factors affecting the evolutionary game system between institutional and individual investors. Additionally, reducing market speculation and increasing investors' access to information—through enhanced performance of institutional investors and strengthened market information disclosure mechanisms—are effective in decreasing stock price synchronization in the market. The choice of the Tehran Stock Exchange for this research highlights its unique characteristics and position as an emerging market, providing a valuable context to examine the impact of institutional investor behavior on market stability.

Keywords: Institutional investors, individual investors, evolutionary game theory

1- Introduction

Attracting small investments and idle domestic funds and directing them towards productive and industrial activities is essential for achieving economic growth and development. In this context, financial markets have emerged in two forms: the money market, which provides short-term credit, and the capital market, which provides long-term credit (Nozari et al., 2024; Fallah & Nozari, 2021). The Tehran Stock Exchange, as one of the pillars of the capital market, plays a significant role in shaping the flow of financing and investment, which is crucial for increasing the country's

* Corresponding Author
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production and, consequently, its advancement. It is often stated that a country's development is directly related to the thriving stock market and the number of its shareholders. The proper shaping of this flow is driven by market forces. Providing accurate and timely information to investors can enhance the stock market's prosperity, ensure the continued presence of investors by protecting their interests, and create a foundation for the optimal allocation of limited economic resources to more profitable projects, thereby contributing to the growth and flourishing of the national economy (Movahed et al., 2023).

In recent years, the influence of institutional investors—such as pension funds, banks, insurance companies, holdings, investment firms, capital supply companies, and governmental entities—has become prominent. Institutional investors significantly affect market efficiency and transparency, both of which are critical to investor trust and market stability. Transparency in financial information, a major concern for investors, guides investment strategies and affects how investors participate in the stock market. Transparent and accessible financial reports enable potential and current investors to make informed decisions regarding buying, selling, and investment.

Research has underscored the role of institutional investors as monitors of corporate performance, influencing stock price behavior and corporate decisions (An & Zhang, 2013). Studies also highlight their informational impact on stock prices, returns, and even the risk of stock price crashes (An & Zhang, 2019;Kalogeras, 2021). For instance, Roll (2020) found that only a small portion of stock price movements align with public news, which occurs concurrently with stock price changes. To gauge the degree of firm-specific information that reaches the market and is reflected in stock returns, researchers use a metric known as stock price synchronization (Hatten et al., 2020). Stock price synchronization measures the extent of firm-specific information in a stock's price; lower synchronization indicates a greater reliance on company-specific information rather than broader market movements.

This study aims to address the following research question: How does institutional investor behavior impact stock price synchronization in the Tehran Stock Exchange, and what implications does this have for market stability? To answer this question, we construct a synchronization model of stock prices based on the behavior of institutional investors using evolutionary game theory. The objective is to analyze the dynamics between institutional and individual investors, focusing on factors such as operational costs, information-gathering expenses, and expected losses. By simulating equilibrium strategies under varying conditions, this research seeks to reveal how institutional investors influence stock price behavior. This analysis will also investigate the impact of increased transparency and reduced market speculation on the alignment between stock prices and firm-specific information, thus contributing to a deeper understanding of institutional investors' role in enhancing market resilience and efficiency.

2- Literature Review

Institutional investors, as a group of investors with access to vast financial resources, play a significant role in the economic development of the capital market and are one of the effective mechanisms for external control over corporate governance. The emergence of institutional investors as capital owners has become increasingly important in corporate governance systems. Institutional shareholders have the potential to influence managerial activities indirectly through ownership and directly by trading their shares. These investors, by participating in companies, take effective actions to resolve agency problems between managers and shareholders. By increasing oversight and control over managerial activities, they enhance managers' accountability to shareholders and other stakeholders, thereby promoting corporate governance.

The presence of an appropriate corporate governance system can help companies attract investor confidence and encourage them to invest, and the implementation of these principles at the company level leads to improved financial performance. This is because managers are motivated to present a favorable image of the financial status of the business unit to shareholders and other stakeholders, in line with maximizing their personal benefits, social welfare, and job security. However, in some cases, the increase in managers' wealth may not necessarily align with the wealth increase of other groups, including shareholders. Considering the theory of conflicts of interest between managers and owners, managers of business units have the necessary motivations to manipulate profits to maximize their interests. Managers may have incentives to present the company's situation positively and, due to their managerial authority in presenting reports, have opportunities to implement such practices. To present their performance in a better light, they seek to distort information. On one hand, they describe the company's situation favorably through profit manipulation, and on the other hand, they diminish the transparency of information.

Johnson defines stock price synchronization as "the degree to which market and industry information is reflected in a company's stock price." Dornfeld, Murk, and Young (2003) and Petrusky and Rollston (2004) define stock return synchronization as "the extent to which market and industry returns explain the changes in a company's stock returns." Based on these definitions, it can be said that synchronization of prices is equal to the ratio of systematic risk to unsystematic risk. The behavior of stock prices is influenced by two factors: market movement and firm-specific information. Market movement is affected by various factors, including internal, external, and political issues, while firm-specific information relates to the company's internal factors.

Investor trust in a company's profits is more dependent on greater firm-specific information. The higher the investor's confidence in a company's profits, the greater the dependence on firm-specific information. If the correlation between company returns and market returns (price synchronization) is low, this indicates a higher presence of firm-specific information. Therefore, a lower synchronization of stock returns among companies reflects that their prices are less dependent on market movements, as there is a larger amount of firm-specific information that market participants can rely on. Roll (2020) stated that the lack of explanatory power increases firm-specific information. He clarified that stock movement depends on the relative amount of company and market information reflected in stock prices.

It is important to note that explanatory power includes market and industry indices, which encompass the relative amounts of market, industry, and firm-specific information reflected in stock prices (Johnson, 2009; Coelhoso et al., 2022), while synchronization of a company's stock price generally includes an index of a market and an industry. Logically, the use of price synchronization in cases where returns and company characteristics are determined by multiple factors can serve as a criterion for firm-specific information. R^2 can be used as a measure of firm-specific information. As relatively more firm-specific factors are reflected in the price, market beta decreases while lambda increases. An increase in lambda increases the variance of the pricing model's errors, which reduces R^2. Additionally, a decrease in market beta reduces the variance of the predicted values, thereby decreasing R^2. Roll (2020) found that when days on which the company is mentioned in financial media are removed, R^2 improves.

In this section, we discuss the formulation of an evolutionary game model for the investment behavior of institutional and individual investors. The assumptions of the base model classify investors in the stock market as institutional investors (O) and individual investors (I). They select and adjust their strategies in the space of possible strategies based on expected returns.

In the face of investment opportunities, the strategy space for institutional investors includes capital injection (M) and non-capital injection (NM), while the strategy space for individual investors comprises imitation (F) and non-imitation (NF). To open positions, institutional investors purchase shares in batches from individual investors at lower prices. They then gradually raise the stock prices, encouraging investors to continue observing. As stock prices rise gradually, initially cautious individual investors become attracted to high returns and begin purchasing shares from institutional investors in small amounts. However, since the overwhelming majority of individual investors are risk-averse, institutional investors continue to neutralize the market sentiment and persist in injecting capital to enhance the investment environment for individual investors (Kalogeras, 2017, Kalogeras,2019).

When significant and positive news is announced, or if the overall stock market is performing well, institutional investors take advantage of this opportunity to rapidly increase stock prices. Relying on the buying behavior of individual investors, institutional investors continue to sell their shares before a price drop occurs, thus realizing final profits. Based on this analysis, the expected profit for institutional investors is defined as $RM-CM$, where RM represents the expected profit from capital injection and CM indicates the expected costs. For individual investors, we posit that their profit depends on the timing of their sales, represented as $R0 - \beta RM$ 0−β, where $\beta \in [-1,1]$. When $\beta > 0$β>0, it implies that individual investors sell their shares too late, and imitation leads to a loss of profit. Conversely, when $\beta < 0$β<0, it means that individual investors sell shares at the right price, and imitation yields positive returns. Institutional investors cannot profit from manipulating stock prices, but they still need to cover their expected transaction costs CM. Thus, the expected profit for institutional investors is $RM-$.Individual investors decide not to follow this path, meaning they invest independently and can earn specific profits. Therefore, the expected return for individual investors is $R0$. When the market is in recession or the market situation is uncertain, institutional investors abandon intensive initial investments and employ investment strategies to preserve capital. Although at this time individual investors choose to imitate investment behavior, this behavior is limited by time, capital, and other factors, and it cannot significantly impact the returns of institutional investors. Consequently, we assume that the returns for institutional investors are $R1$. In contrast, since most shares selected by institutional investors at this time are intended to preserve asset value, we assume that the returns for individual investors at this time are $\delta R1$, where $\delta \in [0,1]$ represents the profit derived from imitation of institutional investors. Based on the above content, this research will answer the following questions:

If institutional owners do not invest, will individual investors imitate them?

If institutional owners do invest, will individual investors imitate them?

Dong et al. (2020) examined the evolutionary game model of stock price synchronicity in relation to investor behavior. The proposed game model was analyzed using repeated dynamic equations and simulations of evolutionary equilibrium strategies under various conditions. The analysis indicates that the operational costs of institutional investors, the costs of gathering pre-trade information, and expected losses are key factors that influence the evolutionary game system between institutional and individual investors. Furthermore, reducing speculation in the market and increasing investors' access to information through the serious actions of institutional investors and strengthening market information disclosure mechanisms are beneficial for reducing price synchronicity in the stock market.

Fakhari and Taheri (2010) investigated the relationship between institutional investors and the volatility of stock returns. The results of their research show that the presence of institutional investors increases oversight of managerial performance, reduces information asymmetry, and ultimately decreases the volatility of stock returns as the percentage of ownership by these shareholders increases.

Kamiabi (2016) studied the relationship between institutional investors and stock price synchronicity in companies listed on the Tehran Stock Exchange. The findings of the research indicate a significant negative relationship between institutional investment and stock price synchronicity. Moreover, the results show that there is a significant negative relationship between the stability of institutional investors and stock price synchronicity, while a significant positive relationship exists between the instability of institutional investors and stock price synchronicity.

Ebrahimi Sorooleya et al. (2017) examined the determinants of individual shareholders' behavior on the Tehran Stock Exchange based on structural equation modeling. This research aimed to expand the scientific literature in the country regarding the factors affecting the behavior of individual investors, thus providing an approach for clarifying their decision-making in the Tehran Stock Exchange. After conducting a thorough and comprehensive review of the scientific literature, the initial conceptual framework was subjected to expert opinions using the Delphi method. Following the third round of Delphi, theoretical saturation in consensus and convergence of responses led to the finalization of the research framework. The research then conducted a survey to gather opinions from individual investors on the Tehran Stock Exchange regarding the factors influencing their behavior and ultimately employed structural equation modeling to elucidate the determinants of individual investors' behavior on the Tehran Stock Exchange.

Najafi Moghadam (2017) studied stock price synchronicity and the role of institutional investors in the Tehran Stock Exchange. In this study, 42 companies were examined over the period from 2010 to 2014 (data from 2009 was also considered to estimate the results for 2010). Subsequently, within the framework of a panel data model, the relationship between institutional investors and stock price synchronicity, as well as the risk of stock price decline, was investigated. It was determined that the presence of institutional investors has a significant negative relationship with stock price synchronicity and the risk of stock price decline in the Tehran Stock Exchange.

3- Research Methodology

In this study, the statistical population consists of companies listed on the Tehran Stock Exchange. The time period considered for the research is based on the maximum available information from 2014 to 2019 (Persian calendar years 1393 to 1398). The statistical sample includes all companies that meet the following conditions:

1. Homogeneity of the Sample: To ensure the sample's homogeneity during the study years, companies must have been accepted on the Tehran Stock Exchange before 2014 and must have been continuously present on the exchange from 2014 to 2019.

2. Financial Year Alignment: To enhance the comparability and uniformity of the selected companies, their fiscal year must end on March 20 of each year.

3. Exclusion of Financial Companies: Due to unclear boundaries between operational and financial activities of financial companies (investment and brokerage firms), these companies are excluded from the sample.

4. Activity Continuity: Companies should not have ceased operations for more than six months or changed their financial periods during this time.

5. Minimum Industry Representation: The number of companies in each industry during the period from 2014 to 2019 should not be less than nine.

6. Data Availability: The necessary data must be accessible.

Operational Definitions of Variables:

1. Dependent Variable: Stock Price Synchronicity

In this research, stock price synchronicity is considered as the dependent variable. To measure stock price synchronicity, first, the R^2 for company i in fiscal year t is calculated using the extended market regression model in the following equation:

$$r_{i,k,w} = \alpha_i + \beta_i \, . r_{m,w} + \eta_i \, . r_{k,w} + \varepsilon_{i,w}$$

Model (1)

In this model, $r_{i,k,w}$ represents the return of company i in industry K during week W, $r_{m,w}$ is the weighted market return in week W, and $r_{k,w}$ is the weighted return of industry K in week W.

Since R2 falls within the range of 0 to 1, to obtain a distribution closer to normal, following the studies of Piotroski and Roulstone (2004), Morck, Yeung, and Yu (2000), and Johnson (2009), the natural logarithm of R2 is used to define the stock price synchronicity variable, denoted as SYNCH.

$$SYNCH_{i,t} = \ln \left(R2_{i,t} / (1-R2_{i,t}) \right)$$

2. Independent Variable: The percentage of institutional investor ownership (IO)

This represents the proportion of the common stock of the sample company that is owned by institutional investors. To calculate this, the number of shares held by institutional investors is divided by the total number of common shares of the company at the beginning of the period (end of the previous period). In other words, the number of shares held by institutional investors is divided by the total number of outstanding shares at the end of the year. For each institutional investor, this ratio must be greater than or equal to 5% of the company's total shares. $(I/T) \geq 5\% = IO$

Where:

- IO: Percentage of institutional investor ownership
- I: Number of common shares held by institutional investors
- T: Total number of common shares at the beginning of the period

Individual Investors (I): These are private individuals or entities that own more than 50% of a company's shares. Companies where ownership has been transferred according to Article 44 and are classified as non-governmental fall into this category. In other words, the company is neither state-owned nor publicly beneficial.

When calculating the return matrix, we must compute the equilibrium point of this evolutionary process. Suppose that within the group of institutional investors, the proportion of capital injection decisions is denoted as where X $(0<X<1)$ and the proportion for the decision to not trade is $(1-X)$. In the group of individual investors, the proportion of imitation decisions is represented by where y $(0<y<1)$ and the proportion for no restrictions is $1-y$.

Variables:

RM: Market return (percentage change in the cash dividend and price index)

R0: Risk-free return (annual interest rate of state-owned banks announced by the central bank)

CM: Cost of capital

Given that measuring and calculating the cost of capital was one of the most challenging aspects of this research, the Gordon Growth Model was selected to calculate the cost of equity, as access to the necessary data for calculating equity cost was available. According to the Gordon Growth Model (Damodaran, 2002), the cost of equity is calculated as follows:

In this model, assuming k represents the cost of equity capital (expected return rate for common shareholders), k can be derived from the following equation:

Equation (2):

In the above model:

D1 is the dividend paid at the end of the first year,

P0 is the price per share at the beginning of the year,

g is the dividend growth rate, which is obtained from the following equation:

Equation (3):

$R=[(1+ \alpha i.t+\beta i,t). Pi,t-Pi, t-1+DPSi,t- \alpha i.t .I] / Pi$

Ri,t: The actual return of company i in period t,

αi,t: The percentage of capital increase from cash contributions and receivables,

βi,t: The percentage of capital increase from retained earnings and reserves,

Pi,t: The stock price of company i at the end of the period,

Pi,t-1: The stock price of company i at the beginning of the period,

DPSi,t: The dividend paid by company i in period t,

I: The subscription price per share..

$uOM = y (RM - CM)+(1 - y) R1 - CM = (RM - R1) y +(R1 - CM)$ (1)

The expected return for institutional investors who choose not to inject capital is:

$uONM =R1.$ (2)

Based on equations (1) and (2), the average expected return for institutional investors is expressed as follows:

$uO= xuOM +(1 - x)uONM$

$X[(RM - R1)y +(R1 - CM) +(1 - x)R1. \quad =$

The average expected return for individual investors can also be expressed in the following equation:

$uI = yuIF +(1 - y)uINF$

$= y [x (R0 - \beta RM) + (1 - x)\delta R1] + (1 - y)R0.$

The equation indicates that the growth rate of the number of institutional investors choosing the capital injection strategy is equal to the expected return (uOM) minus the average expected return (uO). Thus, the equation represents the dynamic repetition of the selection process for institutional investors to inject capital.

$=x(uOM - uO)x=(1 - x) (uOM - uONM) \quad X=dx/dt(5)$

$=x(1 - x)[y (RM - R1) - CM]$

The dynamic equation for the repetition of the imitation selection process of individual investors is as follows:

$Y=dy/dt \quad =x(uIF - uI)x=(1 - x) (uIF- uINF) \quad (6)$

$=y(1 - y) x(R0 - \beta R M) +(1 - x)\delta R1 - R0$

$=y(1 - y)[x(R0 - \beta R M- \delta R1) +\delta R1 - R0$

Based on equations (5) and (6), the two-dimensional dynamic system of the evolutionary game model can be expressed in the following equation:

$F(x) =dy/dt \quad =x(1 - x)[y (RM - R1) - CM]$

$G(y)= dy/dt=y(1 - y)[x(R0 - \beta R M- \delta R1) +\delta R1 - R0 \quad (7)$

According to dynamic system theory, the game system reaches a partial equilibrium under the following conditions: the learning rate of the strategy for all parties involved in the game remains constant. This means that the result of repeating the dynamic equation is 0. Therefore, by combining A and B, the system exhibits five local equilibrium points, namely:

E1(0, 0), E2(0, 1), E3(1, 0), E4(1, 1), E5(x1, y1).

Among them, $x1 = ((\delta R1 - R0)/(\delta R1 + \beta RM - R0))$ and $y1= (CM/(RM - R1))$.

Stability Analysis of Equilibrium Points

The equilibrium point obtained through the repetition of the dynamic equation is not necessarily the evolutionary stable strategy (ESS) of the system. Following the method proposed by Friedman, the stability of the equilibrium points of the two-dimensional dynamic system can be analyzed by examining the Jacobian matrix (denoted as J) of the system:

J= ■(∂F/∂x&∂F/∂y@∂G/∂X&∂G/∂Y)

$a11 = (1 - 2x)[y(RM - R1) - CM],$

$a12 = x(1 − x) (RM − R1)$, $a21 = y(1 − y)(R0 − βRM − δR1)$, و$a22=(1-2X)[X([x(R0 − βR M-δR1) +δR1 − R0]$

The equilibrium point of the repeated dynamic equation is a sufficient condition for the evolutionary stable strategy (ESS):

$trJ =a11 + a22 < 0$ (9)

detJ=■(a11&a12@a21&a22)= $a11a22 − a12a21 > 0$.   (10)

To determine whether the five local equilibrium points meet the aforementioned conditions, we first calculate the value of the Jacobian matrix at each local equilibrium point.

Table 1: Jacobian matrix

Equilibrium Points	a11	a12	a21	a22
E1(0, 0)	− CM	0	0	δR1 − R0
E2(0, 1)	RM − CM − R1	0	0	− δR1 + R0
E3(1, 0)	CM	0	0	− βRM
E4(1, 1)	− RM + CM + R1	0	0	βRM
E5(x1, y1)	0	A	B	0

$A= x1(1 − x1)(RM − R1)$

$$= \frac{(\delta R1 - R0)\beta RM\,(RM - R1)}{(\delta R1 + \beta RM - R0)2} \quad (11)$$

$B = y1(1 − y1) (R0 − βRM − δR1)$

$=(CM (RM - CM - R1)(R0 - βRM - δR1))/((RM - R1)2)$

4- Research Findings

Given that at point E5(x1,y1), a11+a22=0+0=0 equation (9) is not satisfied. Therefore, point E5(x1,y1) cannot become an ESS. Consequently, we only need to consider the other four local equilibrium points. Specifically, we can derive the following five propositions:

Proposition 1. When $R0 > δR1$ and $δR1 < CM + R0$, the ESS of the system is E1(0, 0).

If the ESS of the E1 system is (0, 0), equation (9) is equivalent to $CM - δR1 + R0 > 0$, which means that $δR1 < CM + R0$

Similarly, equation (10) is equivalent to $(- CM)(δR1 - R0) > 0$, from which we can also derive $R0 > δR1$. Therefore, when $R0 > δR1$ and $δR1 < CM + R0$, the ESS of system E1 is (0, 0).

Proposition 2. When $RM < CM + R1$ and $R0 < δR1$, the ESS of the system (1) is E2 (0.

If the ESS of the E2 system is (0, 1), equation (9) is equivalent to $RM - CM - R1 + (-\delta R1 + R0) < 0$, which can be

$RM < CM + \delta)$ to extract $R1 - R0$. Equation (10) is equivalent to $(RM - CM - R1)(-\delta R1 + R0) > 0$ Therefore, this condition must satisfy $RM < CM + R1$ and $R0 < \delta R1$ or $RM > CM + R1$ and $R0 > \delta R1$ with this Now, when we combine $RM > CM + R1$ and $RM < CM + (1 + \delta)R1 - R0$, we get $CM + R1 < RM < CM + (1 + \delta)R1 - R0$, which obviously does not follow the previous rule $R0 > \delta R1$, therefore, taking into account the equivalence and compatibility conditions of equations (9) and (10), ESS when there exists $RM < CM + R1$ and $R0 < \delta R1$, the system E2 (0, 1) shows simultaneity.

Proposition 3. When $RM > (1/(1 - \beta))(CM + R1)$ and ESS, $\beta < 0$, the (1,1) system is E4.

If the ESS of the E2 system is (0, 1), equation (9) is equivalent to $- RM + CM + R1 + \beta RM < 0$, from which we can get $RM > (1/(1-\beta))(CM + R1)$ to extract Equation (10) is equivalent to $(- RM + CM + R1)\beta RM > 0$, which must be satisfied either $RM < CM + R1$ and/or $RM > CM + R1$ and $\beta < 0$. However, the condition $RM > (1/(1-\beta))(CM\ R1)$ is incompatible with the condition $RM < CM + R1$. Therefore, when $RM > (1/(1-\beta))(CM + R1)$ and $\beta < 0$, ESS, $\beta < 0$ is a (1,1) E4 system.

Proposition 4. When $RM>CM + R1$, $R0 <\delta R1$, and $\beta>0$, ESS is not evident.

Proposition 5. According to Propositions 1, 2, 3, and 4, there are two non-discussed ranges. The first is $R0 <\delta R1$, $RM >CM + R1$, and $\beta > 0$, and the second is $R0 <\delta R1$, $RM >CM + R1$, and $RM > (1/(1-\beta))(CM + R1)$. However, the latter requirement is actually equivalent to the former. Therefore, we only need to look at each of these equilibrium points under this constraint. Combined with the previous analysis, it can be seen that E1(0,0), E2(0,1), E3(1,0) and E4(1,1) are not ESS of the system, therefore, there is no ESS.4. Results

To further describe the mechanism of price synchronicity in the stock market from the perspective of investor behavior, we utilize MATLAB software for simulating and analyzing the evolution of stable strategies of these two types of investors in the stock market.

When $R0 > \delta R1$ and $\delta R1 <CM + R0$, the evolutionary behavior of the system is as follows:

Assuming $RM = 2$ ‹$CM= 1$ ‹$R0 = 0.5$ ‹$R1 = 1$ ‹and $\delta =0.3$, the above conditions are satisfied. Figure 1 illustrates the results of the simulation program. The increasing number of stages in the evolutionary iteration leads to a gradual decline in the willingness of institutional investors to inject capital and for individual investors to imitate investment trends.

Ultimately, the evolutionary stability point of interaction between institutional and individual investors is E1(0,0). Therefore, all institutional investors prefer not to trade, and all individual investors prefer not to follow an independent investment strategy to achieve profits.

Institutional Investors

Individual Investors

Figure 1: Simulation Results

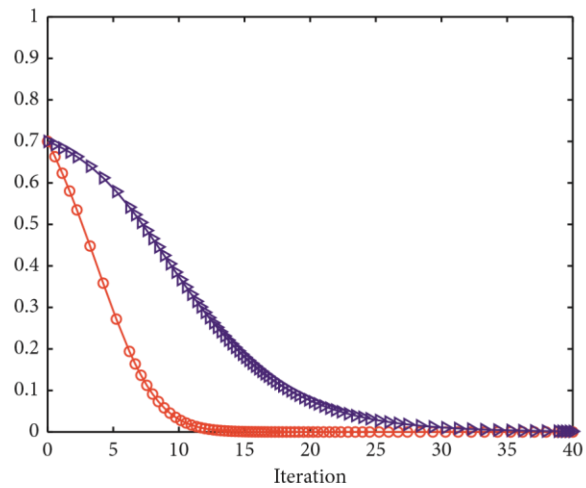

Figure 1: Simulation Results for Institutional and Individual Investors Using Parameters RM2 ، CM1 ،R0 0.5 ،R1 1 ،β 0 و δ 0.3.

Three Main Assumptions of This Situation:

1. Investor Behavior: When individual investors realize that the returns from imitation (δR1) are less than the expected return from independent investment (R0), they show a greater tendency to adopt an independent investment strategy to maximize their utility. Consequently, individual investors begin to follow the investment strategy of institutional investors. If the profits for investors continue to decline without a reduction in trading costs, institutional investors gradually reduce their capital injections. Eventually, these two types of investors establish a stable strategy choice state characterized by non-injection of capital and non-imitation.

2. Institutional Investor Perspective: From the perspective of institutional investors, when information costs are significantly high, control becomes stringent, and transaction risks are extremely high. To protect their own interests, institutional investors decide to decrease or halt their trading strategy of attracting funds from individual investors, aiming to raise stock prices. They opt for a hedging strategy, such as investing in bonds and diversifying their investments. Under such circumstances, individual investors struggle to find suitable targets for imitation and following, yet they are unable to achieve the expected excess returns. As a result, individual investors forgo their primary strategy and choose to analyze independently for stock purchases.

3. Information Cost Perspective: The final explanation analyzes the scenario where the total cost of gathering information in the stock market is significantly low. In this case, every investor can assess stocks based on market information, industry conditions, and company-specific data. Under this assumption, individual investors do not need to imitate or follow any strategy but can utilize their acquired knowledge and information to freely purchase stocks. At this stage, institutional investors find it challenging to elevate stock prices to a high level, and as such, they cannot achieve the expected returns. Consequently, they gradually abandon their previous trading

strategies. When the final strategy choices of both investor types stabilize (non-injection of capital and non-imitation), the investment direction in the stock market, which was previously highly concentrated, will gradually disperse. Each investor will increasingly focus on company performance, leading to lower levels of price synchronization among stocks.

Figure 2: Simulation Results

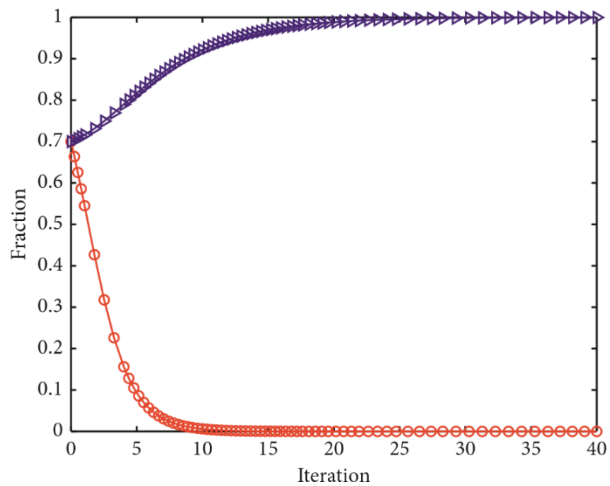

Figure 2: Simulation Results for Institutional and Individual Investors Using Parameters RM= 1.5 ، CM= 1 ،R0= 0.5 ،R1= 1 ،β = 0, and δ= 0.7.

The increasing number of stages in the evolutionary iteration leads to a gradual decline in institutional investors' willingness to inject capital and a gradual increase in individual investors' tendency to imitate. Ultimately, the evolutionary stability point of interaction between institutional and individual investors is E2 (0, 1). This means that all institutional investors decide not to inject capital, while all individual investors choose to imitate.

When operational and informational costs for institutional investors are significantly high, or when the operations carry substantial risk, institutional investors decide to reduce or halt their capital injection speed and turn to the bond market, diversified investments, and other risk-hedging strategies. However, individual investors find it challenging to gather information under this strategy. If the information costs exceed the necessary levels, and if the final returns are insufficient, individual investors will continue to follow the path of institutional investors, imitating their strategies.

Moreover, the choice of strategy for both types of investors will gradually stabilize (non-injection of capital and imitation). At this point, institutional investors have abandoned their initial trading plans and adopted risk-averse strategies to ensure initial returns. Nonetheless, the blind following and imitation by individual investors continue to result in the concentration of funds in a specific direction in the stock market. Thus, the synchronous changes between individual stocks and the market are significant or observable across trading segments.

3.3 RM > (1/(1-β)) (CM + R1) and β < 0: System Evolutionary Behavior

Assuming RM =2, CM = -2, R0 = 0.5, R1 = 1, β = -0.5, and δ = 0.7, the above conditions are met.

Figure 3: Simulation Results

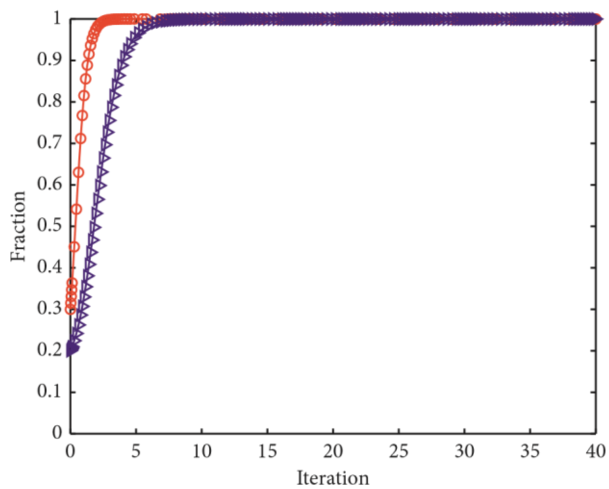

Figure 3: Simulation Results for Institutional and Individual Investors Using Parameters RM =2, CM = -2, R0 = 0.5, R1 = 1, β = 0.5, and δ = 0.7

The increasing number of stages in the evolutionary iteration leads to a gradual increase in institutional investors' willingness to inject capital and the inclination of individual investors to imitate investment trends. Ultimately, the evolutionary stability point of the behavior of institutional and individual investors is E4 (1, 1). This indicates that all institutional investors choose to inject capital while all individual investors mimic the investment strategies of institutional investors.

In this scenario, institutional investors expect to see an increase in profits, while operational and informational costs are relatively minimal. As a result, institutional investors create an incentive to maintain or shift towards capital injection. Given that β < 0, which suggests that individual investors can achieve higher returns by mimicking institutional investors, the evolutionary stability point of interaction between institutional and individual investors is E4 (1, 1).

This situation occurs when the stock market is in a bullish phase. When the stock market performs well, institutional investors utilize their capital. Moreover, individual investors are attracted by the favorable market conditions, leading them to imitate the behavior of institutional investors in purchasing stocks. As a significant amount of money is injected into similar stocks or related sectors, this results in continuous upward and downward movements. Consequently, the influence between stocks and sectors gradually enhances the overall stock market, leading to serious price synchrony across the entire stock market.

R0 < δR1: 3-4, RM > CM + R1, and β > 0: System Evolutionary Behavior

Assuming RM = 3, CM = 1, R0 = 1, R1 = 2, β = 0.2, and δ = 0.6, the aforementioned conditions are met. The increasing number of stages in the evolutionary iteration results in a change in the ratio of strategy selection by institutional and individual investors, while the trend of their interactive behaviors remains relatively constant. No Evolutionary Stable Strategy (ESS) is evident in the behavior of institutional and individual investors.

Figure 4: Simulation Results

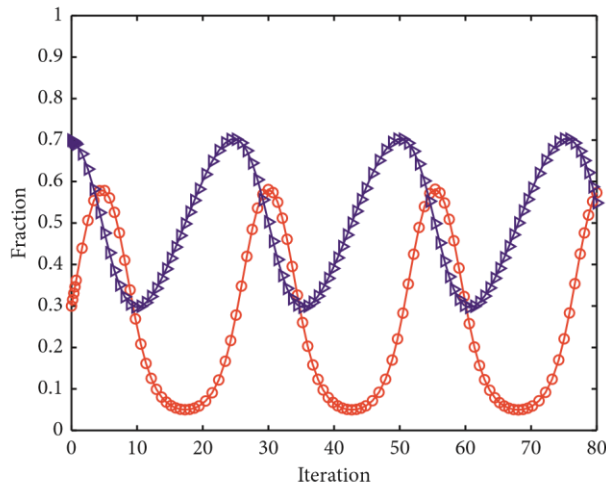

Figure 4: Simulation Results for Institutional and Individual Investors Using Parameters RM = 3, CM = 1, R0 = 1, R1 = 2, β = 0.2, and δ = 0.6

This situation demonstrates that when the expected return of independent investments for individual investors is lower than the returns achieved by institutional investors, the returns for institutional investors from trading exceed the total expected return from trading and non-operational costs. Consequently, when this trading results in negative returns for individual investors, the ratio of institutional and individual investors remains in a state of periodic turmoil without stable evolutionary outcomes.

In fact, when the stock market develops slowly, institutional investors opt for trading behaviors, attracting investors through capital injection to earn profits. In the early stages, individual investors are inclined to adopt imitation strategies and gradually purchase similar stocks based on the investment choices of institutional investors. In this process, when the funds of individual investors enter the stock market, institutional investors who initially choose to invest notice a growth in their profits and are attracted to similar strategies that yield greater returns. However, as the number of institutional investors increases, the returns from the strategies that individual investors choose to imitate gradually decline.

Specifically, individual investors gradually shift to strategies that do not involve following institutional investors. Thus, the initial investment costs incurred by institutional investors cannot be offset by profits, resulting in losses for institutional investors. Consequently, several institutional investors change their strategies and cease capital injection. When the number of institutional investors decreases to a certain level, individual investors, driven by speculative psychology, begin buying and selling stocks again, repeating this process in an imitative manner, with no ESS emerging.

In this section, we explained the behavior of individual and institutional investors in various situations and inferred their theoretical impact on stock price synchronization. When institutional investors choose to inject capital and individual investors opt for imitation, the stock market exhibits the highest degree of synchronization. Additionally, when individual investors abandon imitation and institutional investors diversify, stock prices reach their lowest levels.

5- Conclusion

In this study, an evolutionary game model was presented to analyze price synchronization in the stock market. We considered various factors influencing the behavior of institutional and individual investors. A payoff matrix was constructed for the two types of investor behavior, and the dynamics of different strategies and conditions for ESS were obtained through simulations.

The analysis of stability and simulation results yielded four distinct ESS for institutional and individual investors. The findings indicate that when market conditions are favorable and the operational costs for institutional investors in the stock market are low, the income generated by institutional investors encourages individual investors to imitate them. In cases of insufficient information-gathering ability and the limitations faced by individual investors, such high returns lead an increasing number of individual investors to converge their behaviors with those of institutional investors, resulting in an excessive concentration of types and directions of trades in the stock market. Consequently, a higher degree of synchronization in the stock market occurs, whereby most stock prices are influenced by the broader market. To mitigate financial risks in the stock market, price synchrony between individual stocks and sectors should be reduced, ultimately forming a safe and orderly financial market pattern.

Here are the practical recommendations provided:

1. Improving the Operational Mechanism of Institutional Investors: Institutional investors, as significant participants in the stock market, possess inherent advantages in gathering information and capital operations. They manipulate profits for their own interests, engage in insider trading, and disseminate misleading information, disrupting market economic order. The economic models in this study indicated that the costs associated with institutional investors can diminish the price correlation in the stock market. Therefore, regulatory authorities should strengthen oversight to enhance the performance of institutional investors through penalties and license revocation, restraining the capital injection process to reduce price synchronization in the stock market.

2. Enhancing the Information Disclosure Mechanism in the Securities Market: The securities market fundamentally serves as an information flow market. Information disclosure is not only a crucial basis for investors to make rational decisions but also an essential element for regulatory authorities to effectively monitor listed companies.

3. Addressing Information Disclosure Deficiencies in the Iranian Stock Market: There are shortcomings in the disclosure of accurate information, such as incomplete regulations, weak law enforcement, and untimely or inaccurate disclosures. This situation not only makes it difficult and costly for investors to access effective information but also creates an environment conducive to

the spread of misleading information due to inherent motivations, ultimately leading to price synchronization in the Iranian stock market.

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