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The Iran stock market: efficiency, volatility and links to the international oil market

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Abstract

This study investigates the behaviour of stock prices or stock returns in an oil exporting developing country (Iran). Following an examination of the role of the Iran stock market and oil revenues in the Iranian economy in chapter 2, the extensive review of theoretical and empirical literature on stock market efficiency is provided in chapter 3. Chapter 4 empirically investigates the efficiency of Iran stock market in weak form. Empirical findings from employing conventional and nonlinear unit root tests even in presence of endogenous and exogenous structural break points indicate that the daily Iran stock prices index follow random walk theory and Iran stock market is efficient in weak form.

In view of the distributional characteristics of stock returns, chapter 5 models the volatility dynamics of the Iran stock market. Due to existence of risk premium, in this market investors with long horizon are compensated with high returns for bearing high risk. On the other hand, the empirical analysis shows lack of asymmetric volatility in the behaviour of Iran stock return series. In view of the dominant role of oil export revenues in Iranian economy, chapter 6 examines the possible dynamic relationship between the Iran stock market and international oil market. The results from adopting symmetric and asymmetric multivariate GARCH models based on underlying data generating process indicate lack of return and volatility spillover between Iran stock returns and international oil prices.

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Declaration

I hereby declare that this thesis has not been submitted in whole or in a part to another University for the award of any other degree.

Signature:

Dedication

This research is dedicated to my beloved family (Hanieh and Arshia).

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Publications

Some parts of this research have been revealed in:

Journal articles:

1. Asymmetric Effects in Emerging Stock Markets-The case of Iran stock market, *International Journal of Economics and Finance*, 3(6), pp.16-24, 2011.

2. Emerging Stock market Efficiency: Nonlinearity and Episodic Dependences, *African Journal of Business Management,* forthcoming.

3. The Random Walk Hypothesis in Emerging Stock Markets, *International Research Journal of Finance and Economics*, 50, pp. 51-61, 2010.

3. Emerging Stock Market Performance and Economic Growth, *American Journal of Applied Sciences*, 7(2), pp. 265-269, 2010.

Conference papers:

1. The Random Walk Hypothesis in Emerging Stock Market Evidence from nonlinear Fourier unit root test, *International Conference of Financial Engineering*, London, 2011.

2. Stock Market Efficiency: Theory and Implications, *International Conference on Business and Finance Sciences*, Dubai, 2011.

3. Asymmetric Volatility in Emerging Stock Markets: Evidence from Iran Stock Market, *The Economics, Finance & International Business Research Conference*, Miami, 2010.

4. The Investigation of Stock Prices Behaviour in Emerging Stock Markets, *Workshop and Annual Postgraduate Student Conference*, Azad University (IR) in Oxford, 2010.

CHAPTER 1

INTRODUCTION

1.1. Motivation of the study:

In the last few years, the Iran stock market has experienced significant growth in terms of market capitalization (market value) and trading volume in the context of economic development in Iran. Since the growth (in terms of qualitative and quantitative indicators) of stock markets is of critical importance in the process of economic development, understanding performance, efficiency and in general the behaviour of the Iran stock market is necessary for thorough analysis of the Iranian economy. A well-functioning stock market contributes to economic development through mobilizing and channelling domestic savings into investment projects and plays a crucial role in facilitating the intermediation between savers and investors. At the same time, an efficient stock market contributes to economic growth especially in developing countries where there is scarcity of capital, by attracting foreign portfolio capital and foreign direct investment and expanding financial resources available for new investment plans. Domestic and international investors are interested in assessing the risk of investment. Therefore, the market efficiency, market volatility (as a measure of investment risk) and dynamic behaviour of stock prices should be investigated in analysing the potential role of the stock markets in a national economy.

Since most of the empirical studies in the literature are related to mature, advanced and well-organized stock markets, there is a gap in this literature as far as developing countries are concerned. This study is a contribution to the limited literature on emerging stock markets in general and Iran stock market in particular. The findings of this study would contribute to future research on Iran stock market by adding further insight into the dynamics of this market. In sum, this study has been motivated by the need to develop a deeper understanding of the dynamic nature of Iran stock market and its performance and contribution to the Iranian economy.

1.2. Aim and objectives of the study:

This study aims to examine the dynamic behaviour of the Iran stock market. To this end, it concentrates on the following three specific objectives:

- Examining efficiency of the market in weak form by testing the random walk hypothesis and investigating the stochastic properties of stock prices.

- Modelling volatility dynamics of the market based on underlying distribution features of stock returns and investigating the risk premium and asymmetric volatility phenomena in the behaviour of Iran stock returns series.

- Identifying the dynamic relationship between Iran stock market and International oil market in view of the dominant role of oil revenues in Iranian economy.

In order to provide a better understanding of Iran stock market, the institutional, regulatory and microstructure characteristics of the market are examined. Since the distribution characteristics of stock prices or stock returns are fundamental factors in model building and identifying the underling dynamic of stock market, the stochastic features of the market and underlying data generating process are investigated in depth.

1.3. Research questions

This study attempts to investigate the following questions:

- The extent to which the Iran stock prices index follows the random walk hypothesis.
- How is the randomness of Iran stock prices series affected by the existence of i) endogenous and exogenous break points and ii) nonlinear dynamic behaviour.
- The nature of the risk-return relationship in Iran market and degree to which this market as an emerging stock market appropriately compensates investors for the perceived risks that exist in developing countries.
- The applicability of asymmetric volatility phenomenon to Iran stock market.

- The return and volatility spillover between Iran stock market and international oil market.

1.4. Contributions to knowledge

This thesis serves to extend the current literature on the dynamic behaviour of stock prices or stock returns in an oil exporting country. In particular, this study makes a number of contributions to the literature on financial development, financial econometrics, stock market efficiency and volatility. Firstly, we have done an extensive literature review on stock market efficiency and review of operational and institutional aspects of the Iran stock market. Secondly, we have shown that an emerging stock market is efficient in weak form even in the presence of endogenous and exogenous break points. At the same time, the findings from nonlinear unit root tests (ESTAR and Fourier models) provide evidence that in view of possible nonlinear behaviour in underlying data generating process of Iran stock prices index, shocks on the series have permanent effect and future stock prices are not predictable based on past information. Thirdly, we have modelled the volatility dynamic of Iran stock market through an elaborate data generation process. We have found that the empirical stylized facts namely volatility clustering, leptokurtosis and fat tail are present in Iran stock market. Fourthly, we have established that in this emerging market, investors (with long horizon) are compensated for bearing high risk (in particular political risk). Fifthly, our investigation reveals that there is no asymmetric effect in this market. Sixthly, based on identifying the true data generating process we have proven that in an oil exporting country the shocks and volatility of international oil market do not spill over to volatility of the stock market.

1.5. Outlines of Study

In carrying out the objectives, the main body of the thesis is organized into five chapters:

Chapter two: This chapter reviews the theoretical literature on the role of stock markets in economic development. Also, based on quantitative measures (e.g. market size and market liquidity), role of the Iran stock market in the national economy are examined.

Chapter three: This chapter in view of the stock market efficiency in the context of microeconomics general equilibrium theory, highlights the theoretical and empirical literature review of market efficiency in particular in weak form.

Chapter four: The chapter examines the random walk hypothesis for Iran stock prices index using several unit root test with and without the presence of endogenous and exogenous break points. Also two nonlinear unit root tests are adopted to investigate the randomness of Iran stock prices index series.

Chapter five: This chapter deals with the theoretical analysis and empirical investigation of the volatility of Iran stock market. This chapter uncovers the stylized facts of stock returns and models the dynamic volatility of market based on underlying data generating process. Using several misspecification tests this chapter investigates the risk-return trade off and asymmetric effect aspects.

Chapter six: The dynamic relationship between the Iran stock market and international oil market are investigated in this chapter. This chapter, based on stochastic properties of both markets employs the multivariate GARCH specification to examine the effects of oil price fluctuations on the stock returns and volatility of Iran stock market.

Chapter seven: This chapter contains a discussion of the main results emerging from the research. The chapter also presents policy implications, recommendations and directions for further research in this area, and potential implications of the results.

Chapter2
Overview of the role of oil revenues in the Iranian economy and Iran stock market

2.1. Introduction

This chapter provides a brief review of the contribution of stock markets to economic development and an overview of the role of oil revenues in the Iran economy. In particular, after reviewing some aspects of stock market performance and their role in economic development, the role of oil revenues in economic activity of the Iranian economy is examined. Finally the role of the Iran stock market in the Iranian economy, using some quantitative measures, is investigated. The motivation for examining the quantitative characteristics (e.g. market size and market liquidity) of stock markets is to make possible the assessment of the efficiency and effectiveness of the Iran stock market in the general process of economic growth. In this sense, the fundamental role of stock markets is to transfer funds between savers and business enterprises smoothly. Stock market facilitates the exchange of financial securities, which helps to mobilise internal and external financial resources. Therefore, stock markets are able to positively influence economic growth through encouraging savings amongst individuals and providing opportunities for firm financing. Highlighting the role of oil revenues in the Iranian economic activity indicates the significance of investigating the effect of international oil prices on the behaviour of the Iran stock market.

The remainder of this chapter is organized in three sections: Section (2.2), provides a brief discussion of the role of stock markets in the economic development process. Section (2.3) provides an overview of the role of oil revenues in the Iranian economy. This is followed by section (2.4), which examines the performance of the Iran stock market and its position in the national economy. Finally, section (2.5) concludes the chapter.

2.2. Stock market performance and economic growth

In economics literature, the role of the stock market as that part of financial markets which deals with medium and long term credit in the economic development process has been emphasized by economic growth theories. Stock markets play a determining role in economic growth through the mobilization of domestic savings and the channelling of investments and financial resources into productive enterprises (Caporale et al, 2004). A stock market increases the amount of medium and long term savings by offering investors a variety of financial instruments and investment opportunities. At the same time, a stock market improves efficiency in the allocation of financial resources by offering a broad spectrum of entrepreneurs an opportunity to acquire financial resources for their projects. It is noteworthy to point out that, from an investor's point of view, a stock market helps to allocate financial resources efficiently by directing savings flow to investments with the highest rate of return for a given level of risk.

A stock market as a place for transacting (buying and selling) securities encourages people to channel their savings into productive and corporate investments. In the same way, as a pricing mechanism it allocates financial resources among investment projects through determining the market value of the firm's securities. To put it differently, a stock market helps start ups or growing companies to raise capital at low cost for expansion activities or investment in research and development. A properly functioning stock market allows firms to engage in direct financing through financial instruments as opposed to indirect financing through bank credit. Well-developed stock markets enhance the level of economic efficiency and productivity through expanding share ownership, closer monitoring of companies, and improved business performance. In this sense, since share prices reflect the overall performance of firms, managers are compelled to improve their management standards, efficiency and make wiser investment decisions in order to satisfy the shareholders, leading to improved corporate governance. A stock market creates an opportunity for small investors with small financial resources, thus it helps to aggregate small savings, wandering capital and enhances the rate of economic growth.

By providing the possibility of asset diversification (which minimizes risk of investment in different assets) for people, taking into account their risk preferences or liquidity needs, stock market enhances the motivation for saving. More specifically, a stock market helps investors (participants in stock markets) to price and hedge risk more effectively. At the same time it allows firms to diversify some of the risks they faces by allowing they to be sold to other people who are more willing to bear these risks (Enisan and Olufisayo, (2009)). This enables firms to borrow more for expansion activities or new investments, leading to the greater rate of economic growth. Furthermore, a well functioning stock market allows firms to diversify away unsystematic risk (economic risk), thus increasing the marginal productivity of capital (see Athanasios and Antonios, 2010). In the same way, through improving the level of public confidence, using the public participation in expansion of investment projects and development of entrepreneurship, a stock market makes endogenous and sustainable growth possible.

Efficient stock markets may also reduce the costs of information through the generation and dissemination of firm specific information that stock prices reveal (Yartey and Adjasi, 2007). Reducing the costs of acquiring information is expected to facilitate and improve the acquisition of information about investment opportunities and thereby improves financial resource allocation. By providing the possibility of generating investment, a stock market encourages the transfer of financial resources from the informal economy to productive sectors and prevents capital flight.

Since stock market is a place for medium or long-term finance (the market in which long term financial assets are traded), it affects economic activity through providing long-term commitment of capital for investment projects and enhances prospects for long-term economic growth. In recent years, stock markets have played a new role in the successful implementation of economic growth programmes in particular the privatization and liberalization reform programmes. In this sense, stock market acts as major source of refinancing the state-owned enterprise sector. Similarly, well-organized and active stock markets could attract wandering liquidity specifically in developing countries; thus helping in effective implementation of economic stabilization policies.

Undoubtedly, stock markets are expected to enlarge economic growth by increasing the liquidity of financial assets or instruments and making global and domestic risk diversification possible. Stock market facilitates wide spread of ownership of financial assets, thereby reducing the concentration of economic power, income and wealth in the hands of a few. This means that shares are distributed nationwide ensuring equal participation by all those who desire a share in the ownership of corporations. In this sense, through expanding public ownership and capital formation stock market helps to improve income distribution especially in developing countries. Since foreign investors are willing to reduce the risk of investment by holding an internationally diversified portfolio, stock markets can act as a magnet for attracting foreign capital, leading to higher volume of foreign investment.

By providing competitive conditions, stock market establishes the possibility of financing profitable firms through shares offering; as a consequence financial resources are allocated efficiently. In this sense, stock market reallocates financial resources away from unprofitable firms. Since stock prices which are generally the discounted present value of firm's future dividends reflect expectations about future economic activity; the stock market is the best indicator to forecast future economic activity (see Ngugi et.al, 2005). In this sense, stock market acts as a leading indicator of economic growth.

On the other hand, there are alternate views about the role of stock markets in the process of economic growth. Some critics have argued that stock market development may actually hurt economic growth (Stiglitz (1985, 1994), Shleifer and Vishny (1986), Bencivenga and Smith (1991) and Bhide (1993)) .For instance, the liquidity of stock markets may impair economic growth by reduction in savings rates owing to externalities in capital accumulation. At the same time, in the case of listed companies in stock market, spread of ownership may also negatively affect corporate governance and the performance of these companies; as a result the economic growth is adversely affected.

In general however, the extent of stock market's contribution to economic growth is affected by various factors such as the size, liquidity and efficiency of the market as well as the quality of the environment (economical and political conditions). The social, economic and political conditions of the countries involved determine the quality of the environment. In this regard, the effect of the stock markets on economic growth would be doubtful in countries with high political instability and perceived risks.

2.3. An overview of the role of oil revenues in the Iranian economy

Since Iran has the third largest proven reserves of crude oil and the second largest gas reserves in the world, the Iranian economy is highly dependent on the production and export of crude oil and gas to finance government spending, and consequently is affected by fluctuations in oil prices in international markets (oil shocks). Accordingly, this sector has received most of domestic and foreign investment, leading to reduction in the level of investment in other economic sectors. At the same time, the expansion of investment opportunities in industry, agriculture and other sectors, as well as opportunities for economic diversification are affected by the leading role of the oil sector in Iranian economy. More specifically, as can be seen from table 2.1 the economy of Iran is dominated by oil and gas exports which make up about 70% of government revenue and about 80% of export earnings. It is necessary to point out that the fluctuations of oil and gas exports in the Iranian economy are significantly related to volatility of oil prices in international markets. Due to the dependence of Iranian economy on oil exports, the fluctuations of oil revenue have influenced economic conditions and thus economic development programmes.

Table2.1.The role of Oil and Gas export in Iran economy (in percent)

	1999/2000	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Oil and Gas export to total export ratio	79	85	81	82	81	83	81	82	84	81
oil and gas to total revenue ratio (Government)	43	67	58	70	70	69	72	70	71	66

Source: IMF, country reports and author calculation

In order to get a more comprehensive insight into the role of oil revenue in oil exporting countries, table 2.2 compares the real economic growth rate among the Middle East, North Africa, Afghanistan, and Pakistan (MENAP) oil exporter countries. The remarkable point that can be drawn from table 3 is the significant dependence of economic growth in oil exporter countries on the revenues of oil exports and oil prices. In the years that the price of oil has fallen; economic growth rate has significantly declined and even in some cases (Algeria, Iran, Saudi Arabia, Emirates and Yemen) the real rate of oil GDP growth has been negative. Over the period 2000 - 2009 the largest impact of oil price reduction has happened in 2009. In this year the average growth rate of oil GDP among MENAP oil exporter countries has been a negative -4.7 percent.

In 2008 and 2009, the reduction in real oil GDP for Iranian economy has been greater than the average of MENAP countries, while the growth in real oil GDP of Iran has been bigger than the average of the region in 2006 and 2007. On the other hand over the period 2006 - 2009 the growth rate of real non-oil GDP has been smaller than the average of the region except 2007. In comparison with Saudi Arabia as number one and exporter of oil in the world, the economy of Iran has been affected to a lesser degree by the reduction in oil prices in 2009.

Figure 2.1 shows clearly the dependence of Iran GDP on the revenues of oil exports. Parallel with falling oil prices, the real economic growth rate begins to decrease. After a relative reduction in the oil prices in 2007, the non-oil GDP growth has been reduced and the rate of oil GDP growth has been negative. The rate of non-oil Iran's GDP in 2007 has been more than average rate in MENAP region and in other years has been less than the average of region. Of course, in the period 2000 - 2005 the average growth rate of Iran's non-oil GDP has been greater than the average rate in MENAP region.

Table2.2. Oil and Non-Oil Real GDP Growth Rates for Oil and Gas Exporters In the Middle East, North Africa, Afghanistan, and Pakistan (in percent)

	Average 2000-05		2006		2007		2008		2009	
MENAP oil exporters	Non-oil GDP	Oil GDP	Non-oil GDP	Oil GDP	Non-oil GDP	Oil GDP	Non-oil GDP	Oil GDP	Non-oil GDP	Oil GDP
Average	**5.8**	**5.8**	**7.0**	**2.3**	**7.8**	**0.7**	**5.4**	**0.4**	**3.6**	**-4.7**
Algeria	4.8	4.1	5.6	-2.5	6.3	-0.9	5.9	-2.3	9.2	-6.6
Bahrain	7.8	-1.0	8.1	-1.0	9.2	1.1	6.9	1.2	3.3	0.1
Iran	**5.9**	**2.9**	**6.2**	**2.7**	**8.6**	**1.7**	**2.9**	**-3.7**	**2.7**	**-6.6**
Iraq	...	...	7.5	5.3	-2.0	4.0	5.4	12.3	4.0	4.3
Kuwait	11.3	16.2	7.0	2.9	6.3	-2.3	8.0	4.2	0.7	-7.5
Libya	2.8	5.6	10.7	4.3	14.8	2.8	8.0	0.0	6.0	-1.5
Oman	6.1	0.8	11.4	-1.6	13.7	-1.6	15.5	6.4	2.1	5.9
Qatar	10.0	8.2	19.9	10.7	14.5	12.9	14.5	17.1	8.0	10.0
Saudi Arabia	4.0	4.3	5.1	-0.8	4.6	-3.6	4.4	4.2	2.9	-6.4
Sudan	5.1	49.7	9.7	26.5	7.5	33.0	8.5	-4.4	4.8	2.6
Emirates	9.5	3.9	9.5	6.5	9.1	-2.7	6.3	1.6	1.0	-6.3
Yemen	5.2	0.8	4.7	-8.3	5.3	-13.1	4.8	-8.1	4.1	1.6

Sources: International Monetary Fund, regional economic outlook, 2009.

On the whole, the direct relationship between non-oil and oil GDP which is shown in figure 2.1 implies the dominant role of oil revenue in Iranian economy and the vulnerability of economic activities in Iran to potential volatility in oil prices. These conditions make it difficult for Iran to achieve sustainable economic growth and affect the outcomes of economic development programs.

Another important point in examining the impact of oil revenue on macroeconomic performance in oil exporter countries is that oil revenue tends to show high volatility and uncertainty compared with other fiscal revenues (due to fluctuations in oil prices and extractable oil reserves) and is unsustainable. As a result, today's choices (e.g., investment, rate of extraction, use of oil revenue) are likely to have significant long-term implications for economy of oil exporter countries. On the whole, the dependence of economic activity in the Iranian economy on oil revenues justifies the investigation of the relationship between the Iran stock returns and international oil prices in the chapter five of this thesis.

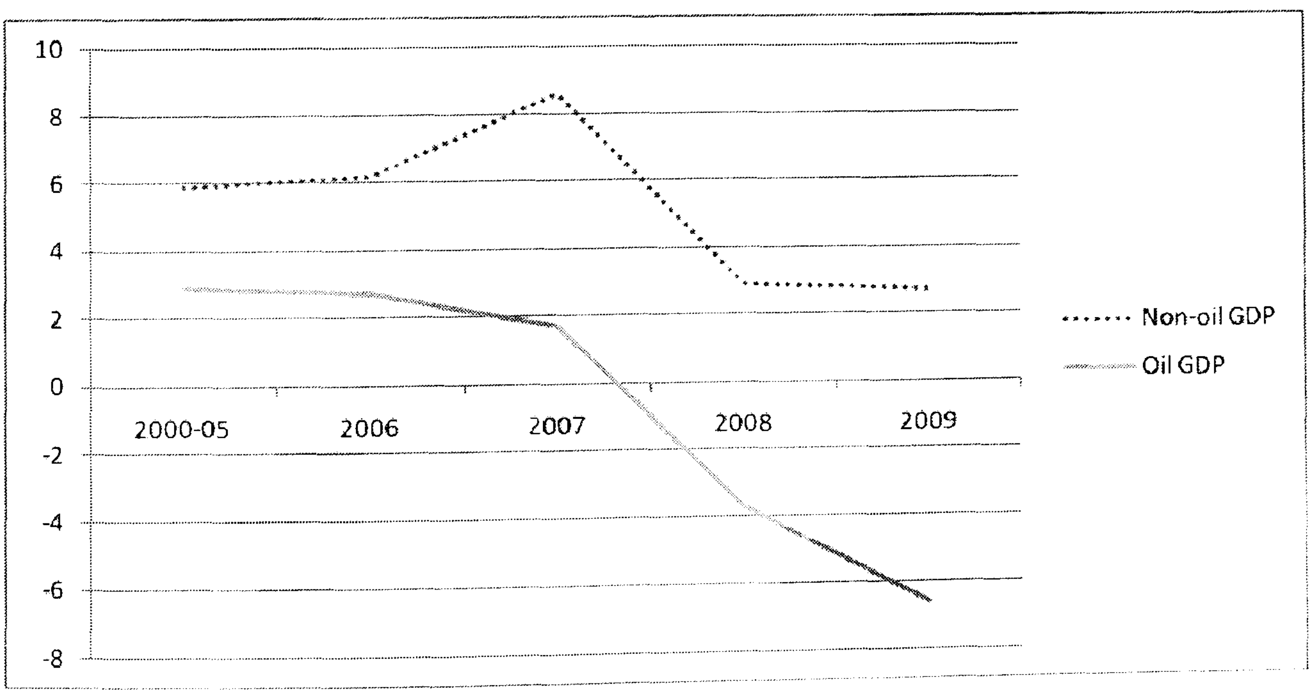

Fig2.1. Time plot of the growth rate of Non-oil GDP and Oil GDP in Iranian economy (in percent)

2.4. Capital Market in Iranian Economy

At the moment, the Iranian capital market is supervised by Iran Securities and Exchange Organization (SEO) which was established in 2006. According to Article one of the Securities Market Law, the SEO shall be a legal and financially independent public non-governmental institution, funded with service charges, admission fees collected from listed companies and other revenues. It is responsible for direct control of institutions' operations, exchanges and the Central Securities Depository and Settlement Company. Before approval of the Law in 2005, the Brokers Organization was responsible for supervision of Iran Capital Market. Since then, market operations are entrusted to the Tehran Stock Exchange Company[1]. In this sense, SEO supervises operation of Tehran stock exchange, Iran mercantile exchange (Metal & Mineral products, Petrochemical and Oil products, Agricultural products) and OTC (Over the Counter) market.

The operation of Tehran Stock Exchange (TSE) officially started in 1967. From 1967 to 1977 the Iranian stock market experienced high economic growth and was considerably developed. In this period, the number of listed companies rose from 6 to 105. In the same way, TSE's market capitalization increased from USD 885 million to USD 3.4 billion during the same time period. The rapid growth of the TSE during this period was due to a number of factors. These include the land reform (also known as the White Revolution), a push towards the development of manufacturing sector, rapid rise in crude oil prices, tax exemption status of listed companies and relative

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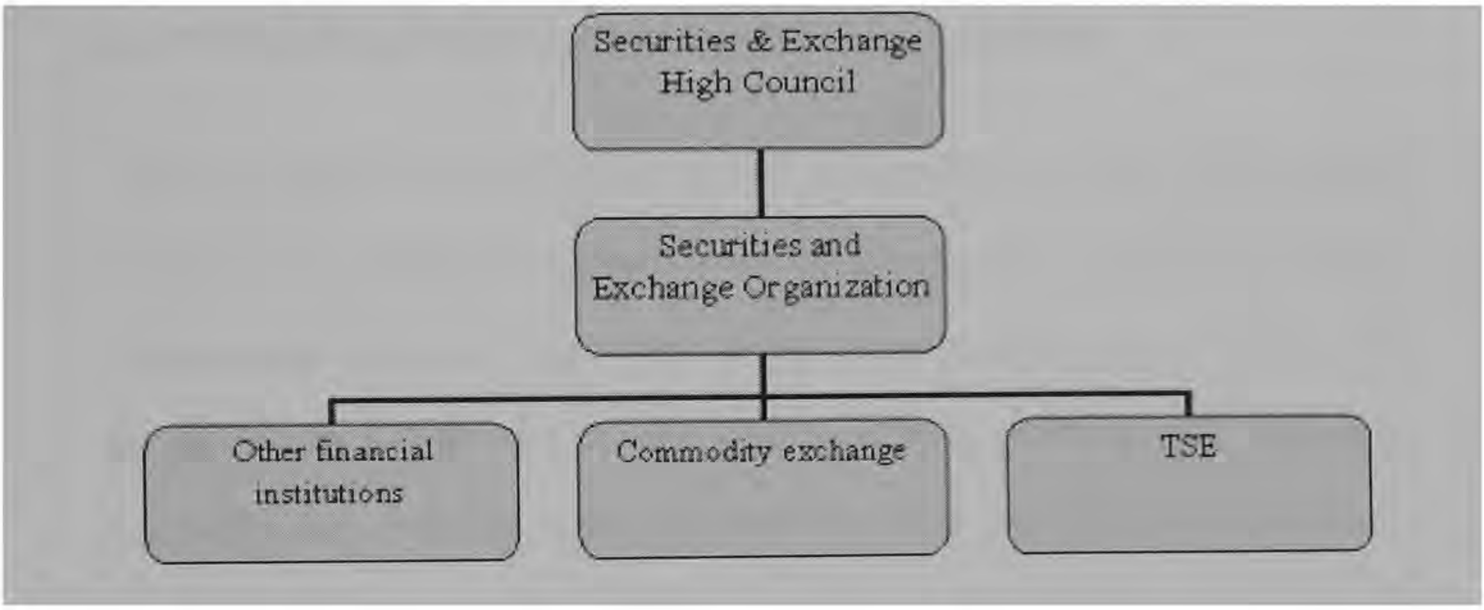
[1] . See the Iran stock market website: http://www.tse.ir/

political stability. In 1978, the number of listed companies decreased to 56 due to economic instabilities. Over the period 1979 to 1998 the Iran stock market countered recession caused by the victory of Islamic revolution and the Iraq-Iran war. In 1988, trade on Tehran stock exchange restarted in order to create incentives for more private sector participation. With implementation of economic adjustment programmes the number of listed companies increased to 249 in 1996. The data dissemination systems and publishing of companies' financial reports improved over the 1996 - 2000 period. In 2003, the Iran stock market experienced high growth; new investors entered the market and raised the trust level of people toward investment in stock market. In this year, the Tehran Metal Exchange was established and one year after that in 2004 the Tehran Agricultural Commodities Exchange started its activities. As has been noted before, based on the new Securities Market Law, SEO was established in 2006 and the Tehran Stock Exchange company as a public company was put in charge of administrative activities. In this year, the Agricultural commodities and Metal exchanges merged and the Commodities Exchange was formed. From 2007, owing to privatization programmes of big state-owned companies through stock market and special attention of government the Iran stock market has entered a new improvement phase.

It should be highlighted that in Iranian capital market the Securities and Exchange High Council (Council) is the highest authority and is responsible for all related policies, market strategies, and supervision of the market. The Chairman of the Council is the Minister of Economy & Finance; other members are: Minister of Commerce, Governor of the Central Bank of Iran, President of the Chamber of Commerce, Attorney General, Chairman of SEO, representatives of the active market associations, three financial experts requested by the Minister of Economy & Finance and approved by the Council of Ministers, and one representative from each commodity exchange [Iran, The Iranian Securities Market Act,2005].Figure2.2, represents the organizational chart of Iranian capital market.

Fig2.2.The regulatory framework of the Iranian capital market



The main task of the Tehran Stock Exchange (TSE) company is to provide reliable facilities for the efficient and orderly conduct of trading securities. It is also entrusted to regulate the activities of brokers and preserve the interests of the investing public through ongoing trading floor and broker management and overall market observation[1]. To be precise, the primary roles of TSE are:

- Establishing, organizing and managing of the Stock Exchange in order to trade listed securities

[1]. See the Iran stock market website: http://www.tse.ir/

- Listing of securities
- Prescribing membership requirements for members and supervising their performance, and regulating their activities
- overseeing the transactions of the Exchange listed securities
- Monitoring the performance of issuers of the listed securities
- processing and disseminating the information regarding the securities orders and transactions of securities

2.4. 1. The role of Iran stock market in Iranian economy

In what follows we briefly analyse the operational measures of Iran stock market using well-known criteria (market size, market liquidity and market concentration). As has been noted in the history of Iran stock market, over the last decades the Tehran stock exchange has experienced rapid growth and remarkable development. Table 2.3 provides detailed information about performance of Iran stock market. As it can be seen from table 2.3, the market value of listed companies has significantly increased over the considered period; in particular in 2009 it was more than ten times the 2000 level. It should be noted that the liberalization and privatization programmes have been effective in developing the performance of Iran stock market. As has been mentioned previously, the amendment of the Article 44 of the Iranian Constitution allowed the privatization of 80 percent of the state assets. Forty percent of these were transferred to vulnerable people through "Justice Shares" and the rest are planned to be publicly offered at the TSE. In this way, three big state-owned banks (namely Mellat, Tejarat and Saderat) were listed in Iran stock market in 2009 and as a consequence the market value of tradable companies in market has increased considerably. In the same way, the total value of traded shares has risen noticeably from 1043 million dollars in 2000 to 17080 million dollars in 2009. In line with privatization plans, state-owned companies are to be transferred to the private sector; therefore Iran stock market has a positive prospect for further expansion and development. For instance, the stock market will be a major source of refinancing for the state-owned enterprises (SEO_S) sector.

Over the last decade, infrastructural reforms, improvement of the regulatory system and operational framework and introduction of new tradable financial instruments in Iran stock market have become increasingly the focus of attention. In this way, on July 4 2010 TSE has developed and launched on trial basis scheme its online trading system, which will be fully launched in near future. It is clear that the online trading system helps to reduce transactions costs and remove bureaucratic rigidities in market. In the same way, in order to diversify the financial products and provide a deeper market, the possibility of trading of futures contracts has been created from 25 July 2010.

2.4. 1. 1. The Iran stock market size

One of the measures indicating the development of stock market is market size criterion. In practise, this concept consists of two ratios. In the first step, we consider the market capitalisation ratio. This measure is aggregate market value of the listed shares divided by gross domestic product (GDP). The capitalization ratio signifies the relative importance of stock market in national economy and demonstrates the ability of the stock market in mobilizing investment capital and diversifying risk of economic activity. Table 2.4 shows the capitalization ratio for Iran stock market over the last decade. As can be seen from table, this ratio increases sharply until 2004 reaching 26% by the end of the year. As a result of falling stock prices in reaction to political risk from Iranian nuclear programmes, the capitalization ratio has fallen to 14.6% in 2008. Increasing public confidence and implementation of privatization programmes has resulted in a rise in this ratio. In this respect, figure 2.3 indicates precisely the trend of development of Iranian stock market regarding its share in national economic activity. It is clear from the figure that the growth of Iran stock market's capitalization ratio has experienced noticeable speed owing to privatization programmes and special attention from government.

Table2.3.The performance indicators of Iran stock market (in USD millions)

Year	Market value of the listed shares	Total value of traded shares	Stock prices Index
2000	5892.5	1043.3	2880.7
2001	7385	1086.5	3554.4
2002	11796.6	2071.2	5044.1
2003	27544.2	4667.8	10886.5
2004	42600.4	12125.2	13543.3
2005	36440.2	7850.1	10258.9
2006	36314.6	4891.2	10074.5
2007	43855.5	8189	9737
2008	48712.7	15243.6	8695
2009	59183.5	17080	11208

Source: Iran stock market website and Author calculations

Another important measure of the stock market size is the number of listed companies in stock market. In this sense, the size of stock market increases in line with the rise in the number of listed companies. From macroeconomic point of view, this measure reflects the role of stock market in financing of investment projects (considering the number of listed firms) in national economy. By the end of 2009, the number of listed companies in Iran stock market was 364. Figure 2.4 demonstrates the trend of movement in the number of listed companies. As can be seen from the figure in spite of fluctuation in this measure, the number of listed companies in Iranian stock market from 285 companies in 2000 has increased to 364 companies in 2009. The reason for significant reduction in the number of listed companies in 2006 was delisting of some companies owing to lack of timely disclosure of information and stagnation of their trading. In spite of decline, due to noticeable development of market, tax incentives and implementing the privatization programme (transfer of the state-owned companies to private sector through the stock market) the number of listed companies recommenced its rise from 2007. It should be noted that the market capitalisation ratio also reflects financial depth in financial market of a society. In terms of positive relationship between stock market development and long-run economic growth the market capitalisation ratio acts as an indicator of the stage of economic development (see Levine and Zervos, 1996). At the same time, this ratio is also considered as an inverse indicator for trading costs. In this sense, an increase in financial depth (market capitalization) is expected to cause a decline in transaction cost (see Hernandez, 2006).

Table2.4.The role of Iran stock market in national economy

Year	Stock market size		Stock market liquidity	
	Market capitalisation ratio(in percent)	Number of listed companies	Total value traded ratio(in percent)	Turnover ratio (in percent)
2000	6.1	285	1.08	17.7
2001	6.4	297	0.94	14.7
2002	10.1	307	1.8	17.6
2003	20.6	345	3.5	16.9
2004	26.4	402	7.5	28.5
2005	19.4	408	4.2	21.5
2006	16.3	320	2.2	13.5
2007	15.3	329	2.9	18.7
2008	14.6	356	4.6	31.3
2009	17.9	364	5.2	28.8

Source: Iran stock market website and Author calculations

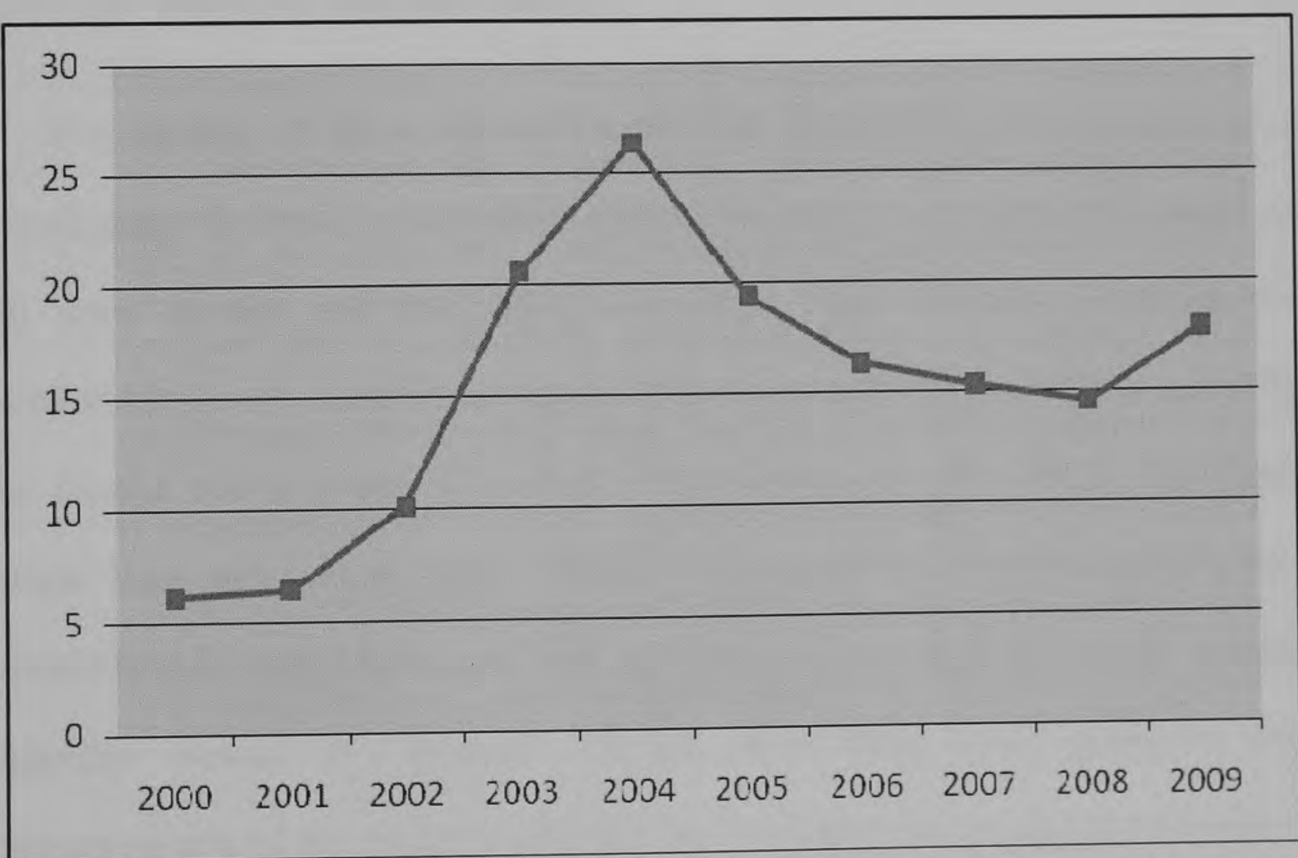


Fig2.3.The time plot of the market capitalisation ratio of Iran stock market

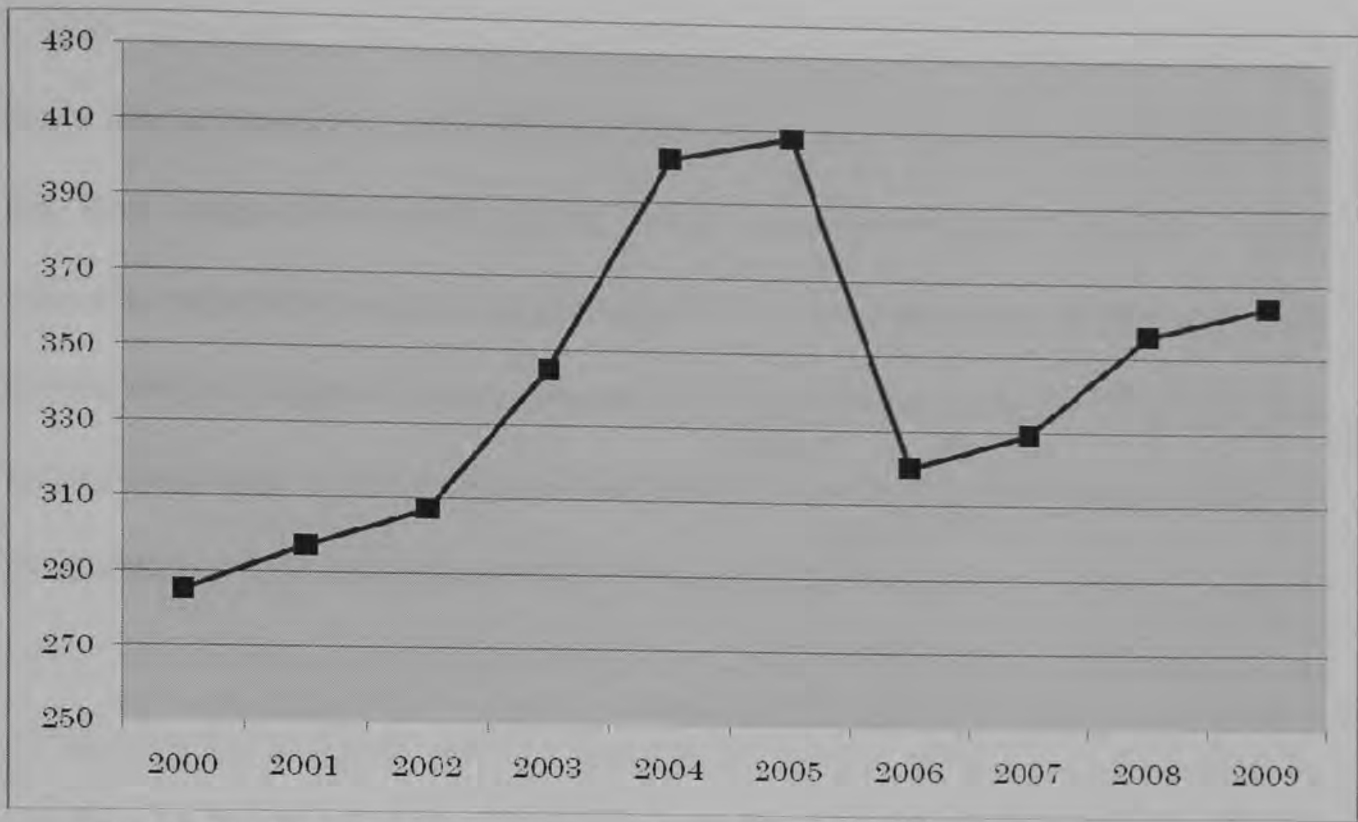


Fig2.4.The time plot of the number of listed companies in Iran stock market

2.4. 1.2. The stock market liquidity

This liquidity of stock market implies the productivity of stock market in conducting its tasks in providing competitive market conditions for investors in stock market and the listed companies. This measure refers to the convenience and ease in buying and selling securities in the market. Liquidity of market is the ability of market in transacting quickly without significant price fluctuations (see Glen, 1994). By allowing investors to modify and diversify their investment portfolios easily any time at low cost, stock market liquidity makes the financial assets less risky and increases the attractiveness of the stock market for new investors. In this sense, the stock market liquidity improves efficient allocation of financial resources, promotes long-term economic growth and enhances the role of stock market in national economy.

Fundamentally, this measure is defined by two ratios. The first indicator of stock market liquidity is the total value traded ratio. This ratio is calculated as the total value of shares traded in stock market divided by GDP. The potential capacity of economic development in countries with high total value traded ratio is higher than countries with illiquid stock market. It should be emphasised that trading value of given stock market is an increasing function of its liquidity (see Amihud and Mendelson, 1986).

The second indicator of the stock market liquidity is the turnover ratio. In practice, this ratio is defined as the total value of shares traded in stock market divided by market capitalization and is an indicator of the trading volume relative to the size of stock market. A high turnover ratio implies low transaction cost and relative ease in buying and selling of shares and financial instruments in stock market. The high level of the turnover ratio indicates the activeness of given stock market. In fact, this measure represents the turnover velocity of securities. This ratio in developed countries is greater than or very close to 100 percent whereas in many developing countries or emerging stock markets this ratio stands in the range of 15 to 30 percent. From technical point of view, a liquid stock market is characterized by a small spread between asking and selling prices. It is worth nothing that it is possible for a large economy with a small but active market to have a low total value traded ratio and a high turnover ratio. From an alternative point of view it should be noted that the high level liquidity of stock market can be a result of the short-term speculative trading.

Since rational investors require a higher risk premium for holding illiquid securities, cross-sectional risk adjusted returns are lower for liquid stock markets .In a liquid stock market, the investors do not lose access to their savings (money) for the duration of the investment because they can easily, quickly, and cheaply, sell their shares and cash their asset. In this sense, increasing the liquidity of stock market persuades investors to invest and establish their portfolio with long term horizon. In a liquid market a large order can be executed with only a small price movement. It should be noted that from a given company point of view in some cases the liquid stock market may affect corporate governance through frequent changing of shareholders' composition. In this sense, the designed long term programmes of company is affected by management changes owing to changes in composition of main company's shareholders.

In terms of total value traded and turnover ratios the liquidity of Iran stock market has expanded considerably. In the case of the turnover ratio, after a decline between 2004 and 2006, the trend has started to rise again, reaching 31.3 percent by the 2008 (see figure 2.5), as a result of a reduction in the volume of transactions. It should be noted that in terms of the total value traded, the performance of Iran stock market has been relatively significant. This ratio has increased approximately five times over the period 2000 to 2009.

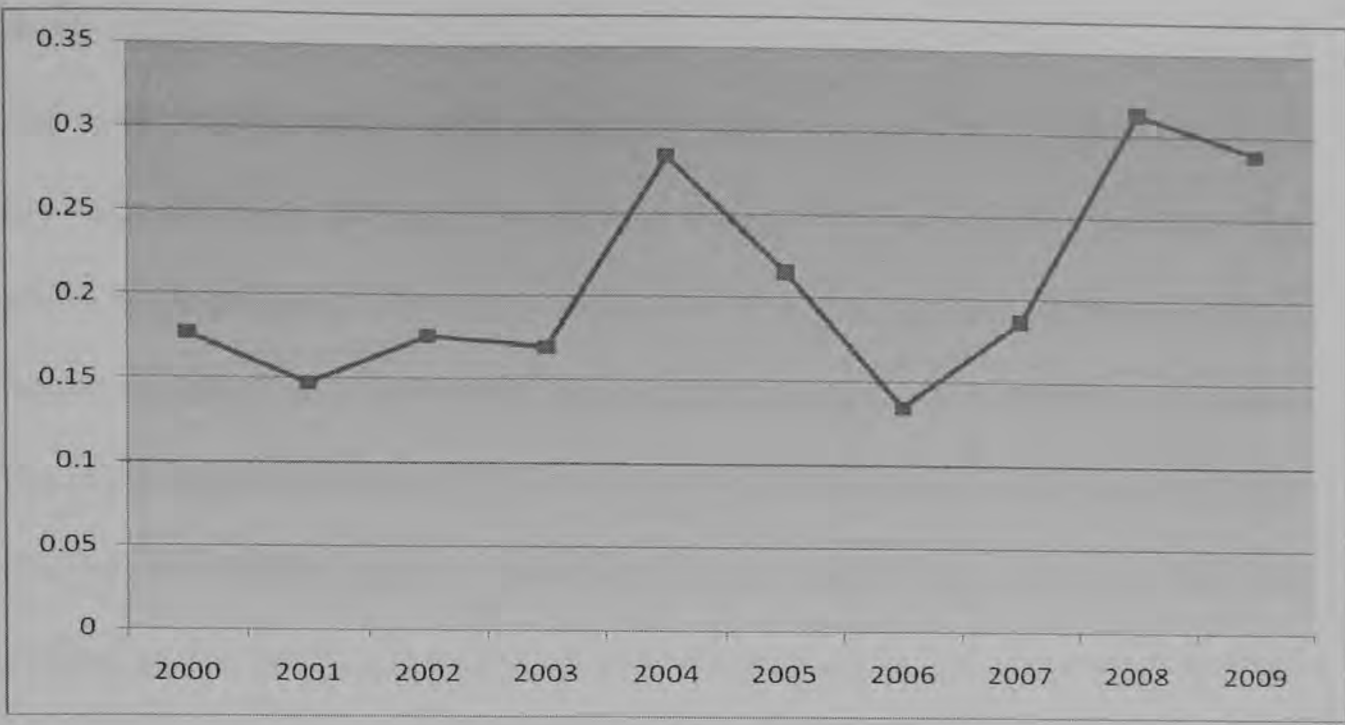


Fig2.5.The time plot of turnover ratio in Iran stock market

The liquidity of stock market expands with greater competition and higher transparency in the market. It is clear that bureaucratic regulations, the existence of market rigidities and untimely reporting of relevant financial information hamper supply of and demand for securities and reduce the liquidity level of the market. Stock market liquidity reduces the required return for investors; while illiquidity increases the cost of capital through raising in risk adjusted returns and prevents stock market from effective processing of information (see Amihud et al., 1997)

2.4. 1.3. The stock market concentration

Market concentration is another important indicator of stock market development showing the extent to which a stock market is dominated by a few companies. In this regards, a high concentration is not desirable for a market because it might have a negative impact on the market liquidity and trading costs (see Derirguc-Kunt and Levine, 1995). The concentration of stock market can be examined through two different criteria. In the first definition, market concentration is the percentage of market capitalization of the largest 5% of all listed companies in terms of market capitalization and share trading value. Table 2.5 shows how concentration of Iran stock market based on 5% of the most heavily capitalized domestic companies and 5% of the most traded domestic shares compared to domestic market capitalization and share trading value, respectively. It is clear from table 2.5 that the degree of market concentration in Iran stock market has been relatively high over the period 2000 to 2009. In this sense, it can be noted that in terms of trading value the concentration of Iran stock market has frequently increased. In terms of market capitalization there have been various fluctuations in market concentration. In particular after a decline in market value of 5% of the most capitalized companies between 2004 -2006, this indicator has started to increase and then it has decreased to 45.6% in 2009.

In the second measure the market concentration is defined as the percentage of market capitalization and turnover value of the largest ten quoted firms. As it can be seen from table 2.6 the concentration degree of Iran stock market according to this definition also is very high. More precisely, the top 10 companies posses 93.3% of turnover value of Iran stock market in 2009. Based on this criterion in average 50% of Iran market capitalization is related to largest ten companies.

Table2.5. Iran stock market concentration based on 5% most capitalized and most traded domestic companies

Year	5% market value	5% trading value	Number of companies
2000	42.5%	63.2%	14
2001	43.1%	60.6%	15
2002	49.7%	50.5%	15
2003	63.6%	46.4%	17
2004	57.6%	53.8%	21
2005	52.1%	53.1%	21
2006	48.5%	52.9%	16
2007	60.3%	73.1%	16
2008	62.2%	86.6%	18
2009	45.6%	87.7%	17

Source: WFE (world federation of exchanges)

Table2.6. Iran stock market concentration based on 10 most capitalized and most traded domestic companies

Year	Market capitalization of top 10 companies	Turnover value of top 10 companies
2000	37.2%	52.8%
2001	36.1%	50.7%
2002	41.1%	43.1%
2003	54.6%	36.4%
2004	40.5%	36.9%
2005	37.0%	38.8%
2006	40.0%	40.0%
2007	49.3%	64.2%
2008	47.2%	72.4%
2009	57.7%	93.3%

Source: WFE (world federation of exchanges)

Table 2.7 compares the Iran stock market with some other emerging stock markets in terms of market concentration measures. As expected the market concentration in emerging developing countries is high. In this regard, Derirguc-Kunt and Levine (1995) argue that there is a negative relationship between market concentration and development of the market. In this view of market's structure and performance, it can be noted that Iran stock market is highly concentrated in comparison with other given emerging stock markets.

Table2.7. Comparison of emerging stock market based on market concentration measures in 2009

Stock market	5%market value	5%trading value	Number of companies	Market capitalization of top10 companies	Turnover value of top 10 companies
Buenos Aires SE	56.8%	49.1%	5	71.9%	69.8%
Colombia SE	50.6%	48.3%	4	72.8%	77.5%
Mexican Exchange	50.1%	61.0%	6	63.1%	73.8%
Bursa Malaysia	72.9%	62.7%	48	39.3%	32.0%
Indonesia SE	69.4%	70..7%	21	48.4%	51.2%
Egyptian Exchange	46.4%	40.6%	16	39.4%	32.6%
Istanbul SE	64.0%	55.1%	16	50.4%	44.3%
Saudi Stock Market	50.8%	32.3%	7	58.5%	35.2%
Tel-Aviv SE	74.2%	70.1%	31	56.4%	46.2%
Warsaw SE	72.3%	70.1%	23	56.7%	62.2%
Tehran SE	45.6%	87.7%	17	57.7%	93.3%

Source: WFE (world federation of exchanges)

2.4. 2. Risk and Return Characteristics of Iran stock market

This subsection attempts to shed light on the risk-return characteristics of Iran stock market. The examination of the future of risk and return of investment in Iran stock market as an emerging market helps to identify its potential capacity to attract international portfolio investment. In the financial economics literature it is popularly believed that emerging stock markets provide higher expected returns in view of their high growth prospects. At the same time, emerging stock markets are more volatile (risky) than developed stock markets. It should be noted that in emerging stock markets high returns are associated with high risks (in particular political risk, liquidity risk and currency risk).

For a better understanding of how risk-return structure of Iran stock market table 2.8 compares the risk-return characteristics of this market with other emerging stock market. The data analysed in this table are the monthly stock returns over the period March, 2001 to Jun, 2009. As it can be seen from the table, the same as other emerging stock market investment in Iran stock market yields in average 1.3% monthly returns accompanied by high risk (Std.=0.060 as measure of market risk). Over the considered period while the average monthly return of developed stock markets (G7 Index) has been negative, the emerging stock market and in particular Iran market have experienced positive stock returns. In the case of reward to risk ratio Iran stock market has been in better position than other emerging stock market. The risk-adjusted outperformance of Iran stock market implies its high growth prospects in view of the wide privatization programmes and economic reforms in Iranian economy. It is important to remark that in terms of unconditional volatility (the amount of standard error) as expected the Iran stock market as other emerging stock markets has experienced high volatility than developed stock markets but it has high return potential. The Iran stock market in view of high return potential and economic liberalisation programmes represents a new investment opportunity for international investors and portfolio managers.

Table2.8. Comparison of risk-return performance (from March 2001 to Jun 2009)

	EM composite	EM Asia	EM Latin America	EM Europe & Middle east	World Index	G7 Index	Iran Index
Mean	0.008	0.007	0.011	0.006	-0.002	-0.002	0.0132
Std.	0.075	0.075	0.088	0.087	0.049	0.048	0.060
Reward to risk ratio	0.104	0.090	0.130	0.072	-0.034	-0.045	0.22

Source: Emerging Markets: Overview and Performance Analysis, The Dynamics of Emerging Stock Markets and personal estimation

2.4. 3. The position of Iran stock market in the world

In order to get a more comprehensive insight into the development of Iran stock market, table 2.9 compares the Iran stock market with some other emerging stock markets in terms of development indicators of market namely market capitalization ratio, turnover ratio and the number of listed companies. In spite of considerable growth in given indicators, the condition of Iran stock market in particular in terms of market capitalization ratio signifies the potential possibility of development of this market regarding economic activity (GDP). The turnover ratio as indicator of activeness of market compared with Argentina, Colombia, Mexico and United Arab Emirate has been in a better condition but to increase its role in national economy and absorb the domestic and foreign investors, it should be improved by increasing the transparency of market and employing new financial instruments. It should be noted that when the turnover ratio is bigger than

100 percent, it implies that may be over speculation exist in the market. In the case of the number of listed companies, the Iran stock market has been in sixth rank of the given stock markets. In particular, by the end of 2009 the number of listed companies in Iran stock market has been more than Istanbul stock market. Generally speaking, it can be noted that Iran stock market in view of the market capitalization ratio and volume of economic activity has high prospects for improvement.

Table2.9.The indicators of stock market development in emerging stock markets in 2009

Stock market	Market capitalisation ratio(in percent)	Turnover ratio (in percent)	Number of listed companies
Buenos Aires SE	14.7	6.5	106
Colombia SE	60.5	13.2	87
Mexican Exchange	40.2	23.9	406
Bursa Malaysia	148.3	30.06	959
Indonesia SE	39.8	43.9	398
Egyptian Exchange	48.5	80.6	313
Istanbul SE	38.1	128.7	315
Saudi Stock Market	84.7	106.7	135
Tel-Aviv SE	96.6	45.8	622
Warsaw SE	35	37.8	486
Abu Dhabi	35.8	23.7	67
Tehran SE	17.9	28.8	364

Source: WFS (World Federation of Exchanges) and IMF (International Monetary Fund)

2.4.4. Foreign investment in Iran stock market

Following infrastructural reforms in Iranian economy, the policymaking focused on the liberalization of Iran stock market and accordingly in early

2010 the foreign investment law in securities and other financial derivatives was revised. In this sense, based on paragraph C, Article 15 of the Law of the Fourth Economic, Social, and Cultural Development and Foreign Investment Promotion and Protection Act, foreign investors can invest in Iran stock exchange. In this regard, the total amount of foreign investment in the entire listed companies of stock market or OTC in Iran, or in any individual listed company, shall not exceed 20 percent. However, for strategic foreign investors (investors who have more than 10% of total shares of a domestic company), the repatriation period of capital will be two years from the buying date. These investors need the SEO approval for selling their equities. Following provision of certain bylaws, conditions for entry of the foreign investor have been improved. It should be noted, based on previous regulations, foreign investors were permitted to hold a maximum of 10% of shares of each company listed and are not allowed to withdraw their capital for three years of their investment. At the moment, however the quantity of foreign investment in the TSE is very low.

2.5. Concluding remarks

This chapter provides a brief review of theoretical literature of the role of stock market in economic development process specifically in developing countries. The history of the Iran stock market as an emerging market and its role in Iranian economy are surveyed in detail. More precisely, since a better understanding of market performance helps to specify possible and suitable models to explain the dynamic evolution of risks and rewards in this market, this chapter presents the quantitative characteristics of the Iran stock market.

It is popularly believe that stock market especially in developing countries can be effective in realization of economic growth and development through mobilizing and channelling domestic savings. At the same time, a mature and efficient stock market plays a crucial role in absorbing foreign financial resources through creating the possibility of securities or other financial instrument to be transacted by foreign individuals or institutions. A well-operating stock market as a barometer of economic activity in society provides a general picture of society expectations about future of economic conditions; therefore its performance can be determinant in designing and implementing effective economic development programmes.

In spite of the fact that Iran stock market is the oldest stock exchange in Middle East region, its role in Iranian economy has been influenced by numerous significant shocks in particular the Islamic revolution and Iraq-Iran war. The revitalization of Iran stock market aimed at enhancement of its role in national economy and as a lever in successful implementation of economic reforms polices at macroeconomics level (liberalization and privatization programmes) which started in 1988. Iran stock market has involved institutional and policy reforms aimed at improving stock market performance by reducing costs of trading and volatility as well as increasing market liquidity and efficiency.

Iran stock market has evolved significantly over the last decade and is undergoing constant innovation to improve liquidity and market microstructure. In particular, the implementation of institutional reforms, namely reorganization of market, changes in the regulatory regime, the modernization of trading system, relaxation of foreign investment restrictions and expansion of market including creating regional stock markets have led to significant development of Iran stock market in terms of market size, market depth, liquidity and the number of listed companies. Undoubtedly, a well organized and well regulated stock market by improving functioning, attractiveness and efficiency leads to initial public offerings (IPO) process of both public and private companies and therefore plays an outstanding role in implementation of economic development programmes aimed at reducing the role of oil revenues in Iranian economy and; attaining a sustainable and high economic growth rate.

Over the last decade, Iran stock market authorities aimed at improve liquidity, market microstructure and enhancing the efficiency of market have been engaged actively in regulatory reforms in market regulations, trading activity, information disclosure, market microstructure (automatic and continuous quotation). In the case of market liberalization, the regulatory reforms have been implemented to reduce legal barriers to cross border investments and specific risks (political, liquidity and currency risks) in an effort to make the Iran stock market more "investable" and attractive for foreign investors. In this sense, it is worth noting that the free entry of foreign investors may have positive effects on market microstructure, through rising liquidity of market; low volatility and efficiency gains (see Ngugi et.al.2005). In the same way, Arouri et al. (2010a) argue that liberalization of stock market relaxing the foreign investment regulations through increasing market liquidity; market size (market capitalization), market depth, market transparency and price competition would enhance the informational efficiency of market. On the other hand, stock market liberalization may result in inefficiency of market owing to information asymmetry between foreign and domestic investors, deviation of stock prices from its fundamental value, speculative bubbles (due to high liquidity of market), and increasing market volatility by unreasonable behaviours of market participants (i.e. speculative trading).

In spite of outstanding growth of Iran stock market in comparison with other emerging stock markets in terms of market size, market liquidity and the volume of foreign investment, there are considerable gaps when compared with the major developed markets. These weaknesses may be due to the lack of good market regulations related to information disclosure and financial reporting, lack of reliable infrastructure (embryonic private sector, few financial instruments, specialized portfolio management institutions and unqualified investors) and the absence of international accounting standards and appropriate laws to protect minority shareholders. Specific risks, particularly political risk and liquidity risk significantly affect the tendency of domestic and foreign investors to invest in Iran stock market. On the other hand, government attitudes and political behaviour affect the performance of Iran stock market. In this sense, it can be noted that the main part of market is dominated by state-owned or semi state-owned investment companies for example Social Security Fund, Civil Servants Pension Fund and Oil Investment Company.

In sum, it can be highlighted that Iran stock market in view of the magnitude of Iranian GDP, level of domestic savings and diversity in economic activity has a potential possibility of development in terms of its role in Iranian economy. In this sense, with respect to high stock returns and low correlation (the same as other emerging stock markets) with international stock market, Iran stock market can be attractive to foreign investors, or international portfolio managers. Under these circumstances, due to the arrival of foreign capital flows market indicators such as number of listed companies, liquidity, and capitalization increase remarkably. It is obvious that continuing reforms in market regulations, market microstructure and reducing the governmental interventions would be helpful to enhance the role of Iran stock market in improving the standard of living of Iranian people (increasing the social welfare).

Chapter 3

The Stock Market Efficiency

3.1. Introduction

The primary role of a stock market is to mobilize and allocate financial resources in society. In this manner, stock market helps businesses or entrepreneurs to acquire funds for start up, expansion and also investment in research and development. Furthermore, a stock market as a market for supply and transactions of financial instruments, encourage people to channel savings into corporate investment. If stock prices present accurate signals for resource allocation, firms are able to make correct production - investment decisions, and investors (participants in stock market) are able to choose the most appropriate stocks for investment. These choices are possible only if the stock prices fully reflect all available information and thus the stock market is informationally efficient. Stock prices and returns in the efficient stock market act as benchmarks for the cost of capital (opportunity cost) and returns on investment projects (see Green et al., 2000). At the same time, since the stock prices are forward-looking, the efficiently priced stock represent investors' expectations and shifts in investors' views about the future prospects of companies as well as the economic environment(see Ngugi *et al.,* 2005), an efficient stock market reflects the national economic prospects. In an efficient stock market, investors can consider the observed stock prices as the market's best assessment of risk-return trade off of the considered asset in decision making process (see Arouri et al., 2010a)

In can be noted that the efficiency of stock market has a determinant impact on the ability of stock market to accomplish its functions of pricing and efficient allocation of financial resources as well as diversification of investment risk. In other words, the success of the stock market in economic development process crucially depends on whether the stock prices are determined by the outcome of supply and demand in a competitive stock market and whether the stock prices display inherent value of companies. Due to the scarcity of financial resources, an efficient stock market is critically important in mobilizing national saving and financing of new investment projects. In short, the efficiency of the stock market is especially important in understanding the role of stock market in economic development process of society. It is widely believed that efficient price discovery mechanism enhances the role of stock market in real economic activity.

From microeconomic theory point of view, market efficiency is an important issue, generally albeit with a variety of meanings according to context (e.g. economic efficiency and allocative efficiency). Established theory of welfare economics has identified that perfectly competitive markets can support Pareto- efficient outcome (Arrow, 1971; Mathur, 1991). Perfect competition requires that market participants are rational and well informed (McKenzie, 1981; Geanakoplos, 1987; Petri, 2004).

In the context of financial markets this prefect competition leads us to recognize that market prices are accurate signals of fundamental values of traded financial instruments. In this sense, the allocation of resources generated by the market is said to be efficient (Pareto optimal) if there does not exist an alternative feasible resource allocation which can make some individual better off without making someone else worse off (Stiglitz,1981). According to Tobin (1982) in a stock market where stock price movements direct financial resources to its highest value uses with an acceptably low error, or at least with less error than alternative capital allocation mechanisms such as industrial policies, the allocation of resources will be allocatively efficient.

In stock markets, stock prices lead to efficiently allocated resources through clearing markets, conveying and aggregating information (Grossman, 1976, 1978; Grossman and Stiglitz, 1980; and Diamond and Verrecchia, 1981; Stiglitz, 1981; Peress, 2005). A stock market provides incentives to gather information, which becomes reflected in stock prices. These prices provide signals for efficient allocation of investment (Allen ,1992; Tadesse, 2004). In sum it can be noted that in an allocatively efficient stock market stock prices should reflect accurately all available information. This means that in order to allocate resources efficiently, stock market should be informationally efficient.

In this chapter we will review the efficient stock market literature and the empirical tests that have been developed within this literature. The remainder of the chapter is divided into five main areas. The theory of stock market efficiency and kinds of stock market efficiency are analysed in section 2. The relationship between stock market efficiency and stock market volatility are analysed briefly in section 3. Section 4 demonstrates the review of empirical literature on the weak form efficiency. The chapter ends with some concluding remarks.

3.2. Theory of Stock market Efficiency

Information plays a fundamental role in the asset pricing process and operation of stock market. Stock prices are affected by relevant information and buyers or sellers make decisions according to realized and available information about firms whose shares are traded in stock market. The fashion in which information is reflected in stock prices forms the main structure of market efficiency theory. In this sense, informational efficiency deals with why stock prices change in stock market and how these movements take place.

There are three aspects of the efficiency of financial markets:

-***Operational efficiency:*** in this situation the participants supplying and demanding funds are able to perform transactions cheaply. Operational efficiency implies that transactions should be carried out at minimum costs. This stresses that the transaction costs in the stock market should be determined in a competitive way. Operational efficiency deals with the accuracy and speed of transactions which are executed in securities markets. High transaction costs prevent price adjustment from taking place instantaneously and precisely (see Obaidullah, 2001)

In view of the effect of transaction costs on investors' decisions , Obaidullah (2001) argue that any move or regulation that reduces transaction costs, simplifies trading system, increases the availability and accuracy of information, develops information processing by participants is a step in the direction of improving the allocative efficiency of the stock market. In addition, in operationally efficient stock market, the degree of liquidity is high and the condition of the market is orderly. Furthermore the organization and structure of market is productive. Regulations and enforcements procedures are designed according to conditions of competitive market.

Another factor which affects operational efficiency is "Thin Trading" particularly in emerging stock market. In these circumstances a certain stock has not been traded frequently for instance for two weeks, therefore the price which can be used to value it is the price at which stock was traded during two previous weeks. However, this price is two weeks old and hence may not reflect the correct value of stock in terms of information concerning it. In the other words, the correct value of the stock will not be manifested without frequent trading. This condition leads to disequilibrium of stock prices.

- ***Allocative efficiency:*** industrial and commercial firms with the significant potential to use investment funds effectively need a method to attract financial resources. Stock markets help in the procedure of allocating society's resources among real investment projects. In this sense, an allocatively efficient market provides vast funds for fast-growth sectors but allocates only small amounts for slow-growth industries. In a market which is allocatively efficient, financial resources are allocated to productive investment projects in an optimal way and all participants in the market benefit. Furthermore, the allocative efficiency determines the stock prices based on the risk-adjusted rate of returns. In other words, in an allocatively efficient stock market the stocks are priced based on the risk of investment associated with them.

- ***Pricing efficiency***: In this sense, any new relevant information is quickly and accurately reflected in prices. In a pricing efficient market the investor can anticipate to earn just a risk-adjusted normal return from an investment as prices adjust immediately and in an unbiased way to any news. This kind of efficiency deals with the impact of information on securities prices. Pricing efficiency, which is known as informational efficiency and operational efficiency are preconditions for allocative efficiency. As noted before, by definition in an allocatively efficient stock market, prices of stocks must equal their fundamental values at all times. Arouri et al. (2010a) argue that informational efficiency forms an underlying assumption for many other financial theories.

These three types of efficiency are strongly linked together .In an operationally efficient market, the information spreads easily, stocks are priced accurately and saving or capital is distributed efficiently among companies. Following the objectives of this thesis, we concentrate on the pricing efficiency and necessary conditions which are needed to create informationally efficient stock market.

The importance of stock market efficiency can be highlighted through the following three reasons:

To encourage share buying: accurate pricing can create incentive effects when individuals are going to invest in firms. If shares are incorrectly priced, many owners of financial resources will have no interest in investing because the stock prices do not accurately represent the inherent attractions of the company. This will seriously reduce the availability of financial resources to companies and inhibit economic growth. Investors need to know they are paying a fair price and that they will be able to sell at a fair price.

To give correct signals to company managers: Since the maximization of shareholder wealth can be represented by the share price in an efficient market, financial decision-making depends on the correct pricing of the company's shares. In implementing a shareholder wealth-increasing decision the manager will need to be confident that the implication of the decision is precisely signalled to shareholders and to management through a change in the security price. It is important that managers receive feedback on their decisions from the share market so that they are encouraged to follow shareholder wealth strategies. In an informationally efficient stock market, information relevant to stocks spreads without delay; the manager of company receives the feedback of its decision from the fluctuation in stock price.

To help efficient allocation of resources: As noted earlier, allocation efficiency requires both operating efficiency and pricing efficiency. If securities are priced correctly and stock market is informationally efficient, allocation of financial resources which are valuable for society will be optimal. Under these conditions, owners of financial resources and shareholders of firms would benefit and as a result, society's welfare would increase.

It is important to emphasise that an efficient market is not synonyms with a perfect market. There is a more restricted definition of perfect market. In such market every investor is assumed to be rational and has immediate and instantaneous access to all relevant information. In this sense, rational investors have an interest in maximizing their expected wealth. They use all available information in order to take advantage of any perceived profit opportunity and, while doing this, they will not make any systematic mistakes in expecting the future. This information is available for investors without cost (Kean, 1983). Furthermore, a perfect stock market is frictionless, i.e. without transactions costs, with fully divisible assets and without any restrictive regulations.

3.2.1. Definitions of an efficient stock market

There have been several definitions of stock market efficiency in the financial economics literature. These definitions have developed according to various interpretations of information types and the manner in which information is reflected in stock prices.

Firstly, the formal definition of market efficiency presented by Fama in 1970:
"A market in which prices always 'fully reflect' available information is called 'efficient'."(Fama, 1970, p.383)

The efficient market hypothesis (EMH) implies that if new information about a firm is revealed it will be incorporated into its share price rapidly and rationally. In an efficient market no trader will encounter an opportunity for making a return on a share (or other security) that is greater than a fair return for the riskiness related to that share (or any other security). The lack of abnormal profit possibilities appears because current and past information is immediately reflected in existing prices. Only arrival of new information causes stock prices to change.

Jensen with focusing on kind of information introduced the following definition of an efficient market (Jensen, 1978):
"A market is efficient with respect to information set θ_t, if it is impossible to make economic profits by trading on the basis of information set θ_t."(Jensen, 1978, p.96)

In this definition, economic profits are defined as risk adjusted returns net of all costs. Information set θ_t refers to the different amount of available information of different levels of market efficiency. He also noted that this definition of informational efficiency constitutes three related aspects: the efficient market hypothesis, the theory of random walks and the rational expectations theory.

Stiglitz (1981) argued that market efficiency (informational efficiency) used by financial economists is only the part of overall market efficiency. This requires that:

• The market must provide the correct incentives for gathering the right amount and kind of information.

• The market prices must reflect the information available to the various traders (participants).

• The firms must be able to transmit the information efficiently about their prospects to potential investors.

Malkiel (1992) introduced a comprehensive definition of the efficient market:

A stock market is said to be efficient if it fully and correctly reflects all the relevant information in determining security prices. Formally, the market is said to be efficient with respect to some information set if security price would be unaffected by revealing that information to all [market] participants. Moreover, efficiency with respect to an informational set implies that it is impossible to make economic profits by trading on the basis of that informational set (Malkiel, 1992, p.260).

In this explanation of market efficiency, Malkiel stated that efficiency of stock market can be tested by revealing information to market participants and measuring of stock prices. As a result, if prices do not change when information appears, then the securities market is efficient with regard to that information. In addition, he introduced an alternative approach to assess the efficiency of stock market, by calculating profits which can be created by trading according to information.

In 2002, Damodaran developed another definition and emphasised the importance of market efficiency in the framework of investment valuation: *"An efficient market is one where the market price is an unbiased estimate of the true value of the investment."*(Damodaran, 2002, chapter6, p.2).

Since in the efficient stock market stock price is supposed to reflect true fundamental value of company, investment valuation will involve justification of the market price. On the other hand, in an inefficient market because of deviation of share price from true value, investment valuation in this case will be directed towards estimating a true value of share (Damodaran, 2002). The equality between price and inherent value of a given stock would be achieved only when there is informational efficiency. For instance, in the secondary market where stocks are continuously traded, a change in the value of a stock may occur with new information which either changes profitability or risk or both. With a change in value, the stock price is adjusted. In an efficient market, this reaction of stock prices to new realized information would be immediate and accurate. In this sense, informational efficiency implies that there are no lags in the distribution and absorption of information into stock prices. Instantaneous and accurate price adjustment also implies that powerful competitive pressures force all contributors to react without any lag and that the markets are dominated by rational investors who would not overreact or underreact. Therefore in an efficient stock market there is no extreme price movement as a result of irrational behaviour of the participants.

In an informationally efficient market the information is unbiased; indicating we cannot use the historical price to forecast the future stock return, and the price change should be random. Furthermore future stock prices are determined by information flows which are unpredictable, random and unknown. In other words, stock price movements are independent of what happened in the past. The investors are not able to speculate by buying the undervalued stocks or selling the inflated stocks. They should trade in the stock market with fair prices. The new information will appear in the future randomly, which is defined to be unpredictable, and the investors can not just outperform within the market by using the already released information. The stock prices adjust to the new information by moving to an appropriate equilibrium price level and they would be stable until realization of new information. In contrast, in an inefficient stock market owing to overreaction or underreaction the stock prices are higher or lower than the appropriate equilibrium level.

Overall, informationally efficient market emerges when new information is quickly, totally and correctly (without bias) incorporated into stock prices. In other words the current market price reflects all available information. Under these conditions the current market price in any financial market could be the best-unbiased estimate of the value of the investment.

The efficient market hypothesis is associated with the idea of a "random walk," which is used in the finance literature to distinguish a price series where all subsequent price changes represent random departures from previous prices. The logic of the random walk idea is that if the flow of information is unrestricted and information is immediately reflected in stock prices, then tomorrow's price will change with only changes of tomorrow's news and will be independent of the price changes today. But news is by definition unpredictable, and thus price changes must be unpredictable and random. As a result, prices fully reflect all known information, and even uninformed investors buying a diversified portfolio at list prices given by the market will obtain a rate of return as generous as that achieved by the experts (see Damodaran, 2002)

In this market all relevant information is fully and immediately reflected in a security's market price, thereby assuming that an investor will obtain an equilibrium rate of return. In other words, an investor should not expect to earn an abnormal return (above the market return) through either technical analysis or fundamental analysis. The “fully reflect” and “available information” phrases in definition of stock market efficiency have been controversial issues in financial arguments, because these terms are vague and non-operational.

As has been mentioned previously, the first attempt to provide a practical definition for market efficiency came from Fama (1970) when he considered a market to be efficient with respect to some information if 'the abnormal expected returns from trading strategies based on that information are zero'. That was what he called a fair game. The fair game and abnormal expected returns definitions have certain weaknesses. Firstly, abnormal returns should be relative to some base, e.g. normal expected returns. The question here is how to determine the normal returns and what is the basis for distinguishing normal from abnormal returns. Fama did not consider this. Secondly, it is well known that the returns of any portfolio are related to the risk of the portfolio, so some of the returns could be due to the differences in portfolio's risk which should be considered in defining abnormal returns. The use of the risk adjusted returns is not considered at all in Fama's definition. Thirdly, the definition did not consider that investors may hold heterogeneous beliefs and this may affect their required rate of return on securities.

Beaver (1981) started by explaining what produces inefficient markets, in his attempts to provide a definition avoiding the weaknesses of Fama's definition, because he thought that the discussion about efficient markets becomes easier after determining the causes of inefficiency. He showed how some investors can observe an inconsistency between assessed inherent value and price, and determined the three conditions under which such individuals exists. Therefore, Beaver defined market efficiency as follows:

"A security market is said to be efficient with respect to an information system if, and only if, the prices act as if everyone observes the signals from that information system" (Beaver, 1981, p.148).

To put it in other words, prices react as if there is widespread knowledge of that information. If prices have this property, they 'fully reflect' the information system. Thus Beaver removed difficulty about comparing abnormal with normal returns by conducting comparison between the share price with its assessed inherent value which is possible and more significant.

Talking about the intrinsic value should by necessity include the consideration of the portfolio's risk. Lastly, his definition considers the heterogeneity of investor's belief by suggesting that everyone acts based on its observation of the signals from the information system.

3.2.2. The levels of stock market efficiency

Three versions of market efficiency are being more specifically distinguished with respect to different types of available information to market participants (investors). The different levels of informational efficiency are *weak*, *semi-strong* and *strong* (see fig3.1). For a market to be efficient in the semi-strong form, it must also be efficient in the weak form. If the market is efficient in the strong form it is also efficient in the semi-strong sense.

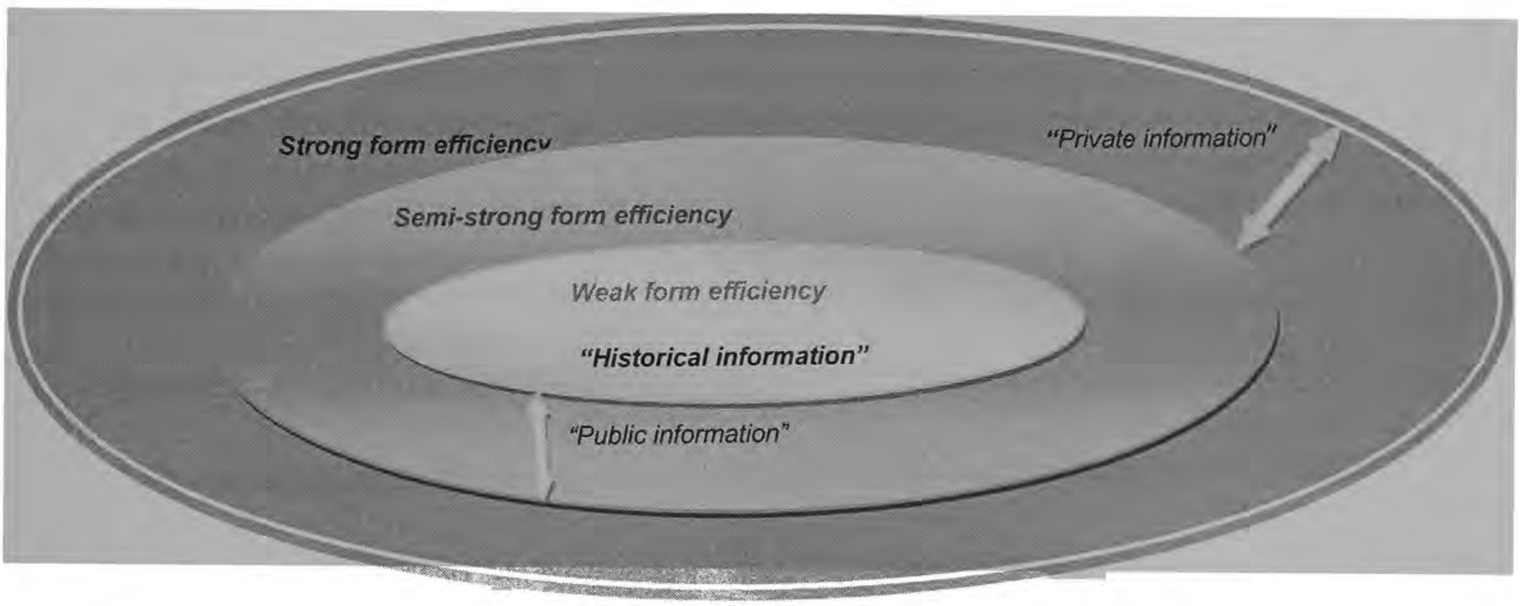


Figure3.1.The levels of stock market efficiency

Source: Author design

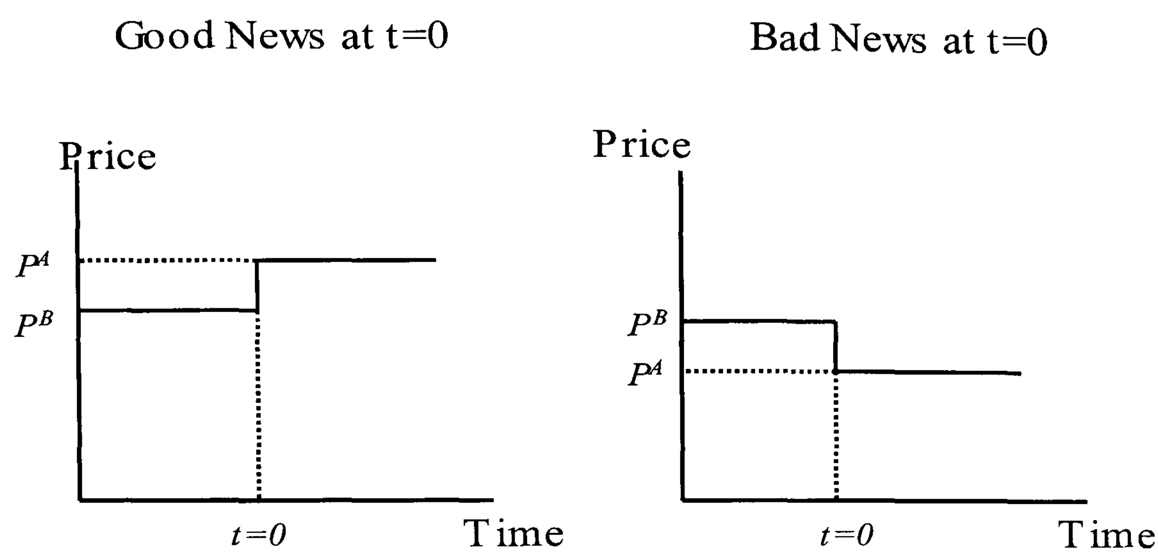


Figure 3.2 .In an efficient market, stock prices should adjust quickly to new information

Sorce:Author design

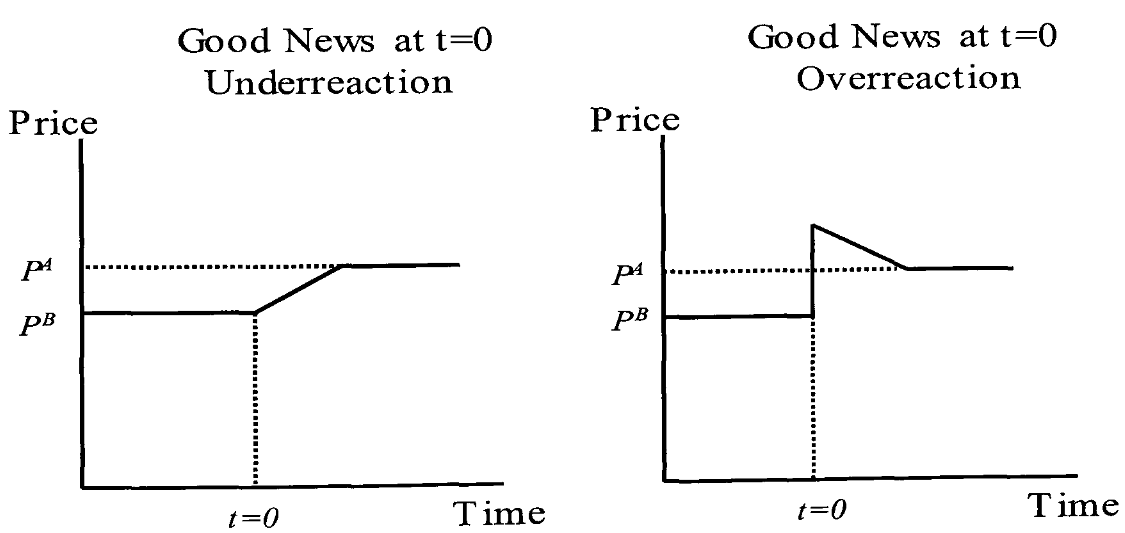


Figure 3.3. In an efficient market, stock prices should not underreact or oroverreact to new information

Source: Author design

3.2.2.1. Weak form stock market efficiency

In this form, stock prices reflect all the information in the past series of stock prices. Relevant information in this level of stock market efficiency includes just historical information (historical prices and volume of trade, past dividends). Under these conditions charts and technical analyses that use past prices alone would not be useful in finding undervalued stocks. Stock prices would only react to new information relevant to companies such as new economic events.

At this level, stock prices follow a random walk process and it is impossible to gain excess returns by looking for patterns in historical stock prices (Barone, 1989). It is impossible to distinguish any pattern in the sequence of security prices; therefore predictions will not improve the chances of the investor (participant in stock market) in creating abnormal stock returns. In other words, a stock market is weakly efficient (with respect to information), if historical information is fully and (in the strictest form) instantaneously incorporated in present stock prices. In such a market, present stock prices reflect all information available in patterns of historical prices, and so future price movements cannot be derived from an assessment of past prices. To put it another way, in an efficient stock market in weak form prediction of future prices of company's share according to the pattern of past prices is impossible.

In 1991, Fama developed a new form of classification to cover more general areas. In this adaptation, tests of the weak form efficiency are considered as tests for return predictability based on examining possibility of predicting stock returns using variables such as dividend yields and interest rates.

3.2.2.2. Semi-strong form stock market efficiency

The *semi-strong* form of efficiency indicates that stock prices reflect and adjust to all published information and that it is unfeasible to receive higher returns by studying published data such as newspapers and annual accounts. In other words, investor cannot expect to earn superior return by analysing financial reports (accounting), announcements of dividend changes, bonus issues, rights issues, stock splits, merger and acquisition plans. This means that the stock prices are adjusted rapidly and in an unbiased way to all public announcements in newspapers, journals, corporate forecasting and annual reports. In this level of market efficiency, present prices reflect all publicity available information, and so future price movements reflect future (and as yet unknown) disclosures of apparent and available information.

The concept of relevant information in this level of stock market efficiency is all historical plus all relevant public information (firm's financial statements, dividend announcements, earnings forecasts, earnings and dividend announcements, financial ratios, accounting practices, stock splits, and expectations about market performance, macroeconomic factors, economic and political news). This level of stock market efficiency is related to the testing of the speed of price reaction of the shares to new information. In this respect, if prices adjust to new information with a lag, the stock market will be inefficient. Under this condition, even if prices reflect all available new information, if they do so with a significant delay, then the semi-strong form of efficiency is violated.

The market is efficient in the semi-strong sense if stock prices respond immediately and without bias to newly published information. Fundamental analysis is employed to investigate of the semi-strong form of efficiency. This approach examines whether stock prices reflect all relevant information and whether it is impossible to predict price changes and it is carried out by studying a company in order to find information about its profitability (Brealey & Myers 2000). In order to better reflect the content, the test of this kind of informational efficiency was called event studies by Fama (1991).

3.2.2.3. Strong form stock market efficiency

In the strong level of informational efficiency stock prices reflect all available public and private information. Relevant information is all historical and public as well as all related private information (insider information such as imminent corporate takeover plans and extraordinary positive and negative future earnings announcements). In essence, the strong form efficient market assumes a perfect market in which all information is cost-free and universally available to all market participants simultaneously. If the market were strongly efficient, even an insider would not be able to earn excess returns from his advantaged position.

Grossman and Stigliz (1980) argue that the existence of perfect informational efficient stock market is impossible. It is because if stock markets are completely efficient, the return to collecting information would be zero. As a result, there would be no reason to trade and securities markets would eventually collapse.

According to Fama's new form of classification, tests of this form are called tests for private information (Fama, 1991). This does not change the three conditions that he stated in 1970 in order for the stock market to be in a strong form of efficiency. These conditions consists of the following: (1) the absence of transactions costs, (2) that investors have access to relevant information without costs and (3) that all investors value stock prices in the same way on the basis of this information. These conditions remind us of the definition of prefect stock market and hence it can be noted that a strong level of market efficiency in real world is not likely to exist.

It should be noted that, the degree of efficiency in a stock market depends on two elements:

1. The type of information that is incorporated into stock prices (what kind of information is available?).
2. The speed of incorporating new information into stock prices (how fast information is reflected?).

In general, it can be concluded that market efficiency refers to both the speed and the quality (i.e. direction and magnitude) of the stock price adjustment to new information. The intense competition between investors because of rapid adjustment of stock prices to new information is a necessary condition for informationally efficient market.

In 1983, Keane divided different levels of market efficiency into three different degrees, namely *perfect efficiency*, *near efficiency* and *inefficiency*. These different degrees can appear in all the three levels of market efficiency. These degrees of efficiency are of practical importance when it comes to carrying out different studies of market efficiency, since it may be difficult to establish whether a market is efficient or inefficient. For instance If these terms would be applied to the semi-strong form of market efficiency, *perfect efficiency* would occur when prices are so close to their value that not even the most expert information-processor could achieve an excess return for his efforts. *Near efficiency* is obtained when prices are sufficiently close to their value to make it is futile for all investors, other than the expert minority, to pursue an active trading strategy. The experts would only earn enough excess returns to cover transactions costs and reward for their efforts. *Inefficiency* occurs if even the non-expert can identify undervalued stocks or, at least, if he is able to profit from the recommendations of the expert who perceives them.

In general, the level of efficiency of the stock market is determined by the extent of accurately analysed information employed in trading of firm's shares. In other words, the degree of stock market efficiency depends on the extent of reflection of relevant information in stock prices.

3.2.3. Conditions for the existence of stock market efficiency

Financial markets are efficient when they are structured and organized in a way that allows perfect competition which result in a fair price (efficient price). In efficient stock markets prices would normally move at random when unexpected relevant information happens at random. The rationale is that past prices, which are based on past information, would rarely help to predict future stock prices. Only future information would play the main role in stock price movements. The assumptions are that, not only stock markets are efficiently organized (with enough liquidity and transparency) but also investors:

1) are rational **2)** are fully informed and reactive **3)** Maximize their expected utility

The theoretical bases of the efficient stock market hypothesis rest on three assumptions, first that investors are assumed to be rational and they value the stock rationally, second that all rational investors make random trades which have the cumulative effect of cancelling each other out and finally irrational investors are similar and their influence on prices is negated by their rational counterparts (see Lucas, 1978; Hogarthand Reder, 1986; Shleifer, 2000). These conditions would make securities prices reflect their fundamental value, taking into account the return prospects and risks. On the other hand, it is possible that security market is inefficient and stock prices are not accurately reflecting the new information. This might result from the following factors:

-The investor is unable to interpret the new information correctly

- The investors have no access to the new information

- The transaction cost in trading system is an obstruction for free trading

- The existence of restriction or limitation on short sale

- The participants in security market might be misled by the change or manipulation in accounting principles and company's financial reports.

In the context of behavioural finance it is argue that investors are often if not always irrational, exhibiting predictable and financially ruinous behaviour (Fischoff and Slovic ,1980; De Bondt and Thaler, 1986; Farmer and Lo, 1999;Barber and Odean, 2001; Huberman and Regev ,2001and Lo, 2004) .

From practical view point, the efficiency of stock market is affected by following factors:

-**Liquidity**: A simple working definition of liquidity is the ease with which a financial asset or share can be bought or liquidated (turned into cash), without any price discounts at a particular point in time (see Lesmond, 2005). If a stock market is illiquid, it cannot be efficient, since transactions will not be performed immediately to respond to new realized information. It is necessary to point out that liquidity is influenced by structure, procedures and regulations which exist in the market. In other words, applying suitable and effective transaction procedures and easing regulation or controlling systems increase degree of market liquidity. For instance, in the presence of "price limits" especially in emerging stock market, the supply and demand mechanism is restricted, consequently liquidity of a certain share decrease.

- **Information disclosure**: according to efficient market hypothesis, weak disclosure of information affects the efficiency of the stock market directly. Under this condition, available information does not reflect the fundamentals of shares or company. In addition, it affects efficiency indirectly, through exhibiting higher price volatility and discouraging trading and price discovery. On the other hand, the quality of information available for investors also affects market efficiency through accurate pricing of securities. This means that standards and practices of accounting and auditing affect market efficiency through the reliable information. Furthermore, the effective exercise of corporate governance influences the degree of stock market efficiency.

- **Transactions costs:** Transactions costs consist of both the explicit costs of trading such as commissions, settlement fees , taxes and the implicit costs of trading, which represent the opportunity costs of delaying or not performing a trade (due to size of trade and/or scarcity of counterpart orders). A stock market with high transactions costs involves lower level of trading and has fewer price movements in response to relevant news and therefore is less liquid and less efficient. In other words, high transaction cost result in participants having fewer propensities to trade based on the appearance of new information.

-Variety of participants: variety of investors (the size and the heterogeneity) affects the efficiency of a stock market through the existence of active participation of investors or the increase a possibility of transaction. A diversity of participants with different risk preferences makes a divergence of views more likely and promotes trading. In other words, the existence of various participants improve the liquidity of stock market and increase the responsiveness of stock prices to new information and therefore it leads to improvement of stock market efficiency.

3.2.4. Implications of stock market efficiency

In an efficient stock market, when information appears the news spreads very quickly and relevant information is incorporated into the prices of securities without delay. An obvious and importance implication of an efficient stock market is that no group of investors should be able to constantly beat the market by means of prevalent investment strategies. An efficient market would also create very negative implications for many investment strategies and actions that are taking for creating excess profit:

(a) In an efficient stock market, the price of financial instrument is determined in random manner and any price fluctuations are owing to the totally randomly arrival of new information. Accordingly, successive price changes in individual securities are independent and the stock price fluctuations are unpredictable.

(b) In an efficient stock market, equity research and valuation would be a costly task that cannot provide excess returns. The chances of finding undervalued stock would always be 50 percent, reflecting the randomness of pricing errors. At best, the benefits from information collection and equity research would cover the costs of doing the research.

(c) In an efficient stock market, a strategy of randomly diversifying across stock or indexing to the market, with little or no information cost and minimum execution costs, would be better than any other investment strategy that creates larger information and execution costs. In other words, portfolio managers and investment strategists cannot create excess returns.

(d) In an efficient stock market, a strategy of minimizing trading, i.e., creating a portfolio and not trading unless cash was needed would be better than a strategy that requires frequent trading.

(e) In an efficient stock market, the share price of a company fairly reflects its value and market expectations about its future performance and returns. The company managers should therefore focus on making 'good' financial decisions which increases shareholder wealth as the market will interpret these decisions correctly and the share price will adjust accordingly. Cosmetic manipulation of accounting information, whether through window dressing of financial statements or by massaging earnings per share, will not mislead the market.

(f) With respect to an efficient stock market where shares are never underpriced, the timing of raising capital of a company or issue new shares is not important.

(g) In an efficient stock market due to appearance of all information in stock prices investors do not need other peoples or companies to manage their portfolio. However, it is often easier and cheaper for investors to diversify their own portfolio.

(h) In an efficient stock market all information relevant to stocks is considered in current prices of stock and stock price demonstrates the expectation of investors about the future of company. Accordingly, by studying market prices we can learn about the future of company's activities such as its profitability or probability of bankruptcy.

According to Jensen (1978), an efficient stock market is one where it is not possible to make any excess returns after deduction of all transactions costs. This means that in an efficient stock market obtaining abnormal return with regards to transactions costs is impossible. On the other hand, if the stock market is assumed to be inefficient, Kean (1983) argues that there are certain costs involved in exploiting these inefficiencies. An investor or analyst will have to consider these additional costs before calculating any profit. First, there are costs of searching for mispriced stocks and transactions costs in switching stocks. An investor also has to consider the increased risk exposure from inefficient diversification resulting from the pursuit of perceived bargains as well as the opportunity costs of holding cash during non-investment periods. If these costs are higher than expected returns, and if the investor does not have a reasonable expectation of earning excess return from the assumed inefficiency, it is then possible to consider the market to be efficient after all (Kean, 1983).

It is also important to bear in mind that all stock markets are not efficient and not necessarily to all investors. This is due to the existence of differential regulation restrictions, tax rates and transactions costs which give advantages to some investors relative to others (Damodaran, 2002). In other words, sometimes structure and enforcement conditions may lead to inefficiency of stock market. Stiglitz (1982) argue that speculative markets cannot be completely efficient at all points in time. In this sense, the profits obtained from speculation are the outcome of being faster in acquainting and interpreting correctly the available and new realized information.

3.3. The Random walk hypotheses

The random walk theory is based on the presumption that investors operate rationally and without bias, and that at any moment they estimate the value of an asset based on future expectations. Under these conditions, all existing information affects the price, which changes only when new information appears. By definition, new information emerges randomly and influences the asset price randomly.

The stochastic variable of stock price is said to be a random walk with drift when:

$$P_{t+1} = \mu + P_t + \varepsilon_{t+1} \qquad (17)$$

Where μ is the expected price change or drift parameter and the abnormal return term follows an independent and identical distribution **[I I D (0, σ^2)]** that known white noise:

$$E(\varepsilon_{t+1}) = 0$$

$$\text{cov}(\varepsilon_s, \varepsilon_m) = \sigma^2, \text{ when s=m}$$

$$\text{cov}(\varepsilon_s, \varepsilon_m) = 0, \text{ when s} \neq \text{m}$$

The independence of the residuals (ε_{t+1}) signifies that the random walk is also a fair game, but in a sense more restrictive than the martingale. Independence implies not only that increments are uncorrelated, but that any nonlinear functions of the increments are also uncorrelated. This is called random walk 1 or **RW1** (see Campbell, et al. 1997).

In spite of the obvious and simplistic nature of **RW1**, the assumption of identically distributed increments is not reasonable for financial asset prices over long time length, because of technical equipment, institutional structures, regulatory legislation, financial instruments and social environment have been changed over the time in stock markets. Hence, the random walk 2 model or **RW2** is introduced with relaxing the assumption of **RW1** to include processes with independent but not identically distributed increments .In other words; in **RW2** random price increments are independent but non-identically distributed (**INID**). **RW2** allows more general stock price process, such as unconditional heteroskedasticity in the increments. The weakest form of the random walk hypothesis is the random walk 3 or **RW3.** **RW3** is the process with dependent but uncorrelated increments **(COV (ε_s, ε_m) =0, COV (ε^2_s, ε^2_m) ≠0).** This means that random price increments are dependent but uncorrelated (see Campbell, et al. 1997). In other words, in RW3 we suppose that the stock price increments just do not have any linear relationship. It is clear that if stock prices behave according to **RW3** process in a stock market, it will be efficient in weak form.

It should be noted that in an efficient stock market in weak form, time series of stock prices behave as random walk process. Therefore in an efficient stock market in weak form according to random walk properties time series of stock prices are non-stationary. A time series is stationary, when it has the constant mean, variance and autocovariance over the time. To perceive the non-stationarity of stock price series, we write the following random walk with drift equations:

$$P_{t+1} = \mu + P_t + \varepsilon_{t+1}$$
$$P_{t+2} = \mu + P_{t+1} + \varepsilon_{t+2}$$
$$\cdots\cdots \qquad \cdots\cdots\cdots$$
$$P_{t+n} = \mu + P_{t+n-1} + \varepsilon_{t+n}$$

Then, with substituting P_{t+1}, P_{t+2}, ... P_{t+n-1} , in the right hand side of each equation:

$$P_{t+n} = P_t + \mu.n + \sum \varepsilon \tag{18}$$

Now the conditional mean and variance of (18) at time t+n can be proposed as follow:

$$E(P_{t+n}) = P_t + \mu.n \tag{19}$$

$$\text{var}(P_{t+n}) = \sigma^2.n \tag{20}$$

It can be seen that the random walk variable P_t is non-statiionary, because both the conditional mean and variance are not constant and in fact the mean as well as variance of stock price time series change over time. In other words, the mean and variance of P_t depend on n (time).

The first difference of a random walk time series is stationary. Therefore, the stock returns as shown by (13) which are the first difference of the prices, are a stationary time series.

$$E(R_{t+1}|\phi_t) = \mu \qquad (21)$$

$$\text{var}(R_{t+1}) = \sigma^2 \qquad (22)$$

Unfortunately, these returns are not scale-free and unit-less, and may not permit comparison of investment performance across many financial assets (see Shiguange 2004). Therefore, the returns applied in the empirical studies are simple returns and log returns. The simple return at time t+1 is:

$$(P_{t+1} - P_t) / P_t \qquad (23)$$

and the corresponding log return is:

$$r_{t+n} = Ln\,(P_{t+1} / P_t) = Ln\ P_{t+1} - Ln\ P_t \qquad (24)$$

The logarithmic return is almost equal to the simple return:

$$r_{t+n} = Ln(P_{t+1} / P_t) = Ln\ P_{t+1} - Ln\ P_t = Ln[1 + (P_{t+1} - P_t) / P_t] \approx \Delta\, P_{t+1} / P_t \qquad (25)$$

It should be noted that equation (25) is useful only for the stock returns close to zero.

3.4. The relationship between stock market efficiency and stock market volatility

In the context of financial economics, volatility of stock markets refers to variations in the stock prices in a certain time period. Stock market volatility is a natural response of stock prices to arrived news (or unexpected information) (Ross, 1989; Engle and Ng, 1993; Mitchell and Mulherin, 1994). In the efficient markets' literature there is an apparent positive relationship between the arrival of good quality information and stock price volatility (see Ross, 1989). As we discussed in chapter three, in an efficient stock market stock prices react in a rapid and unbiased manner to the appearance of new information. In this case, it can be remarked that increased stock market volatility is the result of improvements in informational efficiency of stock market. When the flow of information increases in an efficient stock market, stock price movements are more frequent and the market volatility increases. It is worth nothing that this information consists of the financial information about firms and environmental (economical and political) information or news. In this sense, Kalotychou and Staikouras (2009) argue that volatility can form the basis for efficient price discovery in stock markets.

In an efficient stock market, by definition a change in the available information changes the efficient equilibrium price. The stock prices adjust to the new information by moving to an appropriate equilibrium price level and they would be stable until realization of new information. In view of the instant response of stock prices to new information in the efficient market in weak form, this means that the volatility of stock markets may not be interpreted as a sign of inefficient market. In this sense, volatility clustering as a stylized fact in the stock market is a sign of new information does not imply the informational inefficiency of the market. We will investigate the presence of volatility clustering in chapter five. It should be noted here that an efficient stock market does not imply that the market correctly values stock on each and every occasion, but the market correctly price securities on average in an unbiased manner. In other words, the efficient stock market does not make systematic errors (see Fama, 1970). Errors occur but they all cancel out, due to being random and non-systematic and consequently the securities are priced correctly. In the same way, Clark et al., (2001) argued that the constant fluctuation of stock prices can be viewed as an indication of informational efficiency of market. In this sense, new realized information regularly affects the value of equities and as a result the stock prices adjust in relation to information updates. Since in market stock prices change owing to arrival of new information, the stable stock prices can be interpreted as an indicator of inefficient stock market.

In the empirical literature the relationship between information arrival and volatility of market has been investigated by focusing on trading volume (as a proxy for information flow) (Andersen, 1996; Dufour and Engle, 2000; Xu et al., 2006; Girard and Rita (2007)). In this view of stock market volatility, revision of investors' expectations and subsequent actions of traders are supposed to be reflected in the liquidity of the particular market and specifically on the amount of stocks traded (trading volume).

3-5.Review of empirical literature on the Weak Form efficiency

3-5-1. Introduction

The aim of this section is to provide a broad picture of empirical literature on the weak form efficiency. As previously mentioned, a market is efficient in the weak form if stock prices follow a random walk process. Therefore, test of weak form efficiency is naturally based on an investigation of the relationship between current and past stock prices. Several techniques, such as serial correlation test, runs test, spectral analysis, unit root test, variance ratio test and econometric procedures, have been commonly used for testing weak form efficiency in the different stock markets.

Bachelier (1900) was originally anticipated the idea of market efficiency, but his contribution received more critical acclaim after it was published by Cootner (1964). Subsequent works such as Working (1934), Cowles and Jones (1937), Kendall (1953) ,Cootner (1962) and Fama (1965) who examined serial correlation coefficients for successive price changes and had found that the behaviour of the stock prices follows a random walk process. In favour of random walk hypothesis, Samuelson (1965) published his evidence about random fluctuation of stock prices. The concept of "efficient market" was first introduced theoretically and empirically into economics literature by Fama (1970).

It is important to point out that these studies using serial correlation test have shown that, the sample serial correlation coefficients computed for successive price changes were very close to zero, implying that successive changes in prices were independent. On the other hand, Granger and Morgenstern (1963), Godfrey et al. (1964) applying another method (spectral analysis technique) documented the independent assumption of the random walk hypothesis.

The following section reviews various empirical studies and findings on the weak form efficiency in terms of emerging stock markets and particularly Iran stock market.

3.5.2. Empirical studies on developing and emerging stock markets

In recent years, the testing of weak form efficiency hypothesis has significantly increased in emerging exchange markets because of its important implications for the domestic and international investors. A summary of empirical studies on the weak form efficiency in emerging stock markets is given in table 3-1. According to table it can be seen that researchers have used various methods to test random walk hypothesis or weak form efficiency in developing countries. The serial correlation test including the correlation coefficient test (testing for significance of individual serial correlation coefficient) and Q-test , LB test or LM test (testing for significance of a set of coefficients) was employed by Barnes (1986), Butler and Malaikah (1992), Dickinson and Muragu (1994), Fawson et al.(1996), Moorkerjee and Yu (1999), Olowe (1999), Asal (2000), Abeysekera (2001), Sharma (2002), Wheeler et al.(2002), Worthington and Higgs(2003), Simons and Laryea(2004), Seddighi and Nian(2004), Akinkugbo(2005), Rahman and Hossain(2006), Hanclova and Rublikova(2006), Mollah(2007), Islam et al.(2007), Chander et al.(2008), Hassan and Chowdhury(2008), Chakraborty(2008), Mobarak et al.(2008) and Sharma and Mahendru(2009). While Urrutia (1995), Dockery and Vergari (1997), Grieb and Reyes (1999), Karemera et al. (1999), Alam et al. (1999), Chang and Ting (2000), Cheung and Coutts (2001), Sharma (2002), Abraham et al. (2002), Worthington and Higgs(2003), Buguk and Brorsen(2003), Smith and Ryoo(2003), Lima and Tabak (2004), Simons and Laryea(2006), Alimov et al.(2004), Sarkar and Mukhopadhyay(2005), Khaled and Islam(2005), Cooray and Wickermasingle (2005), Smith(2007), Lock(2007), Ntim et al(2007),Hassan and Chowdhury(2008) and Chakraborty(2008) applied variance ratio test as the main methodology to examine the weak form of market efficiency in their study.

On the other hand, the unit root test as necessary condition for random walk hypothesis was employed by Fawson et al. (1996), Moorkerjee and Yu (1999), and Abeysekera (2001), Worthington and Higgs(2003), Buguk and Brorsen (2003), Maghyereh(2003), Seddighi and Nian (2004), Alimov et al.(2004), Sarkar and Mukhopadhyay(2005),Tas and Dursunglu(2005), Khaled and Islam(2005), Cooray and Wickermasingle (2005), Hanclova and Rublikova(2006), Filis(2006), Gupta and Basu(2007), Sunde and Zivanomoyo(2008), Marashedeh and Shaesrha(2008), Asiri(2008), Hassan and Chowdhury(2008), Seddighi and Nian(2008). It should be noted that in recent years in view of specific characteristics of emerging stock market new techniques of unit root test such as unit root test with one, two or multiple break and nonlinear unit root test have been used by Narayan and Smyth (2004), Ozdemir(2008) and Hassanov(2009).

A look at table 3-1, confirms that the use of traditional method namely runs test was customary in investigating of weak form efficiency in emerging stock exchange. Runs test was employed by Sharma and Kennedy (1977), Barnes (1986), Dickinson and Muragu (1994), Urrutia (1995), Fawson et al. (1996), Mookerjee and Yu(1999), Karemera et al. (1999), Abeysekera (2001), Wheeler et al. (2002), Abraham et al. (2002), Worthington and Higgs(2003), Mustafa(2004), Simons and Laryea(2004), Rahman and Hossain(2006), George(2006), Filis(2006), Mollah(2007), Islam et al.(2007), Hassan and Chowdhury(2008), Chakraborty(2008), Sharma and Mahendru(2009) in their studies. It is necessary to note that runs test was used as a complementary technique in many more studies. On the other hand, with introduction of new methods use of runs test, which is a nonparametric technique, has been reduced.

Econometric procedures such as BDS test, ARIMA method and ARCH-GARCH technique have been developed in the examination of efficiency of stock markets. In this way, econometric methods were employed by Asal (2000), Omet et al.(2002), Poshakwale(2002), Appiah and Menya(2003), Maghyereh(2003), Seddighi and Nian (2004), Sarkar and Mukhopadhyay(2005), Panagiotidis(2005), Rahman and Hossain(2006), George(2006), Hanclova and Rublikova(2006), Filis(2006), Mollah(2007), Al-Zoubi and Al-Zu'bi(2007), Magus(2008), Asiri(2008), Seddighi and Nian(2008) and Mobarak et al.(2008). In short, it should be noted that a variety of techniques has been used to investigate weak form efficiency in emerging stock market. It is worth emphasizing that when choosing the type of stock market efficiency test, properties of emerging stock markets should be considered.

Empirical findings derived from studies in emerging stock markets have been mixed and controversial. Indeed, some studies reject the null hypothesis of weak form market efficiency while the others support the weak form of stock market efficiency. Regarding emerging European stock markets, for instance, the empirical evidence obtained from Wheeler et al. (2002), Smith and Ryoo(2003), rejected the weak form efficient hypothesis for the Poland , Greec, Hungary and Portugal stock markets respectively. On the other hand, Dockery and Vergari (1997) and Hanclova and Rublikova(2006) documented that the Budapest and Czech and Slovak Stock Exchanges were efficient in the weak form, respectively. In the case of a particular country findings have been very mixed. For instance Karemera et al. (1999), Smith and Ryoo(2003), Buguk and Brorsen (2003), Ozdemir(2008) and Mehmet and Kocaman(2008) showed empirical evidence to support the null hypothesis of weak form market efficiency for the Istanbul stock market in Turkey. While Tas and Dursunglu (2005) concluded that Istanbul stock exchange was not efficient in weak form. In addition, while Smith and Ryoo(2003), Panagiotidis(2005), George(2006) obtained empirical evidence to reject the random walk hypothesis in Athens(Greece) stock market, Filis(2006) showed that the Athens stock exchange followed random walk process.

In the case of African countries, Dickinson and Muragu (1994), Olowe (1999), Asal(2000), Simons and Laryea(2004), Akinkugbo(2005), found that the Nairobi , Nigerian, Egypt, South Africa, Botswana stock exchanges respectively were efficient in the weak form. On the other hand, according to Omet et al. (2002), Maghyereh(2003), Simons and Laryea(2004), Ntim et al. (2007), Sunde and Zivanomoyo(2008) studies, the Jordan, Ghana, Egypt , Mauritius and Zimbabwe respectively did not follow the random walk hypothesis. Of course, Appiah and Menya(2003) in a cross-country investigation illustrated that the Egypt, Kenya, Morocco, Mauritius and Zimbabwe stock market were efficient in weak form, while in Botswana, Ghana, Ivory Coast, Nigeria, South Africa and Swaziland stock exchanges rejected the weak form efficiency hypothesis.

In the case of stock markets in the Latin American region the empirical results are very mixed too. Urrutia (1995) using runs test found out that the weak form efficiency for the stock markets in Argentina, Brazil, Chile, and Mexico, while the results of the variance ratio test rejected the random walk hypothesis for all markets. On the other hand, Grieb and Reyes (1999), Worthington and Higgs (2003) provided evidence to reject the random walk hypothesis in Brazil, Mexico, Argentina, Chile, Colombia, Peru and Venezuela respectively. On the other hand, Karemera et al. (1999) based on the results of variance ratio test found that stock return series in Brazil, Chile, and Mexico did not follow the random walk, while Argentina stock market was efficient in weak form.

In recent years empirical studies on weak form efficiency in Asian stock markets have been extensively regarded. In the case of south east stock markets, Mookerjee and Yu (1999), Abeysekera(2001),Lima and Tabak(2204), Islam et al.(2007), Seddighi and Nian(2004), Rahman and Saadi (2008) and Hasanov(2009) documented that the Chinese, Seri Lanka, Singapore, Thailand and South Korea stock market respectively did not follow the random walk theory. Alternatively, Barners(1986), Fawson et al.(1996), Alam et al.(1999), Cheung and Coutts(2001) found that the Malaysia, Taiwan, Hong Kong and Malaysia stock exchanges were efficient in weak form. In the Southern part of Asia, Sharma and Kennedy (1977) , Alam et al. (1999), Alimove et al.(2004), Cooray and Wickremasingle(2005), Chander et al.(2008) and Sharma and Mahendru(2009) showed that the random walk hypothesis could not be rejected for stock price changes on the Bombay (India) , Dhaka (Bangladesh), Seri Lanka and Pakistan stock exchanges respectively. However, Sharma (2002),Poshakwale(2002),Sarkar and Mukhopadhyay (2005), Rahman and Hossain (2006), Hammed and Ashraf(2006), Gupta and Basu(2007), Hassan and Chowdhury(2008), Chakraborty(2008) and Mobarak et al.(2008) provided evidence to reject the hypothesis of weak form efficiency for stock markets in Sri Lanka, India, Bangladesh and Pakistan.

In the Middle East region, there have been various empirical studies with different results. The weak form efficiency was supported by Butler and Malaikah(1992), Mustafa(2004), Marshadeh and Shrestha(2008), Asiri(2008) and Al-Abdulgader et al.(2007) in Kuwait, United Arab Emirate, Bahrain and Saudi Arabia stock markets. On the other hand, Abraham et al. (2002), Smith(2007) and Al-Zoubi and Al-Zu'bi(2007) found the empirical evidence for rejection of the random walk theory in Kuwait, Bahrain, Saudi Arabia and Amman stock markets.

Weak form efficiency of stock market has been examined broadly in the world. A comprehensive review of the literature and empirical studies implies that various methods have been used to test stock exchanges in most countries. Indeed, applying traditional techniques (runs and correlation coefficient tests) has decreased over time and new methods (unit root and ARCH-GARCH tests) have been prevalent which have considered characteristics of stock price behaviour such as nonstationarity and nonlinearity. A significant point in empirical studies is that even when one sort of tests fails to reject the random walk hypothesis, the others methods may actually reject it. On the other hand, in a certain stock market some studies may confirm the weak form efficiency, whereas another study rejects the random walk hypothesis. It is necessary to point out that efficiency of a stock market often fluctuate over time due to changes in regulations, approaches, technology and introduction of new tradable financial instruments. In other words, it is reasonable to think that a stock market especially in developing countries is efficient in certain time period, while it can be inefficient in other investigation period.

Another remarkable point is that the time span or frequency (daily, weekly and monthly) of investigated data also influences the results of study. In this sense the findings of daily stock market index or stock price may be completely different from the results of weekly or monthly data. Indeed, sometimes the findings of whole market investigation may not confirm the results of case-study or a certain industry testing in the stock market.

In short it should be remarked that many factors affect the findings of examination of weak form efficiency in stock markets. Time period of study, types of stock market (developed or emerging market), investigation methodology and examining methods, frequency of data (daily, weekly and monthly) and kinds of investigation sample (whole market or case-study in the market) are crucial features in empirical results of weak form efficiency investigation in the stock markets. Therefore, applying a variety of techniques or different types of data and comparing the findings on the bases of similar data or investigation sample will improve the accuracy of the study. On the other hand, taking into account specific characteristics of stock market improves the reliability of the implication of empirical results.

3.1. Summary of empirical studies on the Weak Form efficiency in emerging stock markets

study	Methodology	Data	Findings
Sharma and Kennedy (1977)	- Runs test - Spectral analysis	Monthly stock price index over the period from 1963 to 1973.	the Bombay stock exchange follow a random walk process.
Barnes (1986)	- Serial correlation tests - Runs test	Monthly stock prices series of 30 individual stocks and 6 sector indices for the 6 years ended June 30, 1980.	Overall, the Kuala Lumpur Stock market is efficient in the weak form.
Butler and Malaikah(1992)	- Autocorrelation tests	Weekly price series of individual stocks listed over the period 1985-1989.	The Kuwait stock market was WFE, Whereas the Saudi Arabia market did not follow RW.
Dickinson and Muragu (1994)	- Autocorrelation tests - Runs test	Weekly price series of 30 individual stocks listed on the Nairobi Stock market over the period of 1979-1989.	The majority of individual stock price series confirm conditions of weak form of EMH.
Urrutia (1995)	- Variance ratio test - Runs tests	Monthly for market indexes in Argentina, Brazil, Chile and Mexico during Dec. 1975 to March 1991.	Results of the variance ratio test reject the RW hypothesis for all markets. However, the run test can not reject the RW.
Fawson, et al. (1996)	- Autocorrelation tests - Taylor's Binomial Distribution test - Run test - Unit root test	Monthly stock market index of the Taiwan Stock Exchange during Jan. 1967 and Dec. 1993	The weak form efficiency Cannot be rejected for the market.
Dockery and Vergari (1997)	- Variance ratio test	Weekly price index over the period from Jan. 1991 to May 1995.	The Budapest Stock Exchange is efficient in the weak form.
Mookerjee and Yu (1999)	- Autocorrelation tests - Run test - Unit root test	Daily stock price indices of Shanghai and Shenzhen stock exchange over the period Dec. 19 1990 to Dec. 17 1993 and from Apr.3 1991 to Dec. 17 1993 respectively.	The weak form of EMH is rejected for both markets.
Olowe (1999)	- Autocorrelation tests	Monthly returns data of 59 individual stocks listed on the Nigerian Stock Market over the period Jan. 1981-Dec. 1992	The null hypothesis of market efficiency in the weak form cannot be rejected.

Grieb and Reyes (1999)	- Variance ratio test	Weekly price index for the market and individual stocks in Brazil and Mexico during Dec. 30 1988 to Jun. 30 1995.	The hypothesis of RW is rejected for all market indexes and most individual stocks.
Karemera et al.(1999)	- Multiple Variance ratio test - Runs test	Monthly stock market indexes over the period from Dec. 1987 to May 1997 (eleven markets) and from Jan. 1986 to Apr. 1995.	Under multiple variance ratio test Argentina, Brazil, Hong Kong, Indonesia, Israel, Jordan, Korea, Malaysia, Singapore and Thailand stock market follow the RW. Findings of the run tests show nine of the total markets to be efficient in the weak form (Brazil, Hong Kong, Indonesia, Jordan, Korea, Malaysia, Mexico, Thailand and Turkey).
Alam et al. (1999)	- Variance ratio test	Monthly return data for market index of Hong Kong, Malaysia, Taiwan, Sri Lanka and Bangladesh covering from Nov. 1986 to Dec.	The hypothesis of weak form efficiency cannot be rejected for all markets, except Sri Lanka.
Asal(2000)	-Serial correlation -Q. statistics -GARCH model	Daily stock price index from 1992 to 1997	The Egypt stock market was efficient in weak form.
Abeysekera (2001)	-Serial correlation - Runs test -Unit root test	Daily, weekly and monthly Stock price index over the period Jan.1991- Nov.1996	The RW hypothesis was rejected in Seri Lanka stock market
Cheung and Coutts (2001)	- Variance ratio test	Daily stock market index over the period Jan. 1 1985 –Jun. 30 1997.	Empirical evidence confirms weak form efficiency of Hong Kong stock market
Sharma(2002)	-Autocorrelation - Variance ratio test	Daily price index during 1948-49 to 1998-99	The Indian stock market did not follow RW.
Omet et al (2002)	-ARCH-GARCH	Daily price index during 1992-2000.	The Jordan stock market did not follow RW.

Wheeler et al.(2002)	- Autocorrelation test - Runs test	Daily returns series of 16 individual stocks listed on the Warsaw Stock market during 1991 to 1996.	The empirical evidence rejected the RW for most of the individual stocks.
Abraham et al(2002)	- Variance ratio test - Runs test	Weekly market price index for the three major Gulf stock markets (Kuwait, Saudi Arabia, and Bahrain) over the period Oct. 1992 to Dec. 1998.	Weak form efficiency is rejected for the Gulf stock markets when the observed indices are used, but it cannot be rejected when infrequent trading of these markets is corrected.
Poshakwale (2002)	-BDS test -GARCH-M	Daily price for the 100 actively traded stocks during 1,Jan.1990 to 30,Nov.1998.	The RW hypothesis was rejected in Bombay (India) stock market.
Worthington and Higgs(2003)	- Autocorrelation - Runs test -Unit root test -Multiple Variance ratio test	Daily stock price index from Argentina, Brazil, Chile,Colombia, Mexico, Peru and Venezuela over the period 31-Dec-1987 to 28-May-2003.	All stock markets were not efficient in weak form
Appiah and Menya(2003)	- EGARCH_M	Weekly Stock price index of Eleven Africa stock markets.	Egypt, Kenya, Morocco, Mauritius and Zimbabwe were efficient, whereas Botswana, Ghana, Ivory coast, Nigeria, South Africa and Swaziland did not follow RW.
Buguk and Brorsen (2003)	- Unit root test - GPH (Geweke and Porter-Hudak) fractional integration test - Variance ratio test.	Weekly market index of the Istanbul Stock market for the period from 1992 to1999.	Overall, the results confirmed random walk hypothesis
Smith and Ryoo(2003)	-Multiple Variance ratio test	Weekly index data during 1991-1998.	Greece, Hungary, Poland and Portugal stock markets were not efficient, whereas Istanbul stock exchange followed RW.
Maghyereh (2003)	- Unit root test - BDS Test -GARCH(1,1)	Daily stock index from Jun. 1994 to Nov.2002.	The RW was rejected In Jordan stock market.
Lima and Tabak(2004)	-Variance ratio test	Daily returns from Jun. 1992 to Dec.2000.	Class A shares for Chinese and the Hong Kong were efficient. However Singapore and Class B shares did not follow RW.
Mustafa(2004)	- Runs test -Autocorrelation	Daily stock price index over the period 2, Oct.2001 to 1, Sep.2003.	The United Arab Emirate stock market consisted with RW.
Simons and Laryea(2004)	- Runs test -Multiple Variance test	Daily stock index for Ghana, Egypt, Mauritius and south Africa over the period 1990 to2003.	Only South Africa stock market Was efficient in weak form.

Narayan and Smyth (2004)	–Multiple unit root test	Monthly stock market index during Jan. 1981 to Apr. 2003.	The null hypothesis of weak form efficiency was in South Korea Stock Exchange accepted.
Alimov, et al (2004)	- Unit root test -Variance ratio test.	Weekly index during Jul.2001 to Oct.2003.	The Bombay (India) stock market followed the RW.
Akinkugbo (2005)	Autocorrelation - Unit root test	Weekly stock price index over the period Jun.1989 to Dec.2003.	The Botswana stock market was adopted with RW theory.
Sarkar and Mukhopadhyay (2005)	-Unit root test -Variance ratio test - BDS test - GARCH(1,1)	Daily stock index over the period from Jan.1986 to Jan.2000.	The Bombay (India) stock market was predictable.
Tas and Dursunglu (2005)	- Runs test - Unit root test	Daily stock index over the period from Jan.1995 to Jan.2004.	Istanbul stock market was not efficient in weak form.
Panagiotidis (2005)	-LM test -BDS test -GARCH test	Daily index over 1, Jun.2000 to 14Mar.2003.	The RW theory was rejected in Athens stock market.
Khaled and Islam(2005)	-Unit root test -Variance ratio test	Daily, weekly, monthly Dhaka index during 1990 to 2001.	The RW for monthly data was not rejected, whereas for daily and monthly were rejected.
Cooray and Wickremasingl (2005)	-Unit root test -Variance ratio test	Monthly index from Jan.1996 to Oct.2003.	India, Seri Lanka and Pakistan were efficient, whereas Bangladesh was not efficient in weak form.
Rahman and Hossain(2006)	- Autocorrelation tests - Runs test – Q statistics	Daily index data from 1994 to 2005	The Dhaka stock market did not follow RW.
George(2006)	-ARIMA - Runs test -ARCH_GARCH	Daily index data during Sep.2000 to Sep.2002	The RW was rejected in Greece stock Exchange.
Hammed and Ashraf(2006)	-ARIMA(1,1) - GARCH(1,1)	Daily index data from Dec.1998 to Mar.2006	The Pakistan stock market did not follow RW.
Hanclova and Rublikova (2006)	- Autocorrelation - Unit root test -ARCH_GARCH	Daily stock price index during 2000to 2004	The Czech and Slovak stock market was efficient in weak form.
Filis(2006)	- Runs test - Unit root test - GARCH(1,1)	Daily stock price index over the period Sep.2000 to	The RW was accepted in Athens stock market.

Smith(2007)	-Multiple Variance ratio test	Sep.2002. Weekly stock price index during Oct.2000 to June 2004.	The Kuwait, Oman stock markets were not efficient, whereas Jordan, Israel and Lebanon stock exchanges did not confirm RW.
Lock(2007)	-Variance ratio test	Weekly stock price index during 1990 to mid 2006.	Taiwan stock market followed RW.
Ntim, et al (2007)	-Variance ratio test	Daily stock price index over the period 12, Nov.1990 to 31, Dec.2005.	The WFH was rejected in Ghana Stock market.
Gupta and Basu (2007)	- Unit root test	Daily stock price index over the period 24, May.1991 to 26, May.2006.	India stock market did not follow RW.
Mollah(2007)	- Autocorrelation - Runs test -ARIMA	Daily stock price index during 1989 to 2005.	The RW was rejected in Botswana stock market.
Al-Zoubi and Al-Zu'bi (2007)	-ARIMA(1,1) -EGARCH	Daily stock price index over the period 1990 to 2000.	Amman stock market was not efficient in weak form.
Islam, et al (2007)	- Autocorrelation tests - Runs test	Daily and monthly stock price index during 1992 to 2001.	Thailand stock market did not follow RW.
Chander, et al (2008)	- Autocorrelation tests – Q and LB method	Weekly stock price index during July 1996 to Dec. 2005.	The Bombay (Indian) stock market was efficient in weak form.
Ozdemir (2008)	- Unit root test (two breaks-LP)	Weekly stock price index over the period Jan. 1990 to Jun. 2005.	The Istanbul (Turkey) stock market confirmed RW.
Sunde and Zivanomoyo (2008)	- Unit root test	Monthly stock price index from Jan. 1998 to Nov. 2006.	The Zimbabwe stock market was not efficient
Marashdeh and Shrestha (2008)	- Unit root test	Daily stock price index from 31, Aug. 2003 to 13, Apr. 2008.	The RW was accepted in United Arab Emirates stock exchange.
Magus (2008)	-BDS test -LM test -ARCH	Daily stock price index over the period 1999 to 2004.	The RW hypothesis was rejected in Ghana stock market
Asiri(2008)	- Unit root test -ARIMA(1,0,0)	Daily stock price index from 1, June. 1990 to 31, Dec. 2000.	The Bahrain stock market was efficient in weak form.

Chander , et al (2008)	- Autocorrelation – Q and LB method	Weekly stock price index over the period Jul. 1996 to Dec. 2005.	The Indian stock market was efficient in weak form.
Hassan and Chowdhury (2008)	- Autocorrelation - Runs test - Unit root test -Variance ratio test	Monthly data from market index and 46 actively traded firms during Jan.1991to May.2003.	Overall, Bangladesh stock market was not efficient.
Seddighi and Nian (2008)	-LM test -DW test - Unit root test -ARCH-GARCH	Daily stock index data during 4, Jan.2000 to 31, DEC.2000.	The RW was rejected in Chinese stock exchange.
Mehmet and Kocaman (2008)	-Time series model (regression)	Monthly index data during 1986 to 2005.	The Istanbul stock market was efficient.
Al-Abdulgader, et al(2007)	-Filter Rule -Moving average strategy	Weekly stock price index over the period 1990 to 2000.	The Saudi Stock Market was efficient.
Chakraborty (2008)	- Autocorrelation - Runs test -Variance ratio test	Daily stock index data during 1, Jan.1996 to 15, Nov.2005.	The RW was rejected in Pakistan stock market.
Mobarak,et al (2008)	- Autocorrelation -ARIMA	Daily Bangladesh stock market index data over the period 1988 to 2000.	The weak form efficiency hypothesis was rejected.
Rahman and Saadi (2008)	-BDS test	Monthly stock index data during Jan.1981 to Apri.2005.	The RW was rejected in South Korea stock market.
Sharma and Mahendru (2009)	- Autocorrelation - Runs test	Weekly Bombay stock market index data over the period Jul.2007 to Oct.2007	The RW hypothesis was accepted.
Hassanov (2009)	- Nonlinear unit root test	Monthly stock index data during Sep.1987 to Dec.2005.	The South Korea was not weak form efficient.

3.5.3. Empirical studies in Iran Stock Market(ISM)

There have been a number of studies on weak form efficiency of Iran stock market. The significant point in these investigations is that all of them found that the random walk hypothesis was rejected in Iran stock market. Fadaeinejad (1994) analyzed the weak form efficiency of Iran stock market(ISM) employing the serial correlation and runs tests. Empirical results from daily prices of 50 companies with highest transactions over the period 1989 to 1993 showed that the behavior of stock prices in ISM did not follow random walk hypothesis. A year later, the random walk hypothesis for ISM was tested by Namazi and Shoshtarian (1995) applying the serial correlation test and filter rule. Using daily and weekly price index they indicated that stock prices in ISM did not follow the random walk and average return from the filter rule more than return from the buy-hold strategy. As a result, ISM was inefficient in weak form.

Galibaf Asl and Nateghi (2006) employing econometrics methods such as ARIMA and ARCH-GARCH models, examined the efficiency of ISM. Empirical findings of statistical analyses on total index and sub-section index over period from 2000 to 2004 have rejected the weak form efficiency hypothesis in ISM. Appling the neural network approach, Kimiagari and Tijery (2006) examined the efficiency of ISM. In this study, with comparison of the return of neural network strategies with return of the buy-and-hold strategy, the efficiency of stock market is investigated. Using the daily total index and "fifty high capitalisation companies' index" from 23/9/2004 to 19/3/2006; they found out that ISM was not efficient in weak form.

3.6. Concluding Remarks

This chapter provides a comprehensive review of the efficient market theory including definitions, levels, conditions and implications. The answer to the question: does an asset price reflect its true fundamental value at all times, is a determinant factor in investment decision making of foreign and domestic investors. In the context of microeconomic general equilibrium theory, the informationally efficient market plays a crucial role in allocating resources efficiently. In this respect, understanding the efficiency of stock market is important in enhancing the role of it in economic development process. In view of the crucial role of informationally efficient stock market in efficient allocation of financial resources in the economy, the investigation of efficiency of the emerging stock market has been a major concern in the empirical literature of financial economics.

Chapter 4
Testing Weak Form Efficiency of the Iran Stock Market[1]

4.1. Introduction

As stated in the previous chapter, the concept of stock market efficiency has dominated the main part of financial literature. Since financial resources like other economic resources are scarce, the efficiency of stock market plays a vital role in allocation of financial resources. The efficient stock market is critically important in mobilizing national saving and financing of new investment projects. Market efficiency is important because efficient stock prices allow companies to decide about diversifying their sources of investment capital and spread investment risk .Also stock prices and yields in efficient stock market provide benchmarks against which the cost of capital and returns on investment projects can be judged (see Green *et al,* 2000). In an informationally efficient market, equity is appropriately priced at equilibrium level and there is no distortion in the pricing of capital and risk.

In the stock market, the intrinsic value of a share is equivalently measured by the future discounted value of cash flows that investors will earn. In weak-form efficient market, current stock prices reflect all relevant and available information. This means that current stock prices reflect the underlying present value of securities and there is no way to make unusual or excess returns by using the available information. Stock prices change only in

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[1] . Some parts of the methodology used and empirical results in this chapter are published as the following paper: Paytakhti Oskooe, S.A., Li, H. and Shamsavari, A. (2010) 'The Random Walk Hypothesis in Emerging Stock Market, *International Research Journal of Finance and Economics,* 50, pp.51-61.

response to new information which by definition must be unpredictable. Therefore stock prices that fluctuate in relation to new unpredictable information must also move unpredictably. The weak form of efficient market asserts that the prices of securities reflect all the past information. Therefore, no market participant can use past data on the prices of share to predict the future value of it. The new information relevant to share is unpredictable and then share price reflect changes of information randomly. In other words, in an efficient stock market in weak form the prices of stock behave randomly, or without any identifiable pattern.

In the light of the mixed empirical results in the literature, we are motivated to examine the empirical support for the efficient market hypothesis in a developing stock market, in particular Iran, as opposed to the advanced industrialised countries. The case of Iran stock market is of particular interest due to a noticeable change in the pace of economic growth following economic reforms since 1999 and also because of significant growth in the transactions volume and number of listed companies in ISM. In recent years Iran stock market as an emerging market in the Middle East region has significantly developed. An examination of efficiency of ISM in analysing its role in financial development of Iranian economy is crucial. This chapter investigates the weak-form efficiency in ISM by using the various unit root tests. Although the subject of random walk hypothesis has been studied before, to the best of my knowledge no previous study has conducted unit root tests to examine the random walk hypothesis in the Iran stock market.

The reminder of the chapter is organized as follows: section 2 outlines and explains the research methodology. Section 3 p presents the data used and preliminary analysis. Empirical results are discussed in section3. The chapter concludes by summarizing the main conclusions and their imlications.

3.5.2. Methodology

Stock market efficiency implies that stock prices respond instantly and accurately to relevant information. In an efficient stock market, price changes must be a response only to new information. Since information arrives randomly, share prices must also fluctuate unpredictably. In an efficient stock market in weak form equity prices should follow a random walk process, where the future price changes should be random and consequently unpredictable. The immediate adjustment property of an efficient stock market in weak form implies that successive price changes in individual securities will be independent, hence indicating a random walk market. The random walk hypothesis is compatible with the weak form of the efficient market hypothesis. The random walk hypothesis asserts that stock price movements will not follow any patterns or trends and that past price fluctuates cannot be used to predict future price changes. As a result, changes of security prices cannot be predicted from previous path of stock prices. In this sense, test the efficiency of a stock market focuses on the stochastic properties of stock prices to infer unpredictability of stock prices.

Since random walk hypothesis indicates the randomness of price movements, in order to examine the weak-form market efficiency we should test the randomness of stock prices. The objective of empirical research on weak form market efficiency has been to test the hypothesis that successive price changes are independent. Accordingly, test for random walk hypothesis have been widely used in empirical research on weak form stock market efficiency. As stated above, weak-form stock market efficiency implies that stock prices follow a random walk process with a drift such as:

$$P_t = \mu + P_{t-1} + \varepsilon_t \qquad (1)$$

where μ is the expected price change or drift, P_t is the natural logarithm of stock price index at time t, P_{t-1} is the natural logarithm of stock price index at time t-1 and ε_t are residuals. Market efficiency under the random walk model implies that successive price changes of a stock are independently and identically distributed, so the past movement or trend of a stock price or market cannot be used to predict its future movement.

From the econometric point of view, the random walk hypothesis implies that p_t should be difference-stationary (i.e., P_t ~I(1)) or has stochastic trend and ε_t should be independent and identically distributed (henceforth **IID**) random variables or a strict white noise. Particularly, a trend in a time series is said to be stochastic if it is unpredictable and variable; in this case we have a difference-stationary time series. A stochastic process means that each value of variable in the series is drown randomly from a probability distribution. Otherwise, if the trend is predictable and not variable, it is considered deterministic trend and the time series is trend-stationary. Therefore, if a series of stock prices change in random, it should be characterized by a difference-stationary process.

Understanding the underlying trend process of stock prices series provides criteria for judging whether shocks on stock prices have a permanent or a transitory effect. In this sense, if the trend of stock prices series is deterministic, and they behave according to trend-stationary process, shocks on series will have a transitory effect, and stock prices will return to their trend path over time. From an investment point of view, this implies that investor can predict future movements of stock prices based on past pattern and trading strategies can be applied to earn abnormal returns. In the other words, the level of the prices will be a considerable predictor of next stock prices movement. Under these conditions, stock prices do not follow random walk hypothesis and stock market is not efficient in weak form. On the other hand, if the trend of stock prices series are stochastic, shocks will have a permanent effect, implying that stock prices will reach a new equilibrium level and future returns cannot be predicted based on historical movements in stock prices. To put it another way, the stock prices change randomly, and as a result stock market will be efficient in weak form.

In this connection a significant procedure to test the random walk hypothesis in the behaviour of stock prices series is the unit root test. This test is designed to investigate whether a series P_t (stock prices) is difference-stationary or trend- stationary as a basic condition for the random walk process. In the other words, unit root test is applied to detect patterns of the trend in a stock price series. If there is not unit root in the time series of stock prices or there is a deterministic trend in stock prices series, this means that it has a constant mean, variance and covariance. Thus there is no stochastic trend in the stock price series and the future movement pattern of stock prices can be identified based on the past behaviour pattern. On the other hand, if there is unit root in the stock price series or stock prices fluctuate based on a stochastic trend, the prediction of future stock prices movement would be impossible. In these circumstances, the stock market would be efficient in weak form.

Since according to theoretical literature the efficient stock market in weak form should follow the random walk theory, in order to investigate the efficiency of Iran stock market we define the following hypotheses:

H_1: Iran stock prices index follow random walk theory

H_2: Iran stock prices index follow random walk theory even in the presence of endogenous and exogenous break points

H_3: In view of the possible nonlinear data generating process, Iran stock prices index follow random walk theory

In the process of a time series, two kinds of trends can be appeared; deterministic or stochastic trends. To clarify these properties the process of time series (**y**) is considered as following equation:

$$y_t = \alpha + \rho y_{t-1} + \beta t + \varepsilon_t \qquad , \alpha \neq 0 \qquad (2)$$

Where ε_t is white noise and t is a time trend. A stochastic trend appears if $\rho = 1$ and $\beta = 0$, then:

$$\Delta y_t = \alpha + \varepsilon_t \qquad (3)$$

Fluctuations of y depend on the sign ofα. It is clear that this kind of trend can be removed by first-differencing. Therefore **y** is referred to as a difference stationary. On the other hand, if $\rho = 0$ and $\beta \neq 0$, the deterministic trend appears:

$$y_t = \alpha + \beta t + \varepsilon_t \qquad (4)$$

In this circumstance, **y** trends upwards or downwards depending on the sign ofβ. This kind of trend cannot be removed by first-differencing, since t doesn't remove from the process. **y**, is then known as a trend stationary process. Furthermore,if $\rho = 1$ and$\beta \neq 0$, stochastic and deterministic trends emerge.

The following discussion presents the basics features of methodology which is used in this investigation. Consider a simple AR (1) process:

$$y_t = \rho y_{t-1} + \delta D_t + \varepsilon_t \qquad (5)$$

Where D_t is a vector of deterministic terms (constant, trend), ρ and δ are parameters to be estimated and the ε_t are assumed to be independently and identically distributed with a zero mean and an equal variance (white noise).

The hypothesis of the existence of unit root in the y series can be evaluated by testing whether the absolute value of ρ is strictly less than one.

If $|\rho| \geq 1$, **y** is a nonstationary, stochastic series and the variance of series increases with time and approaches infinity, whereas if $|\rho| < 1$, **y** is a trend-stationary series. The OLS approach is applied to equation (5) to obtain the estimate of ρ and then using a t-test the null hypothesis **HO: ρ = I** against the alternative hypothesis **HA : ρ <I**. In this procedure, there are some problems. First of all, the OLS estimator of ρ is biased downwards in small samples, since there is a lagged dependent variable in equation (5), which may be concluded that the **y** is stationary when it is not. Second, if the process is non-stationary, then standard large-sample distribution results are invalid. In order to conduct unit root test, Dickey and Fuller (1981) was rewritten equation (5) after subtracting $y_{t-1}$from both sides of the equation:

$$\Delta y_t = \phi y_{t-1} + \delta D_t + \varepsilon_t \tag{6}$$

Where $\phi = \rho - 1$ In this conditions, the null and alternative hypotheses are rewritten as:

$$\textbf{HO: } \phi = 0 \tag{7}$$

$$\textbf{HA: } \phi < 0$$

and applying the following conventional t-test, the null hypothesis is evaluated:

$$t_{\hat{\phi}} = \hat{\phi} / (se(\hat{\phi})) \tag{8}$$

Where $\hat{\phi}$ is the estimate of ϕ , and $(se(\hat{\phi})$ is the coefficient standard error.

Dickey and Fuller (1979) state that under these circumstances, the conventional Student's *t*-distribution is not suitable, and they derive asymptotic results and simulate critical values for various test and sample sizes. In order to provide accurate test statistics, MacKinnon (1991, 1996) implements a much larger set of simulations than those tabulated by Dickey and Fuller. It is necessary to note that the simple Dickey-Fuller unit root test is valid only if the series is an AR (1) process. The assumption of white noise disturbances ε_t is destroyed when the y series is correlated at higher order lags. To deal with this weakness, the Augmented Dickey-Fuller (**ADF**) test is designed for higher-order correlation by assuming that the y series follows an **AR (p)** process and adding lagged difference terms of the dependent variable to the right-hand side of the test regression:

$$\Delta y_t = \phi y_{t-1} + \delta D_t + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{t-p} + v_t \qquad (9)$$

Therefore, with estimating this augmented specification, the null hypothesis **HO:** ϕ **= 0** is tested with regarding to t-test which stated above (8).

Furthermore, two practical issues should be considered in performing an ADF test. First, we decide about including exogenous variables (D_t) in the regression. In other words, we can choice to include a constant, a constant and a linear time trend, or neither in the test regression. Second, we must determine the number of lagged difference terms to be added to the test regression. The usual approach is to incorporate a number of lags sufficient to remove serial correlation in the residuals. The large sample LM test (for general serial correlation) which is introduced by Breusch (1978)-Godfrey (1978) can be used for this purpose. It is applicable when the disturbances follow an AR (p) or MA (q) process, where p and q can be specified as any positive order. Of course, it is necessary to stress that it is also useful whether or not lagged values of the dependent variable appear among the explanatory variables.

As has been noted above, the well-known approach to conduct unit root test is the augmented Dickey–Fuller (ADF) test. The Augmented Dickey-Fuller (ADF) specification to test random walk hypothesis can be rewritten as following models:

$$\Delta p_t = \alpha_1 + \alpha_2 t + \beta p_{t-1} + \delta \Sigma_{i=1}^{k} \Delta p_{t-1} + \varepsilon_t \qquad (10)$$

$$\Delta p_t = \alpha_1 + \beta p_{t-1} + \delta \Sigma_{i=1}^{k} \Delta p_{t-1} + \varepsilon_t \qquad (11)$$

$$\Delta p_t = \beta p_{t-1} + \delta \Sigma_{i=1}^{k} \Delta p_{t-1} + \varepsilon_t \qquad (12)$$

where p_t is the stock price index at time t . The first model (equation 10) includes a constant term (α_1), a trend term ($\alpha_2 t$), k denotes the number of lagged terms and ε_t is a white noise disturbance term. The second model (equation 11) includes a constant term only, and the third model (equation 12) does not include intercept and trend terms. The null hypothesis of stationary for all models is β = 0.

The Phillips-Peron (1988) employs an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root by estimating the non-augmented Dickey-Fuller test equation. They modify the different test statistic so that its asymptotic distribution is unaffected by serial correlation. The PP tests are robust to general forms of heteroskedasticity and autocorrelations in the error terms. Another advantage is that the users do not have to specify a lag length for the test regression. The PP is based on the following statistic:

$$\tilde{t}_{\phi} = t_{\phi}\left(\frac{\delta_0}{f_0}\right)^{1/2} - \frac{T(f_0 - \delta_0)(se(\hat{\phi}))}{z(f_0)^{1/2} s} \qquad (13)$$

Where $\hat{\phi}$ is the estimate and t_{ϕ} is the t-ratio of ϕ, $(se(\hat{\phi}))$ is coefficient standard error and S is the standard error of the test regression. Moreover, δ_0 is a consistent estimate of the error variance in equation (9) which is calculated as:

$$(T - K)\, s^2 / T \qquad (14)$$

Where k is the number of repressors. In addition, f_0 is an estimator of the residual spectrum at frequency zero.

Since the ADF and PP unit root tests do not distinguish between a stationary series and series with a very small random walk component (these tests are not very informative in distinguishing between a unit root and a near unit root case), Kwiatkowski, Phillips, Schmidt and Shin (1992) propose a test different from these other unit root tests in that the series is assumed to be stationary around a deterministic trend under the null hypothesis. The KPSS unit root test uses a similar (though parametric) autocorrelation correction to the PP but assumes that the observed time series can be decomposed into the sum of a deterministic trend, a random walk with zero variance and a stationary error term.

Kwiatkowski, Phillips, Schmidt and Shin derive their test by starting with the model:

$$p_t = \beta' D_t + \mu_t + \varepsilon_t \qquad , \varepsilon_t \approx I(0) \tag{15}$$

$$\mu_t = \mu_{t-1} + u_t \qquad , u_t \approx N(0, \sigma_u^2) \tag{16}$$

D_t = deterministic components

The hypotheses to be tested are:

$$H_0: \sigma_u^2 = 0 \rightarrow p_t \approx I(0)$$

$$H_A: \sigma_u^2 \succ 0 \rightarrow p_t \approx I(1)$$

The KPSS test statistic is the Lagrange multiplier (LM) or score statistic for testing $\sigma_u^2 = 0$:

$$KPSS = (T^{-2} \textstyle\sum_{t=1}^{T} \hat{s}_t^2) / \hat{\lambda}^2 \tag{17}$$

$$\hat{s}_t^2 = \textstyle\sum_{j=1}^{T} \hat{\varepsilon}_j$$

Where:

- $\hat{\varepsilon}_j$ is the residual of a regression of p_t on D_t
- $\hat{\lambda}^2$ 2 is a consistent estimate of the long-run variance of ε_j using $\hat{\varepsilon}_j$.

The hypotheses for Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP) tests are stated as follows:

H0: there is a unit root in the series

H1: there is not any unit root in the series (stationary)

Whereas, in the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) unit root test hypotheses are represented as follows:

H0: there is not any unit root in the series (stationary)

H1: there is a unit root in the series

Due to significant changes in economical or political conditions, the structural break has happened in trend of economic variables. It is necessary to point out that structural changes in stock market are more prevalent because of changes in within market or out of market environment. It is well-known that the traditional unit root test is powerless if the true data generating process of a series exhibits structural breaks. In this sense, the structural change in time series can influence the results of tests for unit roots. In the presence of a structural break Perron (1989) states that the standard ADF tests are biased towards the nonrejection of the null hypothesis. Perron's (1989) procedure is characterized by a single exogenous (known) break in accordance with the underlying asymptotic distribution theory. Perron uses a modified Dickey-Fuller (DF) unit root tests that includes dummy variables to account for one known, or exogenous structural break. The break point of the trend function is fixed (exogenous) and chosen independently of the data. Perron's (1989) unit root tests allows for a break under both the null and alternative hypothesis. Based on Perron

(1989), the following three equations are estimated to test for the unit root. The equations take into account the existence of three kinds of structural breaks: a 'crash' model (18) which allows for a break in the level (or intercept) of series; a 'changing growth' model (19), which allows for a break in the slope (or the rate of growth); and finally one that allows both effects to occur simultaneously, i.e. one time change in both the level and the slope of the series (20).

$$\Delta p_t = \alpha_1 + \alpha_2 t + \alpha_3 D_1 + \alpha_4 D_2 + \beta p_{t-1} + \delta \Sigma_{i=1}^{k} \Delta p_{t-1} + \varepsilon_t \quad (18)$$

$$\Delta p_t = \alpha_1 + \alpha_2 t + \alpha_3 D_3 + \beta p_{t-1} + \delta \Sigma_{i=1}^{k} \Delta p_{t-1} + \varepsilon_t \quad (19)$$

$$\Delta p_t = \alpha_1 + \alpha_2 t + \alpha_3 D_1 + \alpha_4 D_2 + \alpha_5 D_3 + \beta p_{t-1} + \delta \Sigma_{i=1}^{k} \Delta p_{t-1} + \varepsilon_t \quad (20)$$

The dummy variables D_1, D_2 and D_3 are defined by reference to the break date, $t=T_B$, as follows:

$D_1 = 1$ for $t= T_B +1$, otherwise $D_1 = 0$.

$D_2 = 1$ for $t > T_B$, otherwise $D_2 = 0$.

$D_3 = t$ for $t > T_B$, otherwise $D_3 = 0$.

D_1 is a pulse or a jump, D_2 is a change of drift rate (a change in the intercept) and D_3 is equivalent to t^*D_2, a change in the slope. Each of the three models has a unit root with a break under the null hypothesis, as the dummy variables are incorporated in the regression under the null. The alternative hypothesis is a broken trend stationary process.

The Perron's assumption in exogenous determination of break point in conducting unit root test has been criticized in empirical studies. In particular, Christiano (1992) highlighted the "data mining" issue in Perron(1989) method. In this sense, he argued that considering the timing of the break as an exogenously known event invalidates the distribution theory underlying conventional testing. To reduce this bias in the usual unit root tests the endogenous determination of the time of structural breaks was considered in various studies (Banerjee, et al. (1992), Zivot and Andrews (1992)). In this manner, Zivot and Andrews (1992) developed a unit root testing procedure that allows for an endogenously estimated break in the trend function under the alternative hypothesis. This test is a sequential test which employs the full sample and uses a different dummy variable for each possible break date. The break date is selected according to the minimum value (most negative) of t-statistic from the ADF unit root test. Since the selection of the time of the break is treated as the outcome of an estimation procedure, the critical values of t-statistic are different to the critical values in Perron (1989) approach. Furthermore, the Zivot and Andrews (1992) unit root test takes into account the effects of fat-tailed innovations on the performance of test.

In Zivot–Andrews unit root test the null hypothesis is that the series under investigation contains a unit root with a drift that excludes any structural break, while the alternative hypothesis is that the series is a trend stationary process with a one-time break in the trend variable occurring at an unknown point in time. Supposing that T_b be a potential breaking point in $\{P_t\}$, the Zivot–Andrews test Is conducted by estimating the following three equations:

$$\Delta p_t = \alpha_1 + \alpha_2 t + \alpha_3 DU_t + \beta p_{t-1} + \Sigma_{i=1}^{k} \delta_i \Delta p_{t-1} + \varepsilon_t \quad (21)$$

$$\Delta p_t = \alpha_1 + \alpha_2 t + \alpha_3 DT_t + \beta p_{t-1} + \Sigma_{i=1}^{k} \delta_i \Delta p_{t-1} + \varepsilon_t \quad (22)$$

$$\Delta p_t = \alpha_1 + \alpha_2 t + \alpha_3 DT_t + \alpha_4 DU_t + \beta p_{t-1} + \Sigma_{i=1}^{k} \delta_i \Delta p_{t-1} + \varepsilon_t \quad (23)$$

Where DU_t is a sustained dummy variable capturing a shift in the intercept, and DT_t representing a shift in the trend occurring at time T_b. More precisely,, DU_t and DT_t are defined as follows:

$$DU_t \equiv \begin{cases} 1 & if \quad t \succ T_b \\ 0 & otherwise \end{cases}$$ and

$$DT_t \equiv \begin{cases} 1 & if \quad t \succ T_b + 1 \\ 0 & otherwise \end{cases}$$

As can be seen, equation (21) allows a one-time shift in the intercept; Equation (22) is used to test for stationarity of the series around a broken Trend and equation (23) captures the possibility of a change in the intercept as well as a broken trend.

Nowadays, it is well known that that the data generating process of many economic and financial time series is nonlinear (see Granger and Terasvirta, 1993; Franses and Van Diijk, 2003; Brocks, 2008; Tsay, 2010 and Enders, 2010). Non-linearity in stock prices data generating process can result from a number of causes including the following:

a) structural change

b) presence of high amplitude shocks

c) technological innovation

d) changes in market regulation

e) the characteristics of market microstructure

f) unreliable and unqualified information

g) the existence of bid-ask spread

h) short selling and borrowing constraint

i) the existence of market imperfections (market frictions e.g. transaction cost, tax, government intervention)

j) occurrence of unexpected events and the complex dynamics of the environments in which economies operate

This means that the existence of any of the above features leads to the appearance of a nonlinear structure in the stock prices series generating process. Furthermore, stock market efficiency hypothesis implicitly assumes that investors are rational where rationality implies risk aversion, unbiased forecasts and instantaneous responses to new information (Antoniou et.al, 1997). Such rationality leads to stock prices responding linearly to new information. These attributes especially in emerging stock markets with uninformed participants (traders) are not realistic. Therefore, the behavioural biases of investors may result in stock prices responding to new information in a non-linear manner. In addition, given the informational asymmetries and lack of reliable information, noise traders may also delay their responses to new information in order to assess informed traders' reaction.On the other hand, emerging stock markets are typically characterised by low liquidity, thin trading and considerable market volatility which may lead to delay in investors reaction to new information and therefore stock prices change in a non- linear way. Additionally, the price limits which are introduced especially in emerging markets to control market volatility may result in non-linear behaviour in stock prices.

The market psychology concept may be another reason for non-linear behaviour in stock markets (Antoniou et.al, 1997). It is well known that investors and stock markets over-react to bad news and under-react to good news. There are many participants in stock markets with many complex sets of human relationships, motivations, preferences, tastes and reactions. Under these circumstances, the appearance of non-linear structure in stock price or stock return time series is quite possible. At the same time, the time of information dissemination (announcements) especially in the case of macroeconomic conditions also may lead to non-linear feedback in the data generating process of stock market data. For example, monthly announcements will cause non-linearity in daily and weekly series, but not in quarterly series.

Another explanation for the existence of non-linear structure in distribution of stock prices series is the special features of the financial data as "stylized facts". The empirical distribution of stock prices appears as stylized facts when characterised by fat tails, high peakness (excess kurtosis) and skewness. In this sense, the stock price index series is generally not well approximated by the normal distribution. Failure to take into account the special properties of financial data and the institutional features of stock market specific to developing countries may lead to incorrect identification of data generating process or statistical illusions. In this sense, the conventional unit root tests might not have enough power to reject the null hypothesis of a unit root when true data generating process of a sequence is nonlinear. In order to overcome this weakness, alternative nonlinear unit root tests are designed.

In the following in order to take into account the potential nonlinear behaviour in the Iran stock prices index series we employ the nonlinear ESTAR and Fourier unit root tests to investigate the random walk theory in Iran stock prices index.

In view of nonlinear behaviour in the dynamics of stock prices, Kapetanios et al. (2003) have developed a nonlinear unit root test procedure in an ESTAR framework. The logic of using smooth transition autoregressive (STAR) models is the difference of the market's dynamics according to the size of deviation from fundamental equilibrium as the economic theory suggests (Terasvirta and Anderson (1992); Granger and Terasvirta (1993) and Terasvirta (1994)). This test allows smooth transition between the stationary regime and the nonstationary regime around the long-run equilibrium value.

Consider a univariate STAR model of order 1, as follow:

$$y_t = \beta y_{t-1} + \gamma y_{t-1} F(\theta; y_{t-d}) + \varepsilon_t \qquad (24)$$

where y_t is a mean zero stochastic process for t=1,...,T, $\varepsilon_t \approx iid(0,\sigma^2)$, and β and γ are unknown parameters. The transition function $F(\theta; y_{t-d})$ is assumed to be of the exponential form:

$$F(\theta; y_{t-d}) = 1 - \exp(-\theta\, y_{t-d}^2) \qquad (25)$$

where it is assumed that θ >0, and d⩾1 is the delay parameter. The exponential function is bounded between zero and one, and is symmetrically U-shaped around zero. The parameter θ is slope coefficient and determines the speed of transition between to regimes that correspond to extreme values of the transition function. Considering (24) and using (25), we obtain the following exponential STAR (ESTAR) model:

$$y_t = \beta\, y_{t-1} + \gamma\, y_{t-1}[1 - \exp(-\theta\, y_{t-d}^2)] + \varepsilon_t \qquad (26)$$

which after reparametrizing can be written conveniently as:

$$\Delta y_t = \phi\, y_{t-1} + \gamma\, y_{t-1}[1 - \exp(-\theta\, y_{t-d}^2)] + \varepsilon_t \qquad (27)$$

Where $\phi = \beta$ -1.

Imposing ϕ = 0 (which implies that y_t follows a unit root in the middle regime) the ESTAR model can be written as:

$$\Delta y_t = \gamma\, y_{t-1}[1 - \exp(-\theta\, y_{t-d}^2)] + \varepsilon_t \qquad (28)$$

The global stationarity of the process y_t can be examined by testing the null hypothesis **H0**: θ=0 (y_t is a linear unit root process) against the alternative

H1: θ>0 (y_t is a nonlinear stationary ESTAR process). However, testing the null hypothesis directly is not possible since the parameter γ is not identified under the null. It is worth noting that the coefficient θ determines the speed of mean reversion.

To circumvent this problem, Kapetanios et al. (2003) according to suggestion of Luukkonen et al. (1988), replace the transition function by its appropriate Taylor approximation to derive a t-type test statistic. The following auxiliary regression is yielded by replacing the transition function with its first order Taylor approximation:

$$\Delta y_t = \delta y_{t-d}^3 + e_t \qquad (29)$$

where e_t comprises original shocks ε_t as well as the error term resulting from Taylor approximation.

The test statistic for **H0**: δ= 0 against **H1**: δ<0 is calculated as follows:

$$t_{NL} = \frac{\hat{\delta}}{s.e(\hat{\delta})}$$

where $\hat{\delta}$ is the OLS estimate and $s.e(\hat{\delta})$ is the standard error of $\hat{\delta}$.

To accommodate stochastic process with nonzero mean and/or linear deterministic trend in conducting the above presented nonlinear unit root test, the de-meaned and de-meaned and de-trended series is applied (Hasanov, 2009). In the case where the data has nonzero mean, the de-meaned series is obtained by subtracting the sample mean from log level of stock prices index series ($y_t = x_t - \bar{x}$, $\bar{x}$ is the sample mean). In the case of nonzero mean and a nonzero linear trend data, y_t

($y_t = x_t - \hat{\mu} - \hat{\alpha} t$) is constructed where $\hat{\mu}$ and $\hat{\alpha}$ are OLS estimator of μ and α. In other words, to allow application of the test with intercept or intercept and trend terms included, these deterministic terms are removed by using the de-meaned or de-trended series.

In the more general case where errors in (27) are serially correlated, the equation (27) can be extending to:

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \gamma y_{t-1}[1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_t \qquad (27)$$

In this general equation, the t_{NL} statistic for testing θ=0, is obtained from the following auxiliary regression with *p* augmentations:

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \delta y_{t-d}^3 + e_t \qquad (28)$$

In empirical process, the number of argumentations *p* and the delay parameter must be determined prior to the test. The standard model selection criteria or significance testing procedure was used by Kapetanios et al. (2003) for selecting the number of augmentations *p*. In the same time, they suggest that the delay parameter *d* can be chosen by maximizing goodness of fit over *d= {1, 2,…, d $_{max}$}*.

In the case of the impacts of the presence of structural break on the results of unit root tests, Enders and Lee (2006) state that it may take varying period of time for the economic or financial series to display the effects of realized event. To take into account these feature of structural breaks and control for the effect of unknown forms of nonlinear deterministic terms, Enders and Lee (2006) propose a new unit root test that replicates the pattern of structural breaks using a single-frequency Fourier function. In this method, the trigonometric terms is defined to capture unknown nonlinearities in the equilibrium level. More precisely, this test relies on a Fourier approximation for the transition function which captures structural change with one seamless transition regime instead of multiple regime separated by separate structural breaks.

Following Enders and Lee (2006) and (2009); Becker et al. (2006) and Christopoulos and Leo´n-Ledesma (2010) we adopt the Fourier unit root test as follow:

$$\Delta P_t = \rho P_{t-1} + c_1 + c_2 \sin(2\Pi kt/T) + c_3 \cos(2\Pi kt/T) + \varepsilon_t \quad (29)$$

where k is the number of frequencies of the Fourier function, t is a trend term, T is the sample size and $\Pi = 3.1416$. $[c_1 + c_2 \sin(2\Pi kt/T) + c_3 \cos(2\Pi kt/T)]$ is a time- varying intercept and $[c_2 \sin(2\Pi kt/T) + c_3 \cos(2\Pi kt/T)]$ is the key element. In theory, through selecting an appropriate single frequency k, the corresponding Fourier function $[c_2 \sin(2\Pi kt/T) + c_3 \cos(2\Pi kt/T)]$ captures structural changes in the sequence $\{P_t\}$. Furthermore, since the frequency k is data-driven and the resulting Fourier function closely replicates the structural change, it is not necessary to pre-assume the number or the date of each structural break. In sum, this unit root test allows for an unknown number of structural breaks with unknown functional forms; the breaks are detected endogenously and *a priori* specification of the form of the break is not required.

In practice, in order to determine unknown value of k the equation (29) is estimated for each integer value of k in the interval 1–5 ($1 \leqq k \leqq 5$) and the appropriate value of k is selected based on the smallest residual sum of squares. After that, a formal test for the presence of unknown breaks in the data generating process of P_t can then be carried out by testing the null hypothesis **Ho:c_2=c_3=0** against the alternative **H1: c_2=c_3≠0** using F_statistic, ***F(k)***(table 1c Enders and Lee, 2009). If the null hypothesis is rejected the Fournier function captures the nonlinearity. Finally, the test of nonstationarity is carried on by applying OLS to estimate equation (29) and testing the null hypothesis **H_0: ρ=0**. If ρ is significantly different from zero (using the τ_{DF} statistics from table 3, Enders and Lee, 2006), we can reject the null hypothesis of a unit root through taking into account nonlinearity and possible structural breaks and therefore the sequence $\{P_t\}$ is stationary. It should be noted that if the errors terms in equation (29) reveal serial correlation, the augmented form of this test is estimated as follow:

$$\Delta P_t = \rho P_{t-1} + c_1 + c_2 \sin(2\Pi kt / T) + c_3 \cos(2\Pi kt / T) + \sum_{i=1}^{p} \beta_i \Delta P_{t-i} + \varepsilon_t \quad (30)$$

4.5.3. Data and Preliminary Analysis

The data used in this study are comprised of daily stock price index of Tehran stock exchange (TEPIX) which is calculated as weighted(based on company's shares number) market value of all share prices appearing on the TSE Price Board. The sample period includes 2632 observations during the period January 2, 1999 to December 30, 2009.

Figure 4.14, shows that over time the Iran stock price index (TEPIX) has increased. Since March 18, 2003 we observe a sharp upward trend in TEPIX, which has continued to August 4, 2004. After that TEPIX has tended to decline and become more volatile. It can be seen that in the examined period the greatest value of TEPIX occurred in August 4, 2004. Furthermore, from the figure 3.4 appear that the Iran stock price index declined sharply between September 23, 2008 and March 29, 2009 coincides with significant fall in oil prices and world financial recession and started to pick up after that. Overall, with a careful view at the graph it can be noted that the variations in Iran stock prices index has increased since December 4, 2004 which coincides with the start of political challenges concerning Iranian nuclear programme.

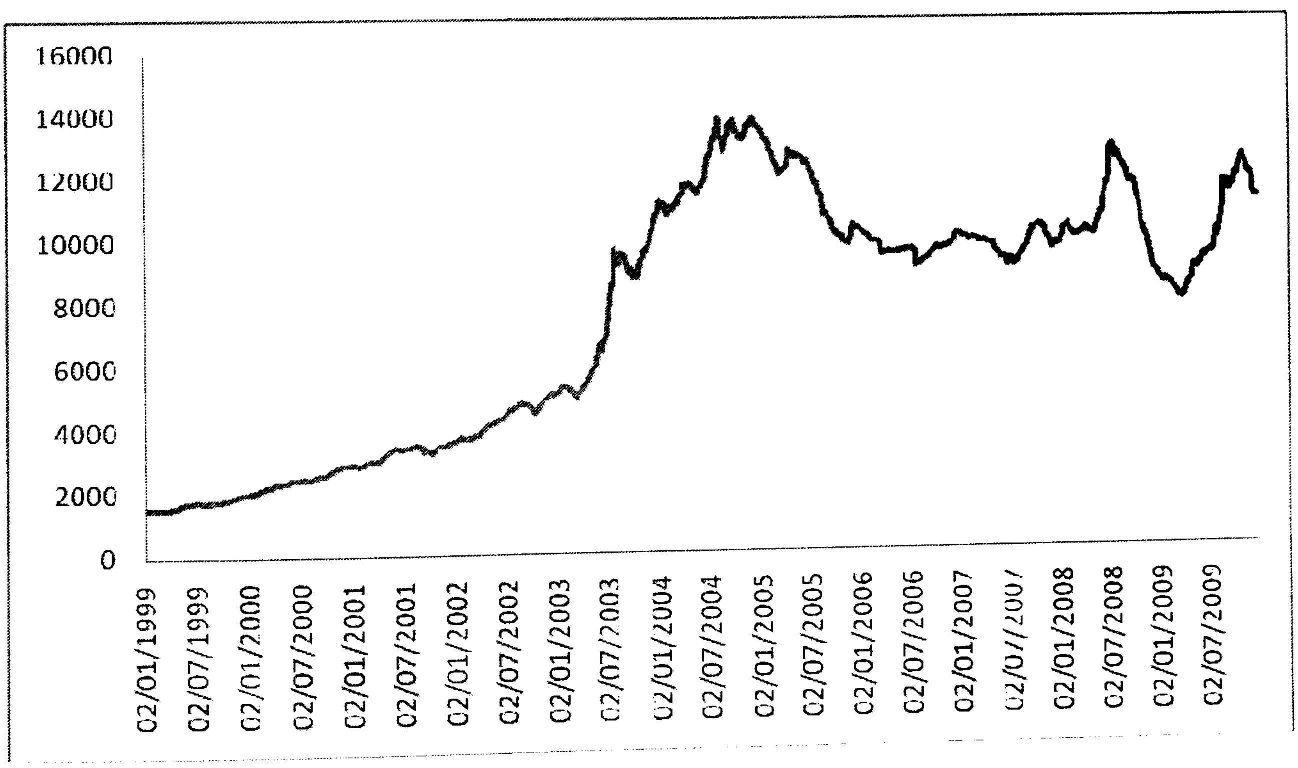


Fig4.1.The time plot of Iran stock prices index (TEPIX)

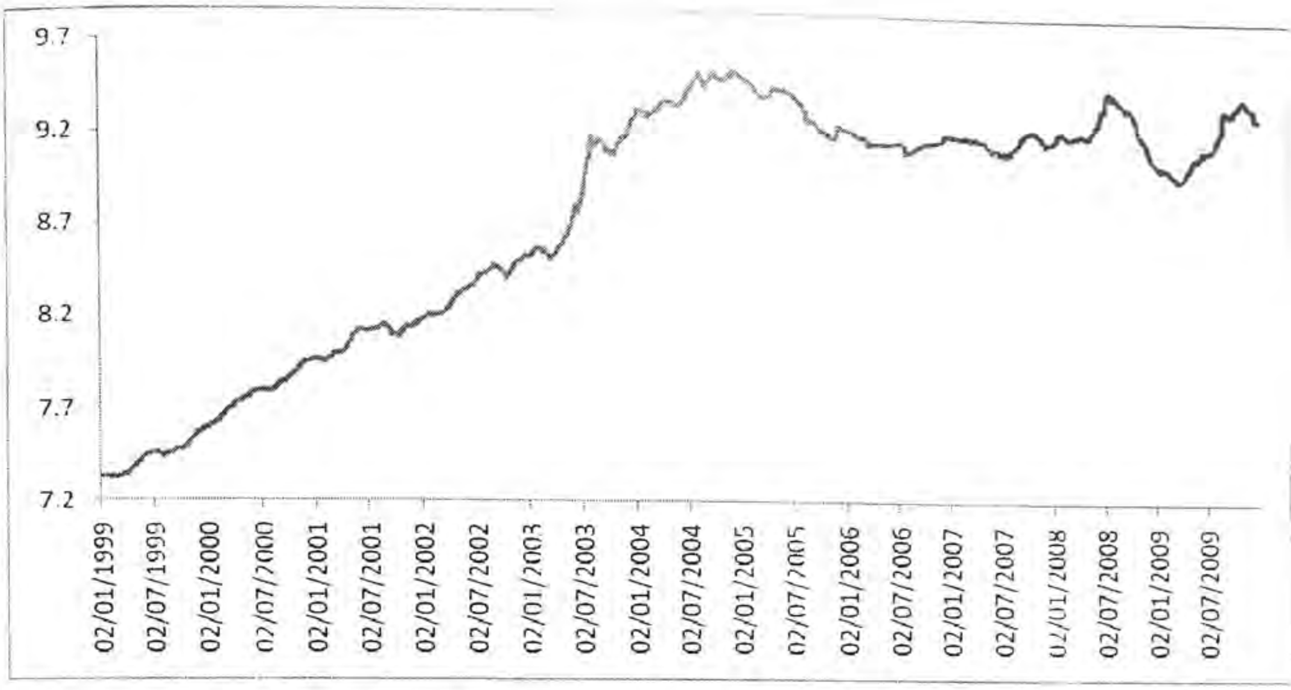
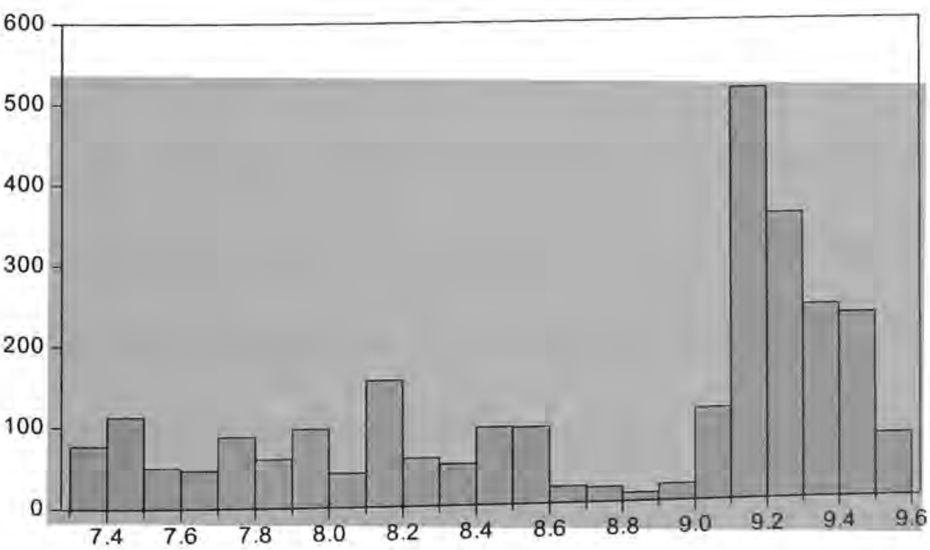


Fig4.2.The time plot of the logarithm of Iran stock prices index (TEPIX)

Summary statistics of stock price index series in Iran stock market are presented in table 4.1. The parameters skewness and kurtosis represent the standardised third and fourth moments of a distribution. These parameters are used with Jarque-Bera statistics to indicate whether a data set is normally distributed or not. Skewness is a measure of asymmetry of the distribution of the series around its mean. The skewness of the normal distribution is zero. Positive skewness means that the distribution has a long right tail and negative skewness implies that the distribution has a long left tail.



Series: LTEPIX	
Sample 1 2632	
Observations 2632	
Mean	8.742106
Median	9.134593
Maximum	9.538348
Minimum	7.326466
Std. Dev.	0.678187
Skewness	-0.700291
Kurtosis	2.021876
Jarque-Bera	320.0464
Probability	0.000000

Table4.1. Descriptive statistics for the logharitm of the Iran stock prices index

Table4.1 shows evidence of negative skewness in distribution of stock prices index, indicating long left tail. Kurtosis measures the peakedness or flatness of the distribution of the series. The kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution is peaked - leptokurtic; if the kurtosis is less than 3, the distribution is flat - platykurtic. Since the kurtosis or degree of excess is smaller than the normal value of 3, distribution of the Iran stock price index series are platykurtic. Finally, the calculated Jarque-Bera statistics and corresponding p-values in table 3.2 are used to test the null hypotheses that the daily distribution of stock price index is normally distributed. *P-values* is smaller than the .01 level of significance suggesting the null hypothesis can be rejected. Therefore the stock price index series is not well approximated by the normal distribution.

3-5-4. Empirical Results

The results of the ADF and PP unit root tests conducted at levels in the presence of intercept, trend and intercept are shown in tables 4.2. According to reported results in Table 3.3 both the ADF and the PP with regards to critical values at %1 and %5 fail to reject the null hypothesis of a unit root in the daily Iran stock price index at level. In this sense, the index series do not contain an intercept and/or deterministic time trend. It is worth pointing out that the efficient market hypothesis is inconsistent with the presence of a deterministic trend in stock prices series. On the other hand, the results in Table 4.3 indicate that the *t*-statistics for both the ADF and the PP models are greater than their respective critical values for the logarithm of Iran stock price index at first difference. This indicates that stock index series is integrated of order one (difference stationary). It can be concluded that the Iran stock price index is non-stationary and becomes stationary at first difference, in other words, Iran stock price series behave according to stochastic process and follow random walk.

The empirical results of the KPSS test on logarithm of Iran stock market index at level and first difference represented in table 4.4. From table 4.4, it can be seen that the null hypothesis of stationary in the daily Iran stock price index at level is rejected. Whereas stationary of stock prices series is confirmed at first difference. In other words, the empirical results from KPSS unit root test at first difference of Logarithm TEPIX imply the difference stationary process in Iran stock market index. As a result, the findings from KPSS test also confirm the behaviour of Iran stock price index series as random walk process. In other words, according to results of KPSS unit root test the weak- form efficiency of Iran stock market is concluded. On the whole, it can be noted that empirical results from conducting ADF, PP and KPSS unit root tests in line with the first hypothesis of this chapter suggest that Iran stock prices index follow random walk theory.

Table4.2. **ADF** and **PP** Unit Root Tests Results on the logarithm of Iran stock market index at level

Type of tests	*Exogenous variable*	*t-Statistics*	*Critical value %1*	*Critical value %5*	*Inference*
ADF	Intercept	-2.2737	-3.432652	-2.862443	Do not reject
ADF	Intercept and Trend	-1.0549	-3.961545	-3.411522	Do not reject
PP	Intercept	-2.3993	-3.432643	-2.862439	Do not reject
PP	Intercept and Trend	-0.8463	-3.961531	-3.411515	Do not reject

Table4. 3. ADF and PP Unit Root Tests Results on the logarithm of Iran stock market index at first difference

Type of tests	*Exogenous variable*	*t-Statistics*	*Critical value %1*	*Critical value %5*	*Inference*
ADF	Intercept	-9.6238	-3.432652	-2.862443	reject
ADF	Intercept and Trend	-9.8385	-3.961545	-3.411522	reject
PP	Intercept	-45.7102	-3.432644	-2.862439	reject
PP	Intercept and Trend	-45.4641	-3.961533	-3.411516	reject

Table4.4: KPSS Unit Root Test Results on the logarithm of Iran stock market index at level and first difference

Type of series	*Exogenous variable*	*t-Statistics*	*Critical value %1*	*Critical value %5*	*Inference*
Level	Intercept	5.0773	0.739000	0.463000	reject
Level	Intercept and Trend	1.3845	0.216000	0.146000	reject
First difference	Intercept	0.7164	0.739000	0.463000	Do not reject
First difference	Intercept and Trend	0.1219	0.216000	0.146000	Do not reject

The graphs (Fig4.2) of natural logarithm of daily stock prices index in Iran stock market offer visual support for the possibility of a break in trend behaviour around December 4, 2004, when the political challenge about Iranian nuclear programme started. Table 4.5 represents the findings of one structural break point Perron's unit root test in both the level and the slope of the Iran's stock prices index series (equation 17).T-statistics for the coefficient of p_{t-1} (log (stock prices index (-1)) must compare with critical value in table VIB of Perron (1989). According to the critical value at λ=0.54(the ratio of the period up to the break point to the whole period), the calculated t value for p_{t-1}(-2.0666) is smaller than any of two critical value. We cannot reject the null hypothesis that the Iran stock market index series is generated by a unit root process.

Since it is reasonable the breakpoint is determined endogenously, we are motivated to apply the Zivot and Andrews (1992) unit root test to examine the random walk theory in the behaviour of Iran stock price index. The results of Zivot and Andrews (1992) test are reported in table 4.6. The null hypothesis that Iran stock prices index has a unit root with a structural break in the intercept, trend and both of them is accepted in 1 percent the conventional levels of significance. In other words, in view of the unknown break point the Iran stock prices follow random walk process.

As a result, according to previous discussion the Iran stock price index follows random walk hypothesis even in the presence of one structural break over the investigated period. To put it another way, shock on stock prices in Iran stock market has permanent effect and movements of stock prices is random, consequently the movement pattern of Iran stock prices is unpredictable. Furthermore, empirical results confirm the existence of structural break in Iran stock price index on 4 December 2004. The empirical findings from the Perron (1989) and Zivot and Andrews (1992) confirm the second defined hypothesis in this chapter.

Table 4.5: Perron unit root test result in the presence of the exogenous break point

Test Type	t-Statistics	Critical value %1	Critical value %5	Inference
Perron	-2.0666	-4.90 - -4.88	-4.24 - -4.24	Do not reject

Table 4.6: Empirical results from unit root in the presence of the endogenous break point

	Intercept	Trend	Intercept and Trend
Zivot- Andrews test statistic	-2.60	-3.39	-5.28
Lag Lenght	8	8	8
1% critical value	-5.34	-4.80	-5.57
5% critical value	-4.93	-4.42	-5.08
10% critical value	-4.58	-4.11	-4.82

To carry out the nonlinear SETAR unit root test, we firstly estimated an AR (12) model for both de-meaned and de-meaned and de-trended series and excluded insignificant (at 10% significance level) augmentation terms. In this regard, the AR(1),AR(2),AR(3),AR(4),AR(8) and AR(11) are selected for both series. Then, we estimated regression (28) with selected augmentations to compute the t_{NL} statistics. At the same time, the delay parameter d through maximizing R^2 over d= {1, 2, . . . , 12} was determined as d=11. Since the t_{NL} test unlike the case of testing linearity against STAR type nonlinearity does not have an asymptotic standard normal distribution, we bootstrapped the t_{NL} test statistic with 10000 replications.

Table4.7 displays the empirical results from unit root test in ESTAR framework. As it can be seen from table, the null hypothesis **H0**: $\delta = 0$ is accepted in conventional significance levels. In other words, the null hypothesis of linear unit root is confirmed for de-meaned and de-trended stock prices series. Accordingly, it can be noted that the Iran stock prices index series follow random walk process even in nonlinear data generating process.

We also estimated the ESTAR model as given in (28). Initial estimates of γ found to be poorly identified, a result that has been observed elsewhere (Sarno, 2000; Kapetanios et al., 2003). Therefore, following previous researchers (i.e. Hasanov, 2009), we set γ to minus unity. The test statistics and estimation results are provided in Table 3.8.

Table4.7. Nonlinear ESTAR unit root test results

	De-meaned series	De-meaned and de-trended series
t_{NL}	-2.5156	0.1097
$\hat{\theta}$	0.0003	0.0002
SE of $\hat{\theta}$	0.0001	0.0002
Critical values of the t_{NL} statistic		
1%	-3.48	-3.93
5%	-2.93	-3.40
10%	-2.66	-3.13

Notes: The tNL statistic was computed by bootstrapping with 10 000 replications. Asymptotic critical values of the tNL statistic are taken from Table 1, Kapetanios et al. (2003, p. 364).

In order to apply the nonlinear Fourier unit root test ,In the first step the equation (29) is estimated with various value of k for interval 1-5 and based on the smallest residual sum of squares the number of frequencies of the Fourier function is verified 1(k=1). In the next step, the null hypothesis of linearity (**Ho: $c_2=c_3=0$**) is tested. As displayed in table 4.8, the sample value of the ***F_statistic*** rejects the linearity the 5 percent significance level. After that the augmented form of test (equation (30)) are estimated and appropriate lags based on randomness of error terms are recognized (p=10). The null hypothesis of unit root (H0: ρ **=0)** is tested using the τ statistic for $\hat{\rho}$ from the final equation with 10 lags. Since the yield τ statistic (1.62) is smaller than τ_{DF} statistic at the 5 percent significance level, the null hypothesis is accepted. This means that Iran stock market index is nonstationary and follows random walk theory. In sum, it should be noted that the empirical findings from nonlinear unit root tests are consistent with the third hypothesis, i.e. Iran stock prices index follow random walk even in view of the possible nonlinear data generating process.

Table4.8. Empirical results for the nonlinear Fournier unit root test

$\hat{\rho}$	**F_test**	**K**	**Lags**	τ
0.01022	18.02	1	10	1.6289

Note: denotes significance in 1% level.

Based on table 1c, Enders and Lee, (2009) the F (k) and τ_{DF} statistics for k=1 and T=100 are 7.04 and -4.95 respectively. These statistics for k=1 and T=500 are 6.83 and -4.81 respectively.

The empirical results from the five types of linear unit root test and two nonlinear unit root tests consistently indicate that the Iran stock market is efficient in the weak form. Obviously, finding evidence to confirm weak-form market efficiency is not unique to our study as many other studies have reached similar conclusions (Narayan and Smyth 2004, for South Korea, Cooray and Wickremasingle 2005, for India, Seri Lanka and Pakistan, Marashdeh and Shrestha 2008, for United Arab Emirates and Ozdemir 2008, for Turkey stock markets). In Iran stock market as an efficient market in weak form, any information that is relevant to the determination of stock prices or returns is rapidly incorporate into prices and accordingly stock prices are adjusted. As a result, participants do not have different comparative advantages in acquisition of information. In this respect, creating abnormal returns from trading or applying different trading strategies is impossible.

In fact, nonstationary stock price index series indicate the absence of obvious dependence in the stock price series or information appearance. This is consistent with price fluctuations that are not subject to a deterministic time trend and in which updates occur only with new information. In other words, the stock price movement happen based on random walk hypothesis or random process. In this condition, investors might not be able to detect patterns in stock prices and exploring historical prices is a waste of time. Furthermore, in Iran stock market the share price of a company reasonably represents its value and market expectations about its abilities, future performance and returns.

3.5.5. Concluding Remarks

Understanding the efficiency of stock market is important in enhancing the role of it in economic development process. Theoretically, in an efficient stock market in weak form, stock prices follow random walk theory. In this sense, motivated by theoretical background and empirical literature, the random walk hypothesis in Iran stock market as an emerging stock market applying Augmented Dickey Fuller, Philip-Perron, KPSS, endogenous and exogenous structural break point unit root tests is examined. Regarding underlying nonlinear data generating process two nonlinear unit root tests namely ESTAR and Fourier are also adopted to investigate the randomness of Iran stock prices index series. The obtained empirical results from all these models imply that the Iran stock market index has a unit root and follows a random walk process. This confirms the weak-form efficiency of Iran stock market which means that in this market past movements in stock prices cannot be used to predict their future changes and investors cannot devise various trading rules or techniques to make abnormal returns from transactions in the market. The presence of efficiency in the stock market has important implications for issuers of equity and investors. In an efficient stock market, equities or other financial instruments are valued fairly and the signal function of market is reliable. Under these circumstances, the companies and investors make decision correctly and safely. Moreover since in an efficient stock market the asset prices fully and accurately reflect all available information and securities are appropriately priced at equilibrium level and there is no distortion in the pricing of capital and risk. Under these circumstances, an efficient stock market in weak form through expanding investor's confidence can attract foreign portfolio investment; encourage domestic savings and improving the mobility of capital and financial resources. Behaviour of stock market as a major index of economic conditions is very important for the policy maker of any country. The prices of securities determined in an efficient market serve as aggregators of information. Therefore, such prices will provide sufficient and suitable information and indicators for efficient allocation of resources in the economy. At the same time, since stock prices are forward looking, they represent a unique feature of investors' expectations and shifts in investors' views about the future prospects of companies as well as the economic environment. In this way, an efficient stock market reflects national economic prospects. It can be noted that efficiency of stock market is important in the optimal allocation of financial resources within an economy and hence in the process of national economic development.

It is evident from the findings in this study that all of the unit tests employed confirm the weak-form efficiency of the stock market in Iran. In spite of this, the conclusions of this research should be argued with caution because of nature of the data and methodology used. In order to make an informed assessment of the operational characteristics of the Iran capital market, it is necessary to take into account the microstructure (institutional framework) of the stock market of Iran in terms of its efficiency and the pricing processes. A question may arise as to whether these results could change if the focus of the study to certain companies or particular industries, applying another methods and using weekly or monthly data. These issues of stock market efficiency can be investigated further in future.

Furthermore, empirical results of analysing distribution characteristics of stock price index series in the Iran stock market indicated that they are not normally distributed. The nature of the underlying stochastic properties of stock prices' distribution in this market should be identified when the efficiency of market is investigated. In this respect, the **IID** assumption for distribution of stock prices or returns should be considered. In other words, future studies should investigate the weak form efficiency of Iran stock market regarding to RW1 and RW2 types of random walk hypothesis.

Chapter 5

Modelling Volatility dynamics of Iran Stock Market[1]

5.1. Introduction

It is clear that the stock market volatility as a key concept is central to modern financial economic theory. Stock market volatility is defined as fluctuations in prices of stock or tradable financial instruments (derivative securities) in a certain time span. In this manner, stock market volatility is measured by the standard deviation or variance of stock prices or stock returns and is often applied as a crude measure of the total risk inherent in financial assets. In this context, modelling and forecasting stock market volatility has been the subject of vast theoretical and empirical investigation in financial economics.

From academic and practical points of view, understanding and determination of stock market volatility are very important. Stock market volatility as simple risk measure plays a crucial role in portfolio construction, risk management, hedging and pricing of financial derivatives such as options and futures. Many value-at-risk models for measuring market risk require the estimation or forecast of a volatility parameter (Brooks, 2008). Furthermore, changes in stock market risk (volatility) affect expected returns of all individual securities in asset pricing models. Prediction of stock market volatility helps individual investors, investment funds and investment firms

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[1]. Some parts of the methodology used and empirical results in this chapter are published as the following paper: Paytakhti Oskooe, S.A. and Shamsavari, A. (2011) Asymmetric Effects in Emerging Stock Markets-The Case of Iran Stock Market, *International Journal of Economics and Finance*,3(6),pp.16-24.

make rational portfolio risk diversification, risk reduction and management-based decisions. In other words, adequate information on volatility helps with rational decisions concerning portfolio diversification by market participants (investors).

A volatile stock market is often associated with an unstable stock market. In this sense, policy makers who are concerned with stability of stock market as an indicator of economic activity, need to understand volatility and its impact on the economy. Since stock market is forward looking (indicates the expectation of the future of economic activity), instability in the stock market may have a negative impact on the economic activity through increasing uncertainty, and this can be a concern for policy makers. Thus, the effectiveness of economic policy depends on an understanding of the relationship between stock market volatility and economic conditions. Furthermore, the identification of stock market volatility will give policymakers the opportunity to anticipate an impending financial crisis.

It should be emphasised that the stock market volatility has positive and negative implications. Volatility may impair the smooth operation of the financial system and unfavourably affect economic performance. In addition, stock market volatility affects consumer spending through the wealth effect (Campbell, 1996; Starr-McCluer, 1998; Ludvigson and Steindel 1999 and Poterba 2000). In this connection, fluctuations and instability in stock market will weaken consumer confidence and thus drive down consumer spending. Stock market volatility may also affect business investment (Zuliu, 1995) and economic growth directly (Levine and Zervos, 1996 and Arestis et al 2001). An increase in stock market volatility can be interpreted as a rise in risk of investment in derivative securities which may result in a shift of funds and savings to less risky assets .These fluctuations can lead to a rise in cost of financial resources to firms and of course new firms or investment projects are significantly influenced. It is worth noting that the presence of high volatility in the stock market would lead investors to claim a higher risk premium. As a result, cost of capital would increase which may impede investment projects and slow down economic growth.

On the other hand, from the point of view of investment strategy in stock market, the stock market volatility is a useful indicator. In fact, fundamentally justified (based on market conditions) volatility can be applied as the basis for efficient securities price discovery. Furthermore, the traders and medium-term investors take into account volatility dependence which implies predictability of future stock prices movements. It should be emphasised that it is important for market participants to have information on stock market volatility in order to make rational decisions regarding portfolio construction, management and diversification.

Stock market volatility as a natural consequence of trading in stock market mirrors fundamentals, information and market expectations. It is necessary to point out that these three concepts are closely dependent on and interact with each other. Changes in corporate profitability, product quality, business strategy and landscape of future programmes of firms lead to adjustments in equity prices and therefore stock market volatility increases. At the same time, stock prices react to changes in various aspects of society such as economic situation, political stability and economic development programmes. It is obvious that the changes in corporate fundamentals and environmental information affect stock prices through the revision of participant's expectations and therefore lead to stock market volatility. Under these circumstances, the chain reaction of stock market participants will force stock prices to reach a post information equilibrium level (Kalotychou and Staikouras, 2009).

There is far less agreement on the news (or unanticipated information) arrival altering the expected returns of stock, as a cause of changes in stock market volatility (Engle and Ng, 1993).On the one hand, the origin of stock market volatility is information which is determined exogenously (outside of stock market). On the other hand, the stock market volatility is caused mainly by changes in internal (market) factors such as trading volume, market liquidity, and changes in enforcement regulation and revision in accounting practices or patterns. Regardless of whether information (the origin of fluctuations in stock prices) is generated endogenously or exogenously, it is clear that stock market volatility is determined by the rate of information flow.

In addition, since stock prices fluctuate according to news flow, if arrived information is more reliable, then stock prices may become more volatile. On the other hand, if the information is unreliable some investors may not react instantaneously to news and delay their reaction until the information can be verified. At the same time, if investors are uncertain about the reliability of some of the information, they usually base their investment decisions on the behaviour of other investors who are perceived to have access to more dependable information (herding behaviour). It should be noted that sometimes unreliable information based on rumours lead to change in the volatility of stock prices.

In view of the second and third main aims of this thesis, the plan of the current chapter is the theoretical analysis and empirical investigation of the volatility of stock return time series in an emerging stock market. In this connection, the statistical distribution of Iran stock return series will be examined and accordingly the volatility of Iran stock market will be modelled. To accomplish this purpose, the chapter is organized as follow:

The literature review and theoretical aspect of the stock market volatility are outlined in section 2. Section 3 presents methodology and empirical method of modelling of Iran stock market volatility. The distribution characterises of Iran stock returns series is empirically analysed in section 4.The empirical results of volatility modelling of stock returns are discussed in section 5. Finally, in section 6 the concluding remarks and implications for policy making are highlighted.

5.2. Time varying volatility

In conventional econometrics models, the variance of the error term is assumed to be constant. However, it has been seen that the variance and covariance of many economic time series especially stock returns are time variant (Mandelbrot, 1963, Fama, 1965, Brooks, 2008, Enders, 2010 and Tsay, 2010). At the same time there is growing evidence that stock returns distribution exhibit stylized facts such as fat-tailed, asymmetric and volatility clustering. In such circumstances, the time series exhibits periods of unusually large volatility followed by periods of relative tranquillity (Enders, 2010). This type of behaviour especially in stock market return series implies that in model-building and empirical studies we should be concerned with especially higher moment characteristics (particularly second moment). In econometrics context, the volatility of time series is conceived as "conditional variance" and time-varying volatility of time series is known as "conditional heteroscedasticity". On the other hand, the unconditional variance (long-run variance) is assumed to be constant. From an investor's point of view, forecasts of the rate of stock return and its volatility over the holding period according to conditional variance is very important. It is worthwhile to note that the conditional mean or variance is crucial in dynamic investigation of financial time series. Engle (1982) introduced the concept of conditional heteroscedasticity and proposed a model in which the conditional variance of time series is a function of past shocks (innovations).

The autoregreressive conditional heteroskedasticity (ARCH) is the first model of conditional heteroskedasticity in the context of theoretical and applied econometrics. The important property of ARCH model is its ability to capture the tendency for volatility clustering particularly in stock return series. In this case, the ARCH process captures the serial correlation of the volatility of stock returns. This econometric model allows the conditional variance to be time-varying, while the unconditional variance is constant. It is notable that the ARCH is a model with conditional heteroscedasiticity (time-varying variance), but unconditional homoscedasticity (constant variance). The ARCH model establishes a variance equation on the basis of the salient systematic pattern in the residual of the mean equation. Especially in the case of financial time series, the residuals of the mean equation according to model building process are serially uncorrelated with mean zero, but with a time-varying (non-constant) conditional variance. To put it another way, the underlying idea of the ARCH models is that the shocks of stock returns are serially uncorrelated but dependent. From a technical prospective, the ARCH process displays nonlinearity in variance of the time series. An ARCH model for stock returns, assuming the distribution of the return series for period t, conditional on all previous returns (or information), is normal with constant mean μ and time-varying conditional variance h_t, can be expressed as:

$$r_t = E_{t-1}(r_t) + \varepsilon_t , \qquad \varepsilon_t \sim NID\ (0, h_t\ ) \tag{1}$$

Where $E_{t-1}(.)$ represents expectation on information available at time t-1,

and $\varepsilon_t = Z_t \sqrt{h_t}$, where z_t is **i.i.d** with zero mean and unit variance .

The mean equation in the ARCH model building process is decomposed into two parts, the predictable component $(E_{t-1}(r_t))$ and the unpredictable component ε_t . It is worth noting that the conditional mean or the predictable component can be expressed as any linear or non-linear functional form of estimation. The conditional variance of ε_t , h_t is:

$$h_t = \text{var}(\varepsilon_t | \varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2$$

The restrictions $\omega > 0$ and $\alpha_i \geq 0$ (i=1,...,p) are required for non-negative variance. Moreover, to ensure the stability of the process it is necessary that $\alpha_i < 1$. The ARCH model apparently implies that the conditional variance is an increasing function of the square of the shock that happened in the previous time period. In this situation, large (small) shocks tend to be followed by large (small) shocks, of either sign (volatility clustering). According to ARCH model the volatility of the stock return in period t depends solely on the previous returns. Either a large positive or a large negative stock return in period t-1 implies higher than average volatility in the next period. It is apparent that stock returns near the mean level μ signify lower than average future volatility.

The main weakness of the ARCH model is that it often requires many parameters and a high order **P** to capture the volatility process. Furthermore, in recent years some practically relevant disadvantages of the ARCH model have been discovered, for example, the possibility of non-negativity constraints violation, the shortcoming of definition and measuring of the persistence of shocks and the problem of modelling asymmetries. Another noticeable weakness of the ARCH models is over prediction of the volatility. In this sense, the ARCH models respond slowly to large isolated shocks to the stock return series (see Tsay, 2010).

To simplify the identification and estimation of a high-order ARCH model and to avoid problems of negative variance parameter estimation, the generalised ARCH (GARCH) model was developed by Bollerslev (1986) and Taylor (1986) allowing the conditional variance to be an ARMA process. The GARCH model was designed by including a lagged variance term (as a smoothing term) in the conditional variance equation and it is a more parsimonious model of the conditional variance than a higher-order ARCH model. This model allows for both autoregressive and moving-average components in the heteroskedastic variance. From a technical point of view, in GARCH specification the initial impact of any shock persists indefinitely, but with an exponentially declining effect. The stock returns volatility is measured by conditional variance (h_t).The conditional variance equation in GARCH (p, q) process can be expressed as:

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \quad (2)$$

The non-negativity restrictions are $\omega \succ 0$, $\alpha_i \succ 0$ and $\beta_i \succcurlyeq 0$.The condition $\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j \prec 1$ implies that the GARCH process is weakly stationary since the mean, variance, and autocovariance are finite and constant over time (covariance stationarity). The α_i represents the short-run persistence of shocks, while the β_i implies the long-run persistence. In this sense, the size and significance of α_i implies the existence of the ARCH process in the error term (volatility clustering). In the same way, the ARCH coefficient measuring the 'news effect', determines the effect of past shocks or innovations on the return process. The GARCH model can be transformed to an infinite order ARCH model with geometrically declining coefficients (see Verbeek, 2004). Accordingly, the GARCH specification implies that the effect of a shock on current volatility decreases over time. In this manner, the GARCH coefficient measures the influence of past volatility on the current behaviour of stock returns.

The conditional variance is changing over time, while the implied unconditional variance (the long-run average variance) is constant and given by:

$$var(\varepsilon_t) = \frac{\omega}{1-(\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j)}$$

In this respect, it can be noted that a time series with conditional heteroscedasiticity is stationary because its unconditional moments are constant. The sum of ARCH and GARCH coefficients in the variance equation $(\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j)$ represents the degree of the persistence of shocks to volatility. If $\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j > 1$ then the response function of volatility increases with time. On the other hand, if $\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j < 1$ this means that shocks decay over time. The closer the sum to unity greater is the persistence of the shocks. In this circumstance, the tendency for volatility response to shocks represents a long memory. Another related aspect to the concept of the persistence of shocks is the half life of the volatility shocks

(Lamoureux and Lastrapes ,1990). This concept measures the number of days over which a shock to volatility diminishes to half its original size and is calculated as:

$$HL = Log\ (0.5) / Log\ \lambda$$

Where λ is the sum of the ARCH and GARCH parameters in the variance equation. In fact, the HL can be used as a measure of volatility persistence.

Since the GARCH process was introduced, with regard to empirical aspects especially in financial time series analysis, a significant number of extensions and modifications have been established in the basic model. In this sense, the non-stationary process, the non-negativity conditions, lack of the asymmetric effect analysis and the disregard of direct feedback between the conditional variance and the conditional mean of are the main weaknesses of the basic GARCH model which have been overcome. These modifications have diminished some of the restrictions or limitations in the original model in financial application. Furthermore, the flexibility of the original GARCH model in empirical applications has been increased.

In financial time series analysis, one limitation of the basic GARCH model is that it has short memory. The approach to capture the observed persistence of volatility in the stock returns is to approximate a unit root. Accordingly, the IGARCH model with the $\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j = 1$ condition was originally designed by Engle and Bollerslev (1986). Dropping the constant term in basic GARCH model, the IGARGH (p, q) model can be expressed as:

$$h_t = \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \tag{3}$$

In this kind of GARCH models, current information remains important for forecasting the conditional variance for all prospects and shocks to system have permanent effects, as a result, the IGARCH model is persistence in variance. From an econometric point of view, the IGARCH model is a typical unit – root conditional variance process. In particular, the presence of unit root permits to capture the infinite-memory phenomenon that may be ignored when applying usual GARCH models.

Symmetric response of stock returns volatility to positive and negative shocks is one of the notable weaknesses in the basic GARCH model. This weakness is due to the fact that conditional variance in the basic GARCH model is a function of the magnitudes (squared) of the lagged residuals and not their signs. However, in stock markets it has been observed that a negative shock to stock price series causes volatility to rise by more than a positive shock of the same magnitude. In other words, the bad news (negative shocks) tends to increase volatility more than good news (positive shocks). Generally speaking, stock market volatility tends to be higher in a falling market than in a rising market. In the light of financial economic theory, such asymmetries are typically attributed to "leverage effects", whereby a decrease in the value of a firm's stock leads to the firm's debt to equity ratio to increase (Black (1976) and Christie (1982)). In other words, a fall in a stock price increases the debt-to-asset ratio of the firm, which in turn increases the volatility of stock returns to the equity holders. Under these circumstances, shareholders who bear the residual risk of the firm, recognize their future cash-flow stream as being relatively more risky (volatility). Pindyck (1984) and Campbell and Hentschel (1992) state another explanation for asymmetric volatility which is known volatility feedback. In this sense, increases in stock returns volatility raise required stock returns and cause an immediate price decline. In other words, since volatility is a measure of risk, an increase in volatility signals a higher risk and also higher expected future risk. To bear this risk, investors will require higher returns thus are willing to pay less for the corresponding equity. The selling activity is proposed as another reason for the asymmetric effect (Avramov et. at (2006)). In this explanation, uninformed traders sell when stock prices fall, leading to an increase in stock returns volatility, while informed investors sell after rises in stock prices leading to decline in volatility. In the framework of dynamic features of stock returns volatility, the tendency for volatility to decline when stock returns increase and to rise when stock returns fall is also called leverage effect. In order to capture the asymmetric effect in modelling the stock returns volatility, the various asymmetric formulations of the GARCH process (nonlinear GARCH models) are developed.

The EGARCH as the non-linear GARCH model was proposed by Nelson (1991), allowing the conditional variance to depend on both the size and the sign of the lagged residuals. This model creates the possibility for asymmetric effects between positive and negative stock returns.

$$Ln(h_t) = \omega + \sum_{j=1}^{q} \beta_j \, h_{t-j} + \sum_{i=1}^{p} \alpha_i \left| \frac{\varepsilon_{t-i}}{h_{t-i}} \right| + \sum_{k=1}^{r} \gamma_k \frac{\varepsilon_{t-k}}{h_{t-k}} \qquad (4)$$

The presence of asymmetric effect is tested by the hypothesis that $\gamma_k \prec 0$. The shock is symmetric if $\gamma_k = 0$, then a positive return shock has the same effect on volatility as the negative return shock of the same amount. If $\gamma_k \prec 0$, positive return shocks generate less volatility than negative return shocks. On the other hand, if $\gamma_k \succ 0$, positive return shocks generate much volatility than negative return shocks. The persistence of shocks to the volatility is given by β.

Since the conditional variance is expressed in logarithm, in this asymmetric GARCH model there is no need to impose non-negativity constraints on the model parameters. Furthermore, in EGARCH model the "volatility-feedback" hypothesis is provided by creating a relationship between volatility and stock returns. From a technical point of view, in EGARCH model the volatility captured by the conditional variance has a direct influence on stock prices.

Another way to capture asymmetric effect in financial time series is modification of the original GARCH model using a dummy variable. In this regard, Glosten, et al. (1993) introduced the following model for the conditional variance:

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} + \sum_{k=1}^{r} \gamma_k \varepsilon_{t-k}^2 I_{t-k}^- \quad (5)$$

Where $I_t^- = 1$ if $\mathcal{E}_t \prec 0$ and $I_t^- = 0$ otherwise.

In this specification, the effects of good and bad news on the conditional variance are completely different. The good news ($\varepsilon_{t-i} \succ 0$) has an impact α_i , while the bad news has an impact of $\alpha_i + \gamma_k$. If $\gamma_{k \succ 0}$, bad news enhances volatility and we can conclude the existence of leverage effect in the stock market. On the other hand, if $\gamma_k \neq 0$, the news (shocks) impact on volatility is asymmetric.

The persistence parameter which shows the persistence degree of shocks is defined as:

$$\phi = \alpha_i + \frac{1}{2}\gamma_k + \beta_j$$

At the same time the asymmetry ratio which represents the asymmetric response of volatility to shocks can be computed as the following measure:

$$A = \frac{(\alpha_i + \gamma_k)}{\alpha_i}$$

Zakoian (1994) proposed the threshold GARCH (TGARCH) with other specification. In TGARCH process the conditional deviation instead of the conditional variance is modelled:

$$\sqrt{h_t} = \omega + \sum_{i=1}^{p} \alpha_i \left|\varepsilon_{t-i}\right| + \sum_{j=1}^{q} \beta_i \sqrt{h_t} + \sum_{k=1}^{r} \varepsilon_{t-k} D_{t-k} \qquad (6)$$

Where $D_{t-k} = 1$ if $\varepsilon_{t-i} \prec 0$, and $D_{t-k} = 0$ if $\varepsilon_{t-i} \succcurlyeq 0$.

In the same way, to allow for asymmetric effect, Ding et.al (1993) extended the basic GARCH model by emphasising the standard deviation in

GARCH process. The PARCH model contains a particular power parameter that makes the conditional variance equation nonlinear in parameters. At the same time, this model captures special features of financial time series in particular asymmetry effects; power transformations and long memory; and non-normal conditional error distributions. The asymmetric PARCH model estimates the optimal power term when the second moment can be specified as:

$$\sigma_t^d = \omega + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^d + \sum_{i=1}^{p} \alpha_i \left(|\varepsilon_{t-i}| + \gamma \varepsilon_{t-i}\right)^d \tag{7}$$

The power term d, captures the conditional standard deviation when d=1 and the conditional variance when d=2. Asymmetric effect is measured by the γ term. If the γ=0 , the asymmetric effect does not appear in the stock market, and as a result stock returns behave symmetric in reaction to different news (good or bad). It can be noted that the exponent d increases the flexibility of the model.

In financial application and many models of asset pricing, the expected stock returns are related to their expected risk (e.g. the Capital Asset Pricing Model and Arbitrage Pricing Model). In this context, it is supposed that investors should be rewarded for bearing additional risk by taking a higher stock returns. Engle, et al. (1987) proposed a GARCH-M specification, which incorporates the conditional variance of stock returns into the conditional mean equation. This specification of GARCH model creates trade-off between the time –varying (the conditional variance) risk and the expected stock returns. Under these circumstances, the conditional mean of stock return series is expressed as an explicit function of the conditional variance. From a technical point of view, this modification of GARCH model captures the underlying non-linearity in the mean and variance of a time series. In empirical applications, the GARCH-M model is proposed as two variants form. In this manner, the log of conditional variance or the conditional standard deviation in the conditional stock returns mean are used.

$$r_t = \mu + \delta\sqrt{h_{t-1}} + \varepsilon_t$$
$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1} \tag{8}$$

The GARCH-M model estimates time-varying risk premiums with time-varying variances. If the coefficient δ which measures the risk premium effect, is positive and statistically significant, higher conditional variance (higher risk) leads to a rise in the mean stock return. A significant and positive coefficient implies that investors are compensated with higher returns for bearing higher levels of risk. In this condition, the investors are assumed to be rational risk-averse, who require a larger risk premium during the periods when the payoff of the share is riskier (see Xekalaki and Degiannakis, 2010).On the other hand, a significant negative coefficient indicates that investors are penalized for bearing risk. It is important to point out that the sign and magnitude of the risk-return parameter depends on the investors' utility function and risk preference, and the supply of assets under consideration (Engle, et al. (1987), Bollerslev, et al. (1992)).This term captures the stylized fact that stock with greater variance in their returns tend to have higher mean rates of return. From an investor point of view, the implication of this modification in basic GARCH model (GARCH-M model) is that δ is the coefficient of relative risk aversion. Indeed, the GARCH-M model implies that there are serial correlations in the stock return series. These serial correlations are represented by δ in the volatility process in mean equation. Therefore, it can be noted that the existence of risk premium is another reason for appearance of the serial correlations in some historical stock return series (see Tsay, 2010).

5.3. Methodology

This section deals with modelling of stock market volatility in Iran stock market. As noted above, modelling and forecasting stock returns volatility is a key exercise in analysis of stock market behaviour. With regard to the application of volatility as a risk measure of stock market, examining the stock market volatility structure in identification of stock market evolutions and investors behaviour is very useful. The main issue in stock returns volatility modelling is application of econometrics models to capture the volatility clustering phenomenon which is observable in stock return time series. In view of the theoretical and empirical background, we design the following hypotheses to examine the volatility dynamics of Iran stock market:

H_1: The volatility of Iran stock returns is time varying

H_2: There is risk premium in the underlying dynamic of the Iran stock market

H_3: The asymmetric effect phenomenon is exist in the Iran stock market

Given the nature of the financial time series, we do not impose any specific data generating process. Since the Generalised Autoregressive Heteroskedasticity (GARCH) specifications are capable of capturing distribution characteristics (stylized facts namely fat tails, high peakness (excess kurtosis), skewness and volatility clustering) of stock returns, we employ this econometric procedure to model the dynamic volatility based on true data generating process of Iran stock returns. In modelling the dynamic of stock market volatility it is desirable to start with a simple model and based on various diagnostic and misspecification tests employ extensions of GARCH specification to capture the exit properties (i.e. risk return relationship, asymmetric effect) in dynamic of stock return series (the specific to general approach).

In the volatility modelling process using GARCH models, the first moment (mean) and second moment (variance) of the series are estimated simultaneously. The autoregressive moving average (ARMA) process is most frequently used to express the conditional mean of the stock return series. In this sense, an ARMA (p, q) specification which refers to a model with p autoregressive terms and q moving average terms is applied to model of the Iran stock returns mean. Empirical studies indicate that thin trading and non-synchronous trading introduce negative first-order autocorrelation in the observed time series of stock returns (Abraham et al. 2002; Appiah-Kusi and Menyah, 2003; Hassan et al. 2003; Al-Khazali et al. 2007; Rayhorn et al. 2007 and Lim et al. 2009). An advantage of using the residuals of ARMA (p, q) model is that it adjusts the effect of infrequent trading, which appears more in stock prices index of thinly traded stock markets (emerging stock market) (Miller *et al.* (1994)). The identification of the ARMA (p, q) is based on the autocorrelation and partial correlation of the residual of estimation of $\Delta p_t = r = \mu + \varepsilon_t$ equation as well as the lowest AIC and BIC criteria.

At the same time, since testing the adequacy of an estimated model is very determining step in model building of given time series data, the adequacy of specified mean equation is examined through the following procedure. From a theoretical point of view, if there is no systematic pattern left in the specified model or the residuals are random, the model would be adequate (well specified). Starting with checking whether the estimated residual series is approximately white noise (serially uncorrelated), is a quite common procedure to evaluate the modified mean model. The LB test-statistic which is developed by Ljung and Box (1978) is the first method to test whether autocovariances or autocorrelations of the residual series are equal to zero. This method tests the joint significance of the first *m* residuals autocorrelations under the null hypothesis of no residual autocorrelation at lags 1 to *m* in the residuals from the estimated mean equation.

$$LB(m) = n(n+2)\sum_{k=1}^{m}(n-k)^{-1} r_k^2(\hat{\varepsilon})$$

where $r_k^2(\hat{\varepsilon})$ is the autocorrelation function for the residual series. The LB test has an asymptotic χ^2 (m-p-q) distribution when testing an ARMA (p, q) model.

It is necessary to point out that the lack of evidence concerning autocorrelation (nonexistence linear dependence) in the residuals of the ARIMA model does not mean that the residuals of the specified model follow a pure random process. At the same time, the nonlinear dependencies may exist between the residual series of the model. In this case, the detection procedures of nonlinear dependencies should be applied in the process of evaluation of the estimated model (see Saadi et al. (2006)). One method to check for conditional heteroscedasticity (inconstancy of variance) in the residual series is the Mcleod and Li (1983) test-statistic. This test in fact is calculated in the same way as the LB test, except that it tests for autocorrelation in the squared residuals.

$$McL(m) = n(n+2)\sum_{k=1}^{m}(n-k)^{-1} r_k^2(\hat{\varepsilon}^2)$$

Where $r_k^2(\hat{\varepsilon}^2)$ is the autocorrelation function for the squared residual. When applied to the residuals of ARMA (p, q) model, the McL test has an asymptotic χ^2 (m-p-q) distribution.

The BDS non-parametric test is another method to test for nonlinear patterns in the residual series. This technique which tests the null hypothesis that a given time series data is independently and identically distributed (i.i.d) was designed by Brock, et al. (1987) and developed in Brock et al. (1996).The BDS test has a good power in detection of the linear as well as nonlinear dependencies and the advantage that no distributional assumption needs to be made in using it as a test statistic for i.i.d. random variables. To define the test, the concept of integral correlation is used, which measures the spatial correlation in n-dimensional space among the points (Grassberger and Procaccia, 1983). Let $\{x_t\}$ be a scalar time series generated randomly according to a density function *f*. form m-dimensional vectors, called m-histories, $x_t^m = (x_t, x_{t+1}, \ldots, x_{t+m-1})$. The correlation integral measures the number of ***m*** vectors within a distance of ε of one another. The sample correlation integral at embedding dimension m is defined as:

$$C_{m,T}(\varepsilon) = \frac{2}{(T_m(T-1)} \sum_{t=1}^{T_{m-1}} \sum_{s=t+1}^{T_m} I_\varepsilon(x_t^m, x_s^m)$$

Where the parameter m is the embedding dimension; **T** is the sample size, $T_m = T - m + 1$ is the maximum number of overlapping vectors that we can form with a sample of size T and $I_\varepsilon(x_t^m, x_s^m)$ is an indicator function of the event $\left\| x_t^m - x_s^m \right\| = \max_{t=0,1,\ldots,m-1} \left| x_{t+1} - x_{s+1} \right| \prec \varepsilon$. Further, the correlation integral at embedding dimension *m* is proposed as:

$$C_m(\varepsilon) = \lim_{T \to \infty} C_{m,T}(\varepsilon)$$

Thus, the correlation integral measures the fraction of pairs that lie within the tolerance distance ε for the particular embedding dimension ***m***. Accordingly, the BDS statistic is defined as:

$$BDS_{m,T}(\varepsilon) = \frac{T^{1/2}\left[C_{m,T}(\varepsilon) - C_{1,T}(\varepsilon)^m\right]}{\sigma_{m,T}(\varepsilon)}$$

where ε is an arbitrary chosen proximity parameter, and $\sigma_{m,T}(\varepsilon)$ is the standard deviation of the difference between the two correlation measures

$C_{m,T}(\varepsilon)$ and $C_{1,T}(\varepsilon)^m$. The null hypothesis of independently and identically distributed random variable is $C_{m,T}(\varepsilon) = C_{1,T}(\varepsilon)^m$. For large samples, the BDS statistic has a standard normal limiting distribution under the null of I.I.D. BDS test is a two-tailed test; we should reject the null hypothesis if the BDS test statistic is greater than the critical values (e.g. if α=0.05, the critical value = ±1.96).

It should be noted that the BDS test statistic is sensitive to the choice of the embedding dimension ***m*** and the bound ε. As mentioned by Scheinkman and LeBaron, (1989) if we attribute a value that is too small for ε, then the null hypothesis of a random I.I.D. process will be accepted too often, regardless of whether it is true or false. It is also not safe to choose too large a value for ε. To deal with this problem, Brock, et al. (1991) suggest that ε should equal 0.5, one, 1.5 and two times the standard deviations of the data. For the choice of the relevant embedding dimension ***m***, Hsieh (1989) suggests consideration of a broad range of values from two to ten for this parameter.

In order to identify the type of nonlinearity we apply the well-known procedure to detect autoregressive conditional heteroskedasticity (ARCH) effect in the residuals of the estimated model, the Engle's (1982, 1984) Lagrange multiplier (LM) test. In this method the null hypothesis of no ARCH effect in the residual series (residuals have a constant conditional variance) is tested by regressing the squared residual on a constant and *i* lagged values of the squared residuals:

$$\hat{\varepsilon}_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \hat{\varepsilon}_{t-i}^2$$

It is necessary to point out that in the evaluation of the estimated GARCH model the standardized residuals ($\frac{\hat{\varepsilon}_t}{h^{1/2}}$) are used. The null hypothesis, H_0: $\alpha_0 = \ldots = \alpha_1 = 0$ is tested against the alternative that at least one $\alpha_i \neq 0$. The test statistic is the squared multiple correlation times the number of observation (Obs*R^2), and follows an asymptotically chi-square distributed variable with ***i*** degree of freedom.

Investigating how well the specified model fits the given data is another approach to assess the adequacy of the designed model. $\mathbf{R^2}$ and the average of the residual sum of squares are conventional goodness-of-fit measures in applied econometrics. The weakness of these measures is that the fit necessarily improves as more parameters are included in the model (Enders, 2010). Due to parsimony more appropriate model selection criteria are the information criteria proposed by Akaike (1974) and Schwarz (1978).These criteria compare the in-sample fit, which is measured by the residual variance, against the number of estimated parameters. In the case of ARMA (p, q) model, the value of p and q which minimize AIC (k) are selected as the appropriate order for the ARMA model:

$$AIC(k) = T\ln(SSR) + 2k$$

Where k=p+q+1 denote the total number of parameters in the ARMA model.

In the case of Schwarz criterion (BIC) the larger penalty is considered to additional parameters (because lnT>2 for T>8):

$$BIC(k) = T\ln(SSR) + k\ln(T)$$

Therefore, the SBC will select a more parsimonious model than the AIC criteria. In addition, the SBC has superior large sample properties (see Enders, 2010). On the other hand, Monte Carlo studies have proved that in small samples, the AIC is more effective than the SBC.

After specifying the mean equation and pre-whitening the data (remove any linear dependence) , the GARCH model is applied as a variance equation on the basis of the systematic pattern left in the residuals of the mean equation. The estimation starts from the basic GARCH model and according to various diagnostic or misspecification tests, t or F statistics, AIC and BIC criteria and asymmetric effect test, the adequate model is selected. It would therefore be interesting to compare the empirical performance of each of this model using a consistent dataset. A model of the stock returns volatility should capture all dynamic features of the model of mean and the model of the variance. It is well known that misspecification of the conditional mean or variance may lead to spurious implication to explain behaviour of stock return series. In order to establish adequacy of specified GARCH model the above discussed diagnostic MCL, BDS and ARCH-LM tests are applied to the standardised residuals from the estimated model. In addition, the following AIC and BIC criteria are used to select the best fitted GARCH model. It is worth noting that the AIC and BIC criteria are computed according to the standardized residuals:

$$AIC(k) = -\ln L + 2k$$
$$BIC(k) = -\ln L + k\ln(T)$$
$$L = -\sum_{t=1}^{T}\left[\ln(h_t) + \varepsilon_t^2 / h_t\right]$$

Where h_t is estimated value of the conditional variance, ε_t^2 is fitted value of the squared residuals, and L is maximized value of the log-likelihood function.

After specifying the basic GARCH model, since the risk-returns relationship has a determinant role in asset pricing process, we turn to test the risk-return trade-off hypothesis in Iran stock market using GARCH-M specification. At the same time, in view of the well-documented asymmetric effect we investigate this stylized fact in the volatility dynamic of Iran stock market. To detect asymmetric volatility in the stock return series, Engle and Ng (1993) proposed a set of tests, known as sign and bias tests. These tests should be applied to investigate whether an asymmetric GARCH model is required for modelling the volatility of stock return series. In volatility modelling of the stock return series, the diagnostic Engle-Ng set of tests are used to detect misspecifications related to asymmetric effect on the residuals of a fitted GARCH model for the stock return series. The underlying idea is that, if the volatility process is correctly specified, then the squared standardized residuals should not be predictable on the basis of observed variables. These tests can be individually computed from the following equations:

a) Sign bias t-test: $\hat{\varepsilon}_t^2 = \phi_0 + \phi_1 S_{t-1}^- + e_t$

b) Positive size bias t-test: $\hat{\varepsilon}_t^2 = \phi_0 + \phi_1 S_{t-1}^- \varepsilon_{t-1} + e_t$

c) Negative size bias t-test: $\hat{\varepsilon}_t^2 = \phi_0 + \phi_1 (1 - S_{t-1}^-) \varepsilon_{t-1} + e_t$

d) Joint test for three effects:

$$\hat{\varepsilon}_t^2 = \phi_0 + \phi_1 S_{t-1}^- + \phi_2 S_{t-1}^- \varepsilon_{t-1} + \phi_3 (1 - S_{t-1}^-) \varepsilon_{t-1} + e_t$$

Where ε_t is the error term under the null, S_{t-1}^- is dummy variable that takes the value of one when $\varepsilon_{t-1} < 0$ and zero otherwise. The sign bias test examines the impact of positive and negative innovations on volatility not predicted by GARCH model. The significant ϕ_1 in first equation indicates that positive and negative shocks have different impacts upon future volatility. At the same time, the positive size test examines how well the specified model captures the impact of large and small positive shocks on volatility. On the other hand, the negative size test verifies the efficiency of the fitted GARCH model in the capture of large and small negative innovations. Test statistic under the null hypothesis of no asymmetric effects H_0: $\phi_1 = \phi_2 = \phi_3 = 0$ is LM test which asymptotically follow a χ^2 distribution with 3 degrees of freedom.

Another simple procedure to detect asymmetric effect (leverage effect) in the stock returns volatility process is proposed by Enders (2010). In this method the null hypothesis that there are no leverage effects is tested by estimating the following regression equation:

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1} + \alpha_2 \varepsilon_{t-2} + \ldots$$

The underlying idea in this method is that the squared residuals should be uncorrelated with the level of the error terms when there are no leverage effects. The null hypothesis H_0: $\alpha_1 = \alpha_2 = \ldots = 0$ is tested with ***F***-statistic. If the sample value of ***F*** for the null hypothesis exceeds the critical value from ***F*** table, it can be concluded there are leverage effects (asymmetric effects) in stock returns data generating process.

The family of GARCH models are typically estimated by the method of maximum likelihood (ML). The fundamental issue in the estimation of GARCH models in the log-likelihood function framework is the conditional distribution of the error term ε. The three assumptions commonly employed in empirical applications are: the normal (Gaussian) distribution, the student's *t*-distribution, and the Generalized Error Distribution (GED). According to empirical findings about distribution characteristics (stylized facts) in particular fat tails property, of financial time series, it is very unlikely that stock return series follow the normal distribution especially in emerging stock markets. Therefore, in estimation process we use the other two distributions which take into account the fat tail characterise of stock returns distribution.

For the GARCH (p, q), with the student's *t*-distribution for error term, the likelihood function is specified as:

$$L(\theta)=\frac{T}{2}\left[\ln(v-2)+2\ln\left[\pi^{1/2}\Gamma\left(\frac{V}{2}\right)-\ln\Gamma\left(\frac{V+1}{2}\right)\right]-\frac{1}{2}\sum_{t=1}^{T}\left[\ln(h_t)+(V+1)\ln\left(1+\frac{\varepsilon_t^2}{h_t(V-2)}\right)\right]\right]$$

Where **Γ (.)** is the gamma function and V is the degree of freedom (V>2) which controls the tail behaviour. Under a conditional t-distribution, the additional parameter 1/v is estimated. The log likelihood function for the conditional t-distribution converges to the log likelihood function of the conditional normal GARCH model as $1/V \rightarrow 0$ (or $V \rightarrow \infty$).

However, with the GED (Generalized Error Distribution) assumption for a GARCH (1, 1) model, the likelihood function is expressed as:

$$L(\theta)=-\frac{1}{2}\ln\left[\frac{\Gamma(1/r)^3}{\Gamma(3/r)(r/2)^2}\right]-\frac{1}{2}\ln(h_t)-\left[\frac{\Gamma(3/r)\varepsilon_t^2}{h_t\Gamma(1/r)}\right]^{r/2}$$

Where the tail parameter (**r**) assumed is greater than zero (r>0). The GED is a normal distribution if **r**=2, and fat-tailed if **r**<2.

5.4. Distribution characteristics of the Iran stock returns

Modelling the stock prices or stock returns behaviour is a fundamental issue in the applied financial economics studies. In this sense, identifying the underlying data generating process is a vital task in investigation of the behaviour of stock prices in stock markets. The model-building process should take into account the special properties (the salient features) of financial data or statistical illusions of stock returns to achieve reasonable analysis. In other words, analysis of the distribution of characteristics of stock prices or stock returns is crucial in investigating the behaviour of stock prices, correct model specification, estimation and forecasting.

In order to analyse the distributional characteristics of stock return series in Iran stock market and understand information about a probability distribution function of stock returns, measures of location (mean), dispersion (variance, and standard deviation), asymmetry(skewness) and concentration in tails (kurtosis) are calculated. The parameters, mean and variance signify the standardised first and second moments of a distribution, while the skewness as the standardised third moment measures the asymmetry of a distribution and the kurtosis as the central fourth moment determines the degree of peakedness and tail fatness of a distribution. The skewness statistic is zero for any symmetric distribution such as normal distribution. At the same time, the kurtosis statistic is 3 for the normal distribution. The skewness and kurtosis statistics together are applied with Jarque-Bera (JB) statistics to detect whether a data set is normally distributed or not. This test investigates whether the series is normally distributed by measuring the difference between the skewness and kurtosis of the series with those from the normal distribution. Furthermore, the z-statistic is used to assess the null hypothesis that the expected stock return is zero:

$$z = \frac{\bar{r}}{s/\sqrt{n}}$$

Where $\bar{r}$ is the stock returns mean, s is standard deviation and n is the number of observations.

In order to identify the empirical behaviour of stock returns distribution in Iran stock market, we use the daily closing price of the Iran stock market index, from January 2, 1999 to December 30, 2009, with a total of 2632 observations. The data is obtained from Iran Stock market website. Market prices index are transformed to daily returns **r= Ln** (P_t / P_{t-1})*100 where P_t and P_{t-1} are stock prices index prices at date *t* and *t* - 1 respectively.

Table 5.1 provides the descriptive statistics (the unconditional distribution statistics) for Iran stock returns. The wide gap between the maximum (5.2581%) and minimum (-5.4530%) returns gives support to the high variability of price variation in the Iran stock market. A visual analysis of the market volatility can be seen in Figure 5.1. The mean of stock return series is constant, while the variance keeps changing over time. The large changes (of either sign) in stock returns tend to be followed by large changes, and small movements (of either sign) being followed by small movements. This is a property of stock returns distribution known as volatility clustering or volatility pooling (a type of heteroscedasticity) that Iran stock return series seems to exhibit. The implication of volatility clustering is that volatility shocks today will influence the expectation of volatility some periods in the future. In financial economics literature this is known as volatility persistence. In these circumstances, the current level of volatility tends to be positively correlated with its level during the immediately preceding periods. It is necessary to point out that the volatility clustering depends on the frequency of the data. In this sense, it is usually revealed in daily and intraday data.

Positive skewness means that the Iran stock returns distribution is skewed to the right of its mean and has a long right tail. This implies that in Iran stock market large positive returns tend to occur more often than large negative ones. In other words, large positive movements in stock prices are not usually matched by equally large negative movements. Accordingly, the distribution of Iran stock return series is non- symmetric. In other words, the stock returns distribution is asymmetric to the right with few extreme and positive values. At the same time, the kurtosis or degree of excess, in the Iran stock returns series is bigger than the normal value of 3. As a result, the distribution of Iran stock returns is peaked_ leptokurtic. In the case of the kurtosis measure, it can be noted that the unconditional distribution of Iran stock return series is "fat-tailed" (relatively high probability for extreme value).

In view of the skewness and the kurtosis statistics of Iran stock returns distribution it can be concluded that the distribution of stock returns departs from normal distribution. Furthermore, according to the calculated Jarque-Bera statistics and corresponding p-value in table 1, the stock return series is not well approximated by the normal distribution. The theoretical graph and ***QQ***-plot shown in Fig 5.1 and Fig 5.2 also confirm that the daily Iran stock returns are not normally distributed. Generally speaking, in line with the findings of other empirical studies in emerging stock markets, Iran stock return time series are characterized by some "stylized facts" such as fat tails, high peakness (excess kurtosis), skewness and volatility clustering. In addition, according to z-statistic it can be noted that the expected return in Iran stock market is zero.

Table5.1. Descriptive statistics for Iran stock returns

Mean (%)	0.0756
Median (%)	0.0592
Minimum (%)	−5.4330
Maximum (%)	5.2581
Standard Deviation (%)	0.5169
Skewness (s)	0.5595
Kurtosis (κ)	25.9423
Jarque-Bera Statistic	57838.40
P-value	(0.00000)
Z	0.0028
Observations	2631

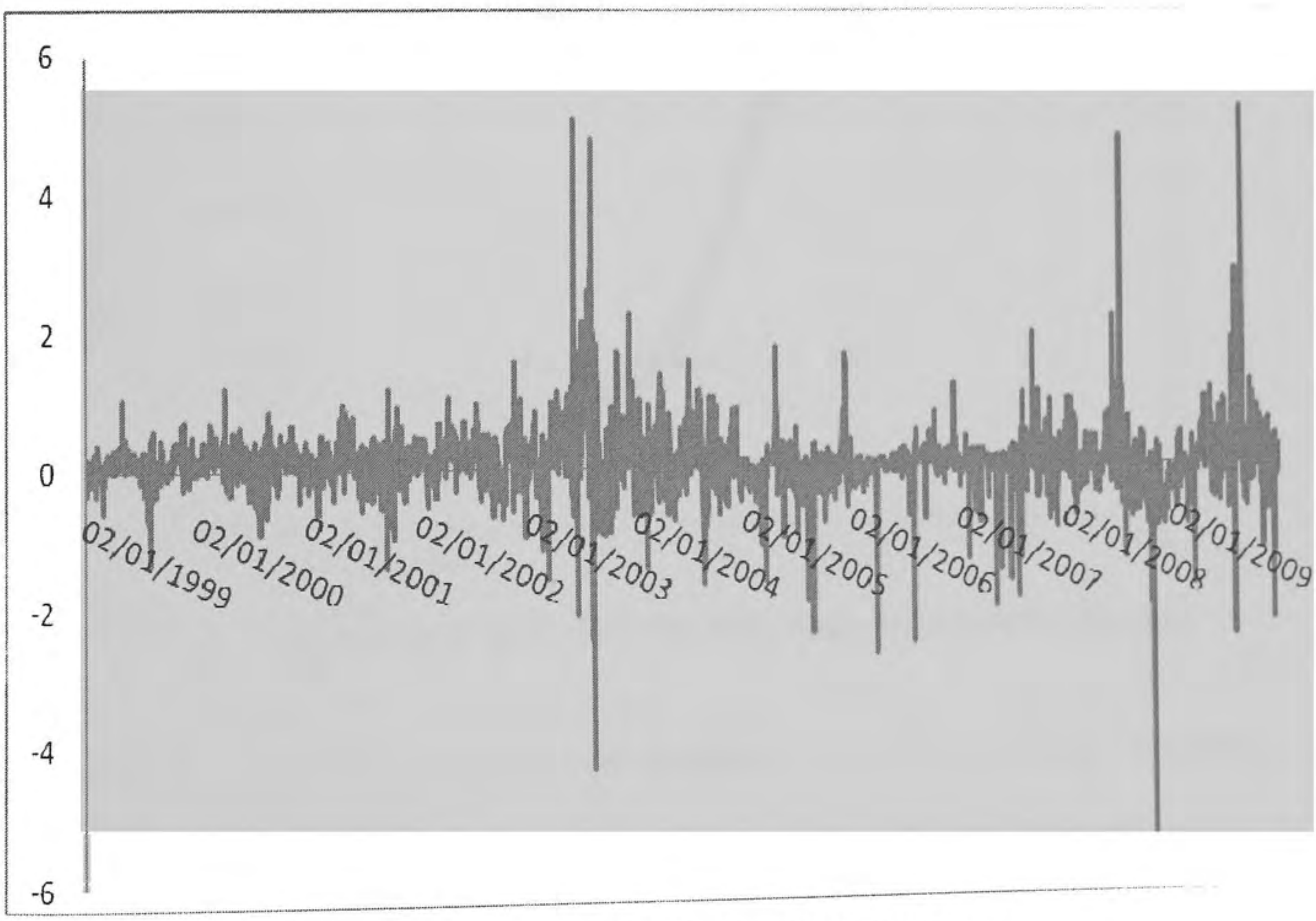


Fig5.1.The time plot of daily Iran stock returns

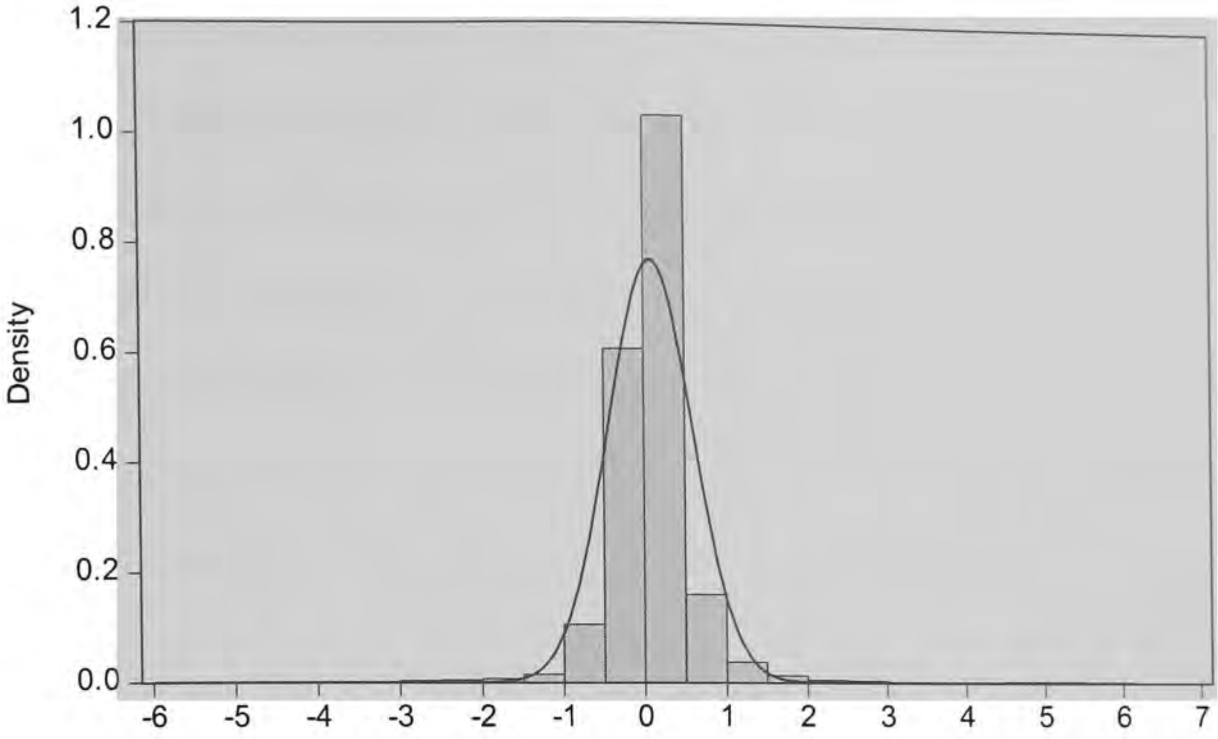


Fig5.2.The theoretical distribution plot of the Iran stock returns

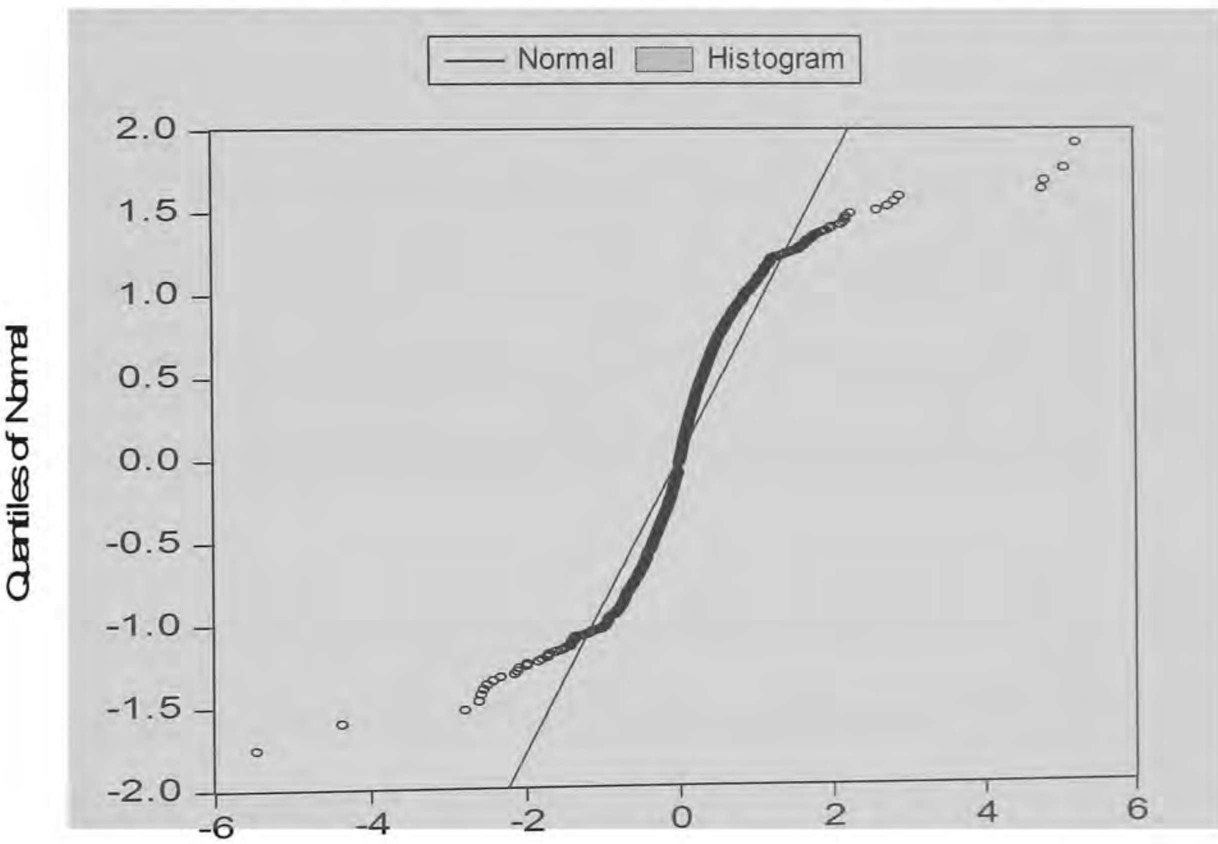


Fig5.3.The Q-Q plot for the daily Iran stock returns

Table5.2 shows the sample autocorrelation of daily returns, squared returns and absolute returns for Iran stock market. The hypothesis of no serial correlation is rejected at the 1% level of significance, implying high level of autocorrelation. The high level of autocorrelation in stock return series can be caused by the imposition of daily price limits on stock prices in

Iran stock market. At the same time, the squared and absolute returns are positively autocorrelated indicating dependencies in the second moments of the stock return series (the daily stock returns are not serially independent). This property represents existence of the volatility clustering (time dependency in volatility) in Iran stock return series. From figure 4.4 it can be seen that the autocorrelation function of squared returns decreases as the lag order increases, indicating the systematic autocorrelation pattern of variance. At the same time, the figures 4.5 and 4.6 display positive autocorrelation of absolute returns with bigger degree than squared returns. The high dependence in series of absolute returns highlights that the Iran stock returns process is not made up of independent and identically distributed random variables. Also, the decay rates of the sample autocorrelations of squared and absolute returns appear much slower suggesting possible long memory behaviour. This is an indication of persistence in shocks on stock prices or volatility in Iran stock market.

Generally speaking, it can be highlighted that Iran stock return series does not appear to be a sequence of i.i.d random variable. In this sense, Iran stock returns distribution function departs from normal distribution. Furthermore, the same as other stock market the "stylized facts" appears in Iran stock returns data generating process. To achieve reliable analysis and design of the behavioural model for stock prices or stock returns in Iran stock market, the special distribution characteristics should be considered in dynamic modelling of Iran stock return series.

Table5.2. Sample autocorrelation of daily returns, squared returns and absolute returns for Iran stock market

	R_t		R^2		|R|	
Lag	AC	Q-Stat	AC	Q-Stat	AC	Q-Stat
1	0.360	341.13	0.200	105.02	0.395	411.24
2	0.284	554.30	0.127	147.44	0.281	619.49
3	0.155	617.47	0.167	220.90	0.244	776.95
4	0.160	684.96	0.058	229.83	0.167	850.58
5	0.139	735.72	0.059	239.13	0.158	916.06
6	0.126	777.60	0.041	243.49	0.147	973.23
7	0.127	819.86	0.053	250.85	0.154	1036.2
8	0.185	910.64	0.036	254.25	0.152	1097.5
9	0.204	1020.3	0.060	263.84	0.176	1179.5
10	0.209	1135.7	0.060	273.47	0.200	1285.8
11	0.148	1193.2	0.099	299.52	0.223	1417.5
12	0.144	1248.3	0.077	315.15	0.211	1534.7
13	0.107	1278.7	0.064	326.03	0.194	1634.5
14	0.115	1314.0	0.089	347.05	0.212	1753.6
15	0.118	1350.7	0.058	355.96	0.188	1847.4
16	0.100	1377.0	0.091	378.12	0.182	1935.5
17	0.145	1432.9	0.111	410.50	0.188	2029.2
18	0.130	1477.6	0.057	418.98	0.153	2091.6
19	0.099	1503.4	0.057	427.45	0.135	2139.7
20	0.069	1515.9	0.054	435.13	0.130	2184.6
21	0.069	1528.6	0.056	443.40	0.144	2239.4
22	0.071	1541.9	0.067	455.29	0.159	2306.5
23	0.065	1553.2	0.041	459.79	0.167	2380.5
24	0.068	1565.5	0.030	462.20	0.137	2430.1
25	0.087	1585.5	0.035	465.45	0.155	2494.2
26	0.092	1608.1	0.046	471.19	0.164	2565.5
27	0.071	1621.5	0.045	476.55	0.142	2618.9
28	0.080	1638.7	0.043	481.61	0.148	2676.9
29	0.078	1654.8	0.060	491.20	0.134	2725.0
30	0.041	1659.4	0.023	492.60	0.112	2758.6
31	0.007	1659.5	0.030	494.96	0.108	2789.8
32	0.015	1660.1	0.035	498.27	0.130	2835.1
33	-0.001	1660.1	0.040	502.50	0.134	2883.2
34	0.040	1664.3	0.033	505.40	0.123	2923.2
35	0.048	1670.4	0.023	506.76	0.122	2963.4
36	0.062	1680.8	0.026	508.60	0.102	2991.1

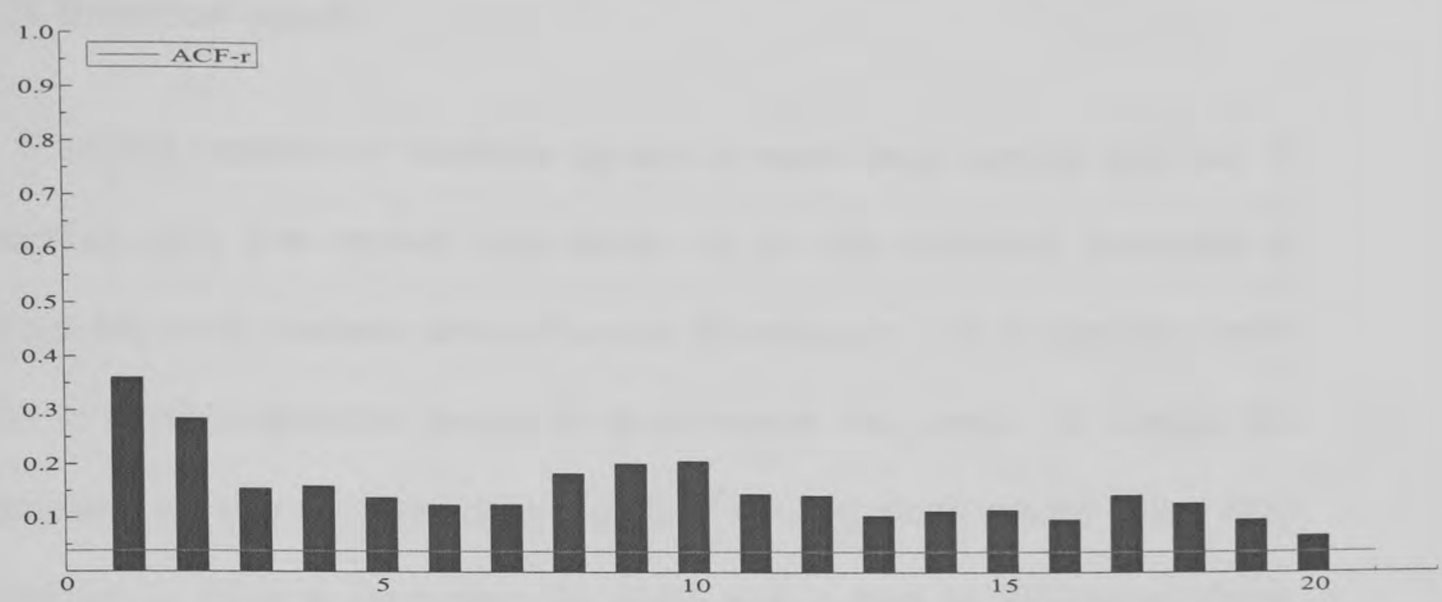


Fig5.4. Autocorrelation function of stock return series

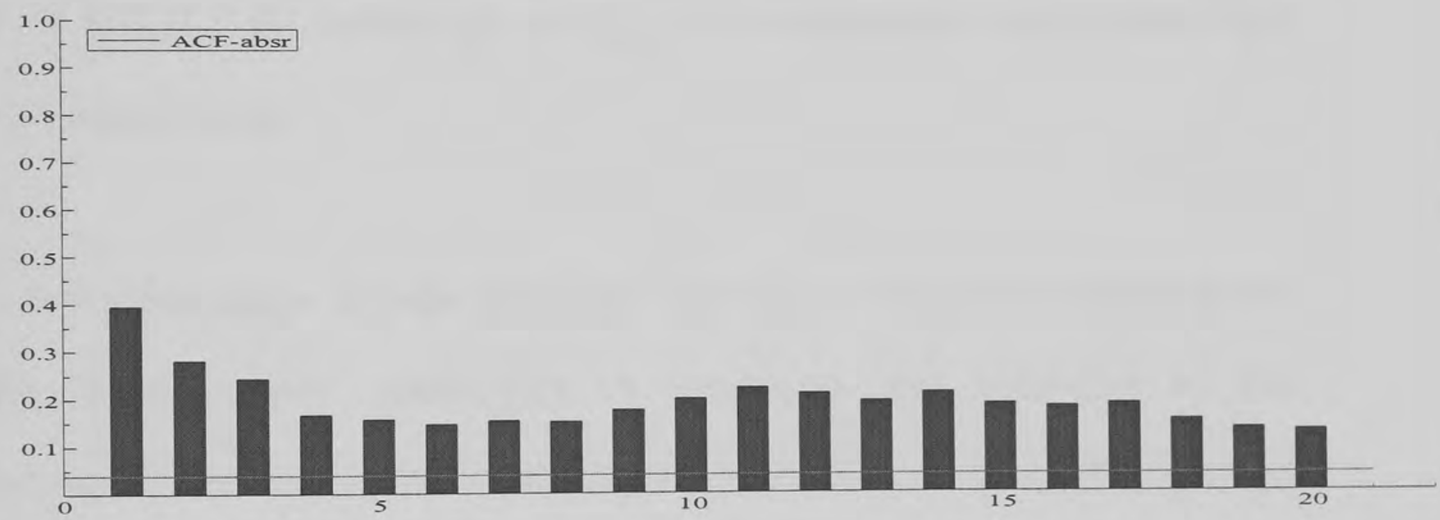


Fig5.5. Autocorrelation function of absolute stock returns

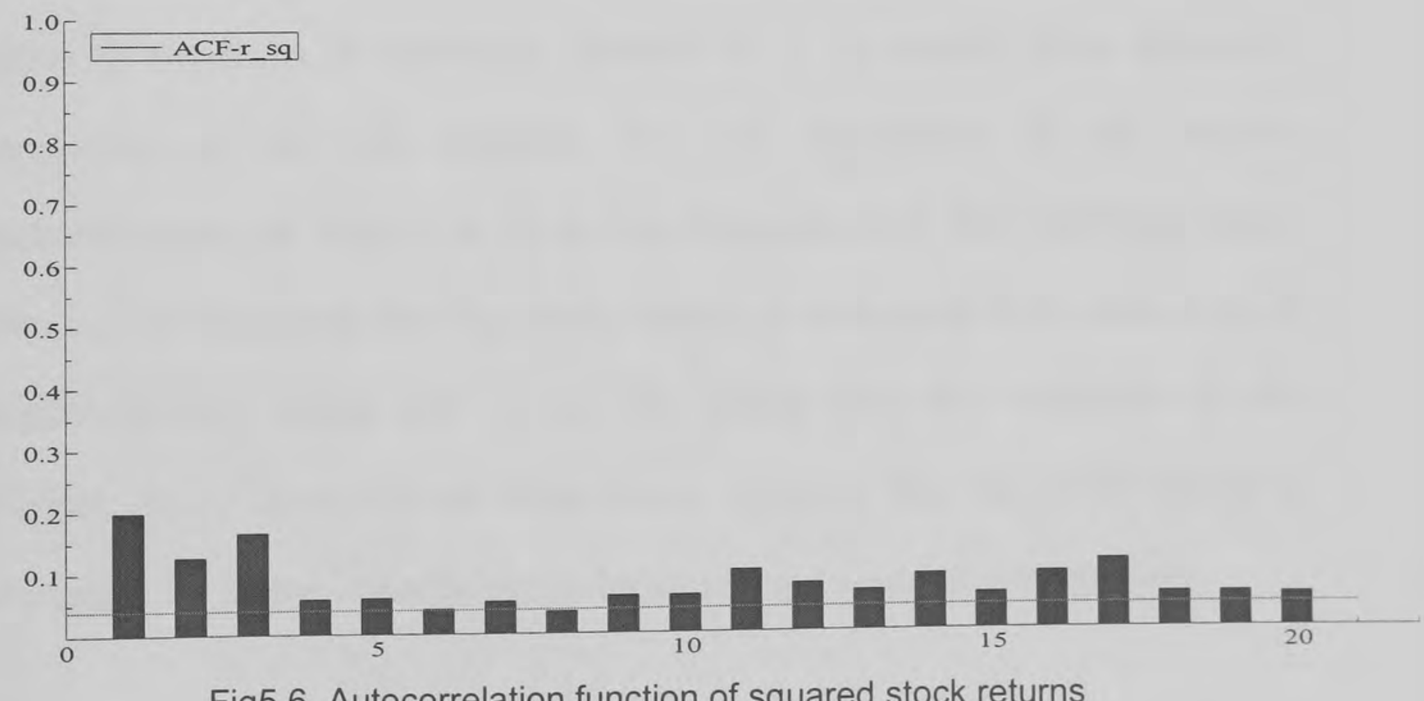


Fig5.6. Autocorrelation function of squared stock returns

5.5. Empirical results

Empirical research in nonlinear dynamics needs large sample data set. In addition, long time interval data series can be non-stationary, especially in emerging stock markets where financial liberalization and deregulation have led to multiple structural breaks in stock market data series. To handle this problem, we use the daily closing price of the Iran stock market index, from January 2, 1999 to December 30, 2009, with a total of 2632observations. Market prices index is transformed to daily returns $r = \ln(p_t / p_{t-1})$ where p_t and p_{t-1} are stock prices index at date t and $t - 1$ respectively.

At the first stage, in order to model the mean of Iran stock returns series the autoregressive specification is employed and according to the autocorrelation and partial correlation of the residual and diagnostic test(LB), the ARIMA (9, 1, 8) model is adopted for mean modelling of Iran stock return series. Table 7 represents the serial correlation test for the residuals and the squared residuals of estimated ARIMA (9, 1, 8) model. More precisely, according to the LB statistics the null hypothesis of no residual autocorrelation at lags 1 to 36 in the residuals from the estimated mean equation is accepted. On the whole, based on outcomes from table 4.3 (LB statistics) and figure 4.7, it can be noted that the residuals of the ARIMA (9, 1, 8) model are white noise, implying that the mean model is adequate for all the linearity dependence in the Iran stock return series.

As discussed earlier, if the residuals have a non-constant conditional variance the GARCH model is appropriate to model of the conditional variance of the stock return series. The McL, BDS and ARCH-LM tests are employed to identify hidden systematic pattern (high moment dependencies) or time-varying variance (heteroscedasticity) in the residual series of the mean equation.

Table5.3. Test for serial correlation of the residuals of ARIMA (9, 1, 8) model

LB(5)	LB(10)	LB(15)	LB(20)	LB(25)	LB(30)	LB(36)
-	5.56	11.67	25.13	26.90	32.47	41.86
McL(5)	**McL(10)**	**McL(15)**	**McL(20)**	**McL(25)**	**McL(30)**	**McL(36)**
-	325.52*	350.37*	376.34*	382.59*	384.95*	396.62*

Note: * denotes significance at the 1% level, *MQ* (*k*) is the modified *Q*-statistic at; *ML* (*k*) is the McLeod-Li test.

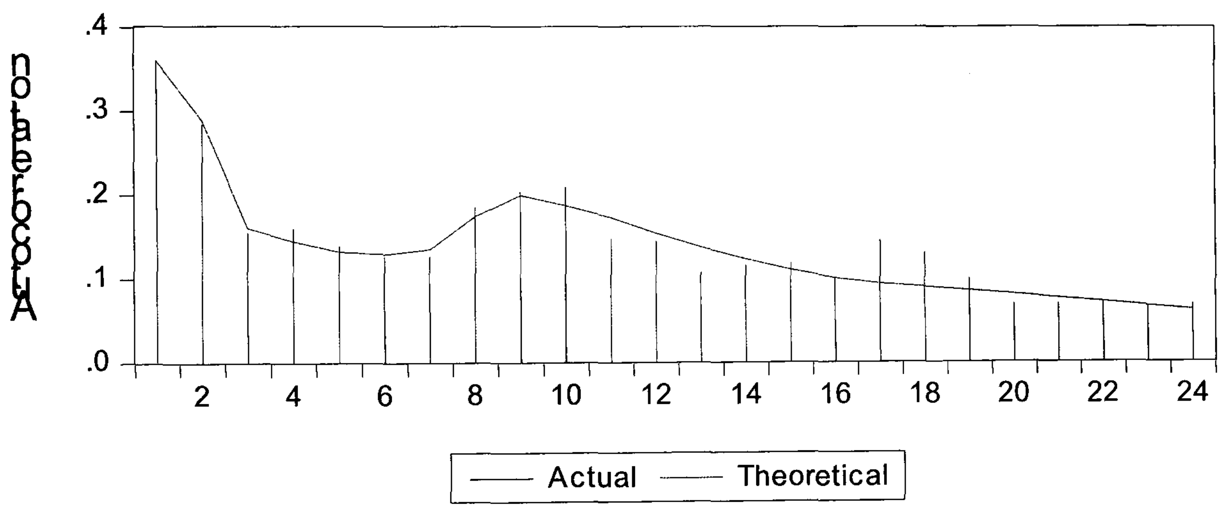
As can be seen from table 5.3, the significant values of McL test statistics imply that the squared residuals of ARIMA model display significant autocorrelation, indicating evidence of nonlinear dependencies in the Iran stock returns series. Despite the fact that residual series of the ARIMA model are uncorrelated (according to LB test statistics) the autocorrelation of the squared residuals indicates the dependency of the residuals series. This dependency implies the existence of ARCH effect (heteroscedasticity) in the residual series of the mean equation. At the same time, to verify the presence of nonlinear dependence, we employ the BDS test to the residuals of the whitened residuals series. The BDS test statistics displayed in table 5.4 strongly reject the I.I.D assumption, which addresses an obvious indication of the existence of nonlinear dependencies in stock returns series.

In other words, the BDS test for linearly filtered stock returns clearly indicates a non-linear component in Iran stock series.

Table5.4. The *BDS* test statistic for the residuals of pre-whitening ARIMA model

m	*ε/σ*		*ε /σ*		*ε/ σ*		*ε/ σ*	
2	0.5	23.8030	1	20.9495	1.5	19.9949	2	17.4831
3	0.5	29.1741	1	22.9067	1.5	21.3397	2	19.1900
4	0.5	34.8051	1	24.3329	1.5	21.4987	2	19.2989
5	0.5	42.0064	1	25.4999	1.5	21.5550	2	19.0266
6	0.5	51.3633	1	26.9768	1.5	21.7823	2	18.8026
7	0.5	63.7197	1	28.7280	1.5	21.9243	2	18.4533
8	0.5	80.3183	1	30.5012	1.5	22.0124	2	18.1165

Note: *m* is embedding dimension, *ε* is the bound, all statistics are significant at the 1% level. The critical values for *BDS* test are 1.96 for 5% and 2.58 for 1%.



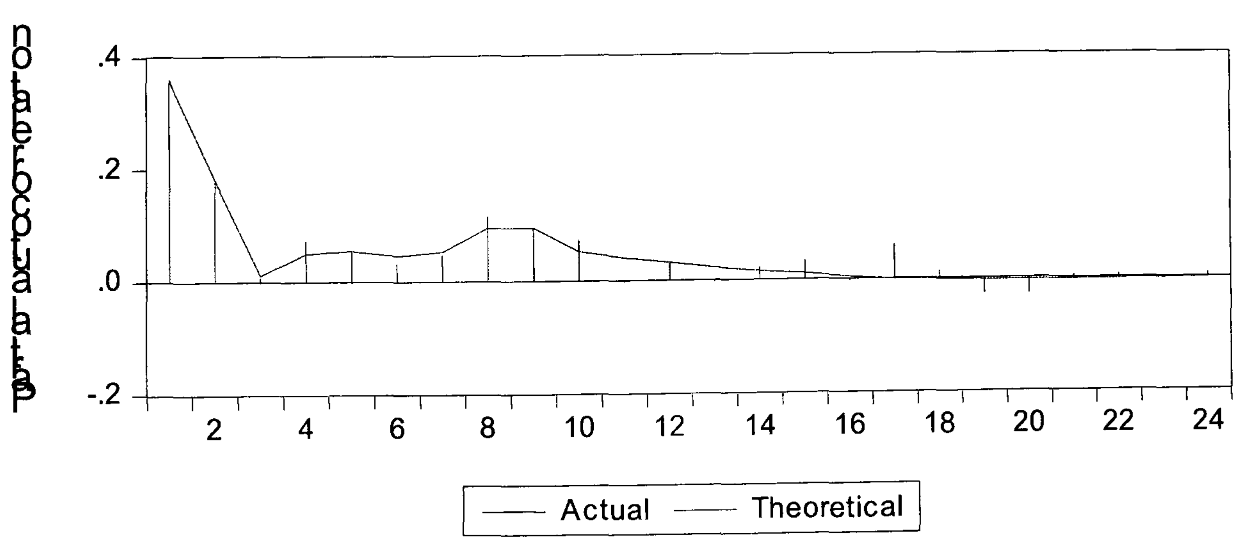


Fig5.7ACF and PCF plot for the residuals of fited ARIMA model

Since the squared residuals measure the second moments of the series, significant autocorrelations of the squared residuals are evidence of time varying conditional heteroskedasticity in the daily stock returns as well as in the residuals of the ARIMA model. In order to test of the existence ARCH effect in the residuals of ARIMA model we carry out the ARCH-LM test. According to the results in table 5.5, the existence of ARCH effect is strongly confirmed. Overall, after the identification of non-stationarity and removal of linearity as causes of the rejection of the I.I.D assumption, we have documented the inherent nonlinearity in the Iran stock returns data generating process.

Table5.5. ARCH-LM test for the residuals of ARIMA (9, 1, 8) model

ARCH (1)	*ARCH (2)*	*ARCH (3)*	*ARCH(4)*	*ARCH (5)*
112.67*	167.75*	206.55*	210.07.52*	209.97*

Note: * denotes significance at the 1% level, χ^2 -test.

In spite of the existence of inherent nonlinearity in stock returns series based on the results from the BDS test, it is not clear whether nonlinearity appears through the mean or the variance of the returns series. In order to uncover the source of nonlinear behaviour, we apply the GARCH-M model which allows the appearance of nonlinear behaviour in the mean and the variance of time series. To consider the special characteristics of stock returns distribution particularly fatter tails (given the evidence from Table 5.1), the student's t-distribution was employed for the GARCH estimates (assuming that the conditional distribution of the error term is student's t).

We have examined several GARCH models and according to the results of diagnostic tests (residual test) on mean and variance equations as well as BIC criteria we conclude that the ARMA (9, 1,8)-GARCH (1, 1) -M model is most likely to succeed in describing the Iran stock return generating process. As it can be seen from table 5.6, the AR (1) and AR (9) coefficients (lagged returns) are highly significant across GARCH models. The MA error may capture the effect of non-synchronous trading [stock prices are often recorded at regular intervals (e.g. daily closing price) but not all stock trade at the same time] and is highly significant.

The coefficients of the conditional variance equation, α and β, are statistically significant at 1 percent, the conventional level of significance implying a strong support for the ARCH and GARCH effects in stock returns data generating process. In other words, the estimation results reject the hypothesis of time-invariant conditional volatility Iran stock returns. These findings confirm the first hypothesis of this chapter implying that the conditional variance h_t is found to change over time as a result of volatility clustering effects, indicated by statistically significant α parameters, at the 1percent level .The volatility clustering effect represents the arrival of information in clusters. A unit shock to the model will initially increase the variance by about ½ (0.5232) of the shock. This (shock to volatility) will die (there is reversion to the mean) out over the following days, with a half life of log (0.5)/log (00.5232+0.4410) =17days. This means that shocks to volatility are long-lived and persistence. The variance will eventually converge to its unconditional (long run) value of 0.00000271/ (1-0.5232-0.4410)

=0.0000757. On the other hand, the estimated ARCH coefficients in the conditional variance equation are considerably larger than GARCH coefficients. The implication is that volatility is more sensitive to new information than it is to its lagged values in the market place .In addition; the sum of the parameters estimated by the conditional variance equation is close to one. A sum of α and β close to one is an indication of a covariance stationary (weakly stationary) model with a high degree of persistence; and long memory in the conditional variance. $\alpha + \beta = 0.96$ is also an estimation of the rate at which the response function decays on daily basis. Since the rate is high, the response function to shocks is likely to die slowly. On the whole, the findings show the presence of significant autoregressive conditional heteroscdasticity in the underlying data generating process of Iran stock return series.

5.5.1. Risk returns trade - off in the Iran stock market

As has been noted, the GARCH_M model by establishing connection between the conditional volatility and the mean of stock returns provides a convenient measure of risk premium. From empirical results in table 4.6 the risk premium parameter δ as a measure of the risk-return trade-off is positive and statistically significant (at %1). This finding is consistent with the second hypothesis (H_2) and shows the existence of risk premium in the Iran stock market. This means that in Iran stock market the investors are compensated for assuming higher levels of risk. In other words, in this market higher risk specified by the conditional variance will lead to higher stock returns. The result of positive risk premium parameter δ confirms a positive relation between risk and return, which is consistent with the basic assumption of the risk-aversion theory, and indicates that on average investors and portfolio holders are compensated with higher stock returns for bearing risk.

A possible explanation for the existence of risk premium is the presence of the supposed risk (e.g. political risk, ambiguousness of economic policy, unstable macroeconomic environments and uncertainty about future) of investing in emerging stock market. It is necessary to point out that the low liquidity as a common feature of emerging stock market plays a significant role in explaining the existence of risk premium in these markets. In this view, investors in general prefer to have their assets in a form that takes less time and money to realize. Generally speaking, it can be noted that the existence of risk premium particularly in emerging stock market implies the importance of other risk measures apart from the variance (conditional standard deviation) of asset returns to investors.

As a final step, we examine whether our specification of the model in fact fits the data well. According to the Ljung-Box (LB) statistics on the standardized residuals and the McL test statistics on the standardized squared residuals of ARMA (9, 8) – GARCH (1, 1) _M model in table 4. 7, it can be seen that there is no evidence of serial correlations and nonlinear dependencies in the Iran stock returns series.

Table5.6.The estimation results of ARIMA (9, 1, 8) and ARMA (9, 1, 8)-GARCH (1, 1) _M models

Coefficient	ARIMA (9, 1, 8)		ARIMA (9, 1,8)-GARCH		ARIMA (9, 1,8)-GARCH-M	
		P-value		P-value		P-value
μ	0.0008	0.0153	0.0007	0.0000	0.0008	0.0000
ϕ_1	0.8423	0.0000	0.7375	0.0000	0.6910	0.0000
ϕ_9	0.0528	0.0074	0.0429	0.0000	0.0486	0.0000
MA (1)	-0.5813	0.0000	-0.2864	0.0000	-0.2093	0.0000
MA (3)	-0.1131	0.0000	-0.0555	0.0000	-0.0442	0.0080
MA (8)	-0.6890	0.0000	0.0210	0.0314	0.0267	0.0037
ω			2.30E-06	0.0000	1.71E-06	0.0000
α			0.4863	0.0000	0.5232	0.0000
β			0.4909	0.0000	0.4410	0.0000
δ					12.0317	0.0000
$\alpha+\beta$			0.98		0.96	
Log likelihood	10353.65		11357.99		11365.61	
AIC	-7.8929		-8.6559		-8.6610	
BIC	-7.8795		-8.6335		-8.6364	
JB	97440.33	0.0000	46104.19	0.0000	47292.97	0.0000

Note: ϕ, α, β, δ are the AR, ARCH, GARCH and risk premium parameters respectively. JB is the Jarque–Bera test for normality of the standardized residuals series.

Furthermore, in table 5.8 from the findings of ARCH-LM test it can be concluded that there is no evidence of conditional heteroscedasticity in the data. This implies that the fitted volatility model is adequate and it has accounted for all the volatility clustering in the stock return series. The *JB* test in table 5.6 rejects the null hypothesis that the standardized residuals are normally distributed. To get more comprehensive conclusion about the normality assumption, we look at the *QQ*-plot given in Figure 4.8. Deviation in both tails from the normal *QQ*-line is significant, thus the normality for the residuals of the fitted volatility model may not be suitable. It can be highlighted that the non- normal distribution of the standardized residuals is not really a problem because if the equations for the mean and variance are correctly specified, the parameter estimates will still be consistent. Of course the non- normal distribution of the standardized residuals may be due to outliers that cannot be explained by the GARCH model. It is well known fact that the moment statistics such as kurtosis and skewness are sensitive to outliers.

Table5.7. Test for serial correlation of the residuals of ARIMA (9, 1, 8) - GARCH (1, 1)-M model

LB(5)	LB(10)	LB(15)	LB(20)	LB(25)	LB(30)	LB(36)
5.80	16.81	34.56	49.01	56.37	63.52	72.00
McL(5)	**McL(10)**	**McL(15)**	**McL(20)**	**McL(25)**	**McL(30)**	**McL(36)**
6.23	9.84	13.59	19.11	25.11	28.98	44.02

Note: MQ (k) is the modified Q-statistic at; ML (k) is the McLeod-Li test.

Table5.8. ARCH LM test for the residuals of ARIMA (9, 1, 8)-GARCH (1, 1) _M model

ARCH (1)	*ARCH (2)*	*ARCH (3)*	*ARCH (4)*	*ARCH (5)*
0.3467	1.2727	5.0060	5.6420	6.1807

Note: χ^2 -test.

To assess whether the ARIMA (9, 1, 8) – GARCH (1, 1) _M model has succeeded in capturing all the nonlinear structure in the stock return series we employ the BDS test to its standardized residuals. As mentioned above, based on represented statistics in table 5.8, the autocorrelation coefficient for both the standardized residuals and squared standardized residuals show that the fitted model captures all the linear as well nonlinear dependencies in the Iran stock return series. Table 5.9 demonstrates the BDS statistics on the standardized residuals from the ARMA (9, 1, 8)–GARCH (1, 1)_M model. In line with the findings from table 5.8, the BDS test except ***ε/σ = 0.5*** fails to reject the null hypothesis that the standardized residuals are I.I.D random variables at 5% and 1% degree of significance. This confirms that the ARMA (9, 1, 8)–GARCH(1, 1)_M process captures all the nonlinearity in the series, and therefore it can be noted that the conditional heteroscedasticity is the cause of the nonlinearity structure revealed in the stock returns series. In other words, based on the outcomes from BDS test on the standardized residuals of fitted model, it can be noted that the conditional heteroskedasticity is responsible for all the nonlinearity in Iran stock return series.

Table5.9.The *BDS* test statistic for the standardized residuals of ARMA (9, 1, 8) - GARCH (1, 1) _M model

m	*ε/σ*		*ε /σ*		*ε/ σ*		*ε/ σ*	
2	0.5	3.2804	1	0.5999	1.5	-0.7730	2	-0.6011
3	0.5	3.3287	1	0.1609	1.5	-1.4794	2	-1.2937
4	0.5	4.0408	1	0.6641	1.5	-1.2505	2	-1.3043
5	0.5	4.5294	1	0.5960	1.5	-1.3332	2	-1.3293
6	0.5	5.5304	1	1.0741	1.5	-1.0389	2	-1.1939
7	0.5	5.9958	1	1.4816	1.5	-0.8914	2	-1.2640
8	0.5	6.4481	1	1.6309	1.5	-0.8658	2	-1.3676

Note: *m* is embedding dimension, *ε* is the bound, and the critical values for *BDS* test are 1.96 for 5% and 2.58 for 1%.

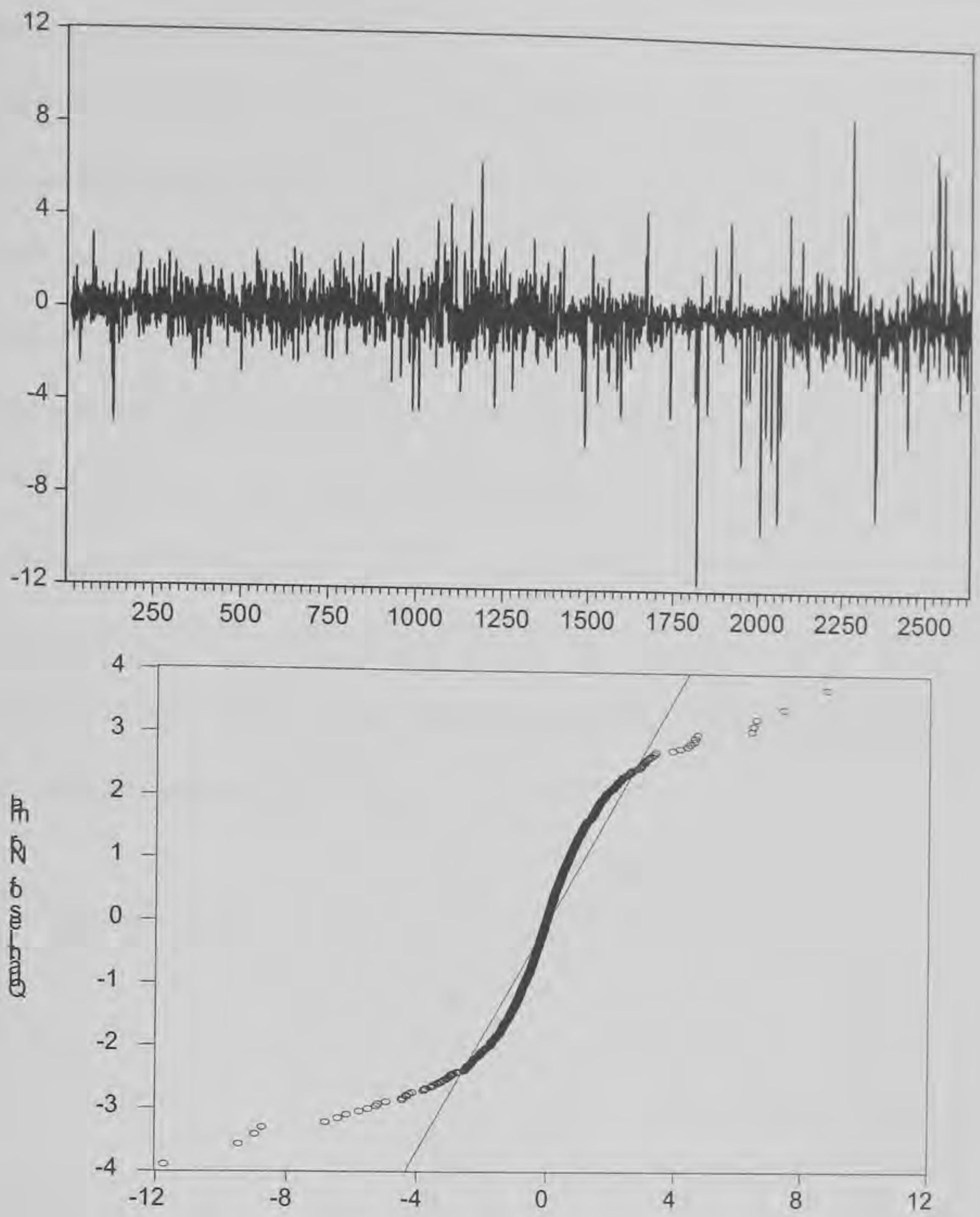


Fig 5.8. ARIMA-GARCH(1,1)-M standarized residuals

Finally, Figure 5.9 represents the conditional volatility obtained from the fitted model. It is apparent from the graph that the conditional standard deviation varies over time. This is inconsistent with the common assumptions of constant variance or standard deviation and Gaussian returns underlying the theory and practice of option pricing, portfolio optimization and value-at-risk (*VaR*) calculations. In this sense, it can be noted that based on the stock returns data generating process, the assumptions of constant variance is invalid for Iran stock market as an emerging markets. As it is evident from figure 9, the volatility of Iran stock market has developed since December 4, 2004 with the start of the political challenges concerning Iranian nuclear programme (political risk). It is worth noting that the increase in the volatility of Iran stock returns can be due to other reasons such as economic privatization programme (initial public offerings (IPO) process through stock market), improvement in process of information disclosure system, changes in microstructure of market, geographic development of market (establishment of regional stock exchanges), introducing new tradable financial instruments and change of the "daily price change limit" range. It seems that after 2008 the volatility of Iran stock market influenced by the world financial crises has increased.

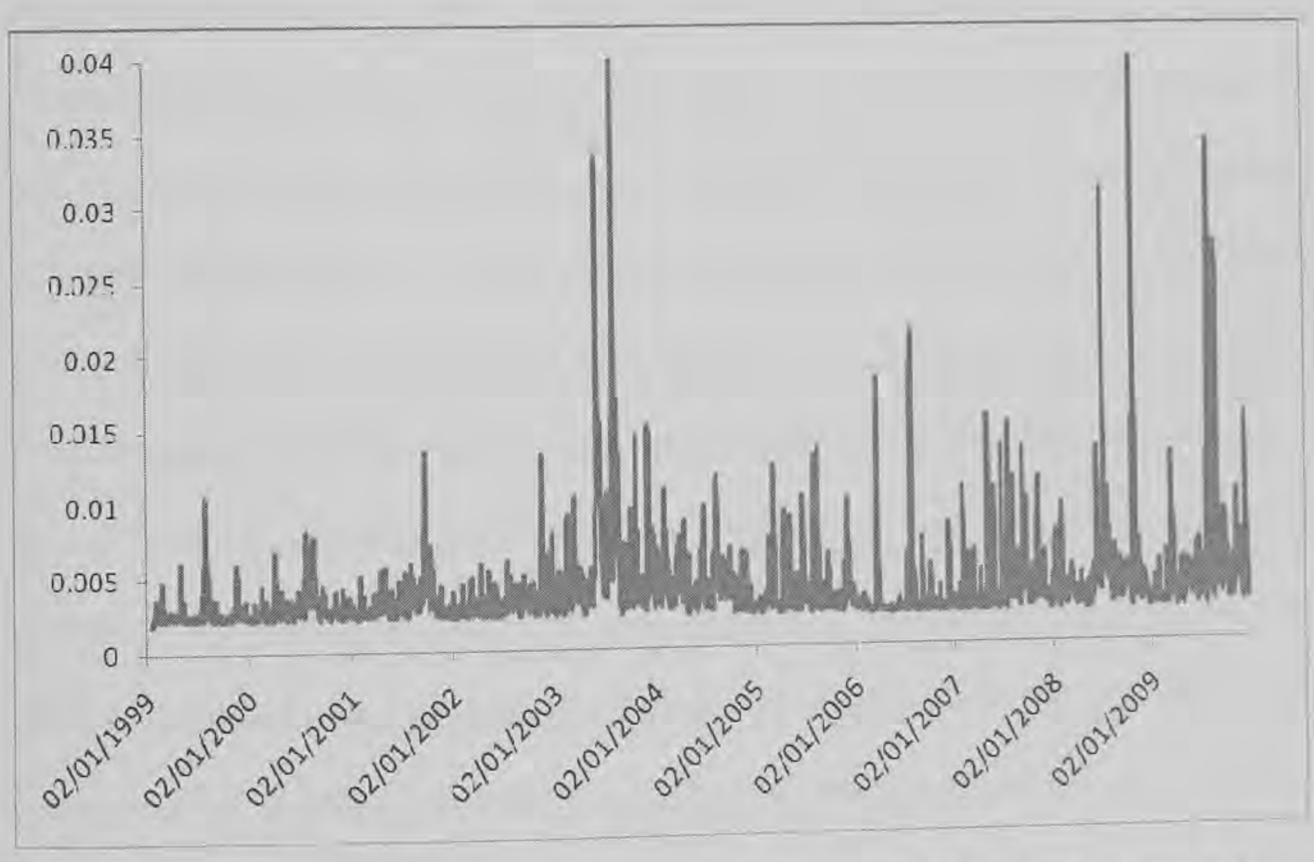


Fig5.9. Time varying volatility (conditional standard deviation) of Iran stock returns series

5.5.2. Asymmetry effect in Iran stock returns

As mentioned earlier, the estimated ARMA (9, 1, 8) – GARCH (1, 1) and ARMA (9, 1, 8)–GARCH (1, 1)-M models cannot detect asymmetric volatility in the dynamic of stock returns. In this section we examine the existence of asymmetric effect in stock returns volatility to investigate different effects of positive or negative shocks on the structure of stock market volatility. To this end, we apply the Engle and Ng (1993) and Enders (2010) nonlinear misspecification tests on the standardised residuals of ARMA (9, 1, 8) – GARCH (1, 1) model to assess capability of fitted GARCH model in capturing possible asymmetric effect in volatility dynamic of Iran stock market. As shown in table 5.10, probability associated with test statistic is greater than 0.05, the conventional level of significance, we can conclude the sign bias coefficient is insignificant implying the ability of estimated GARCH model in predicting the impact of positive and negative innovations on stock market volatility. Furthermore, in view of the prob-value (0.8850) the result from negative size bias test signifies that there is no negative sign bias in Iran stock market. In other words, the fitted GARCH model well captures the impact of large and small innovations. However, there is positive size bias in the residuals of estimated GARCH model but it is statistically insignificant. At the same time, the estimated coefficient for positive size bias is 0.1665, the prob-value is 0.2453; we can reject the null hypothesis that the positive shocks have different effect on future volatility. At the same time, the sample LM statistic for the null hypothesis is 2.1991 with three degree of freedom, the prob-value is 0.5450, and we can conclude that there is no asymmetric effect in Iran stock return behaviour. On the whole, the joint test on the standardised residuals from the ARMA (9, 1, 8) – GARCH (1, 1) model cannot reject the null of symmetry for Iran stock market. To put it another way, the volatility of Iran stock market is symmetric and there is no asymmetric effect in the stock return response to new information. However, Engle and Ng (1993) argued that the joint test is more powerful than the individual tests. Therefore, the symmetric GARCH model would be adequate to model the dynamic volatility of Iran stock market. In the same way, Zivot (2009) argued that the negative value of sample correlation between r_t^2 and r_{t-1} provides some evidence for potential asymmetric effect. As shown in table 5.10, the correlation between r_t^2 and r_{t-1} is positive indicating strong evidence for the lack of asymmetric effect in the dynamic of Iran stock return series.

Table5.10. Test for Asymmetry

Corr (r_t^2, r_{t-1})	**Sign bias test**	**Negative size bias test**	**Positive size bias test**	**Joint test F-test, $\chi^2_{(3)}$**
0.1747	-0.0840 (0.6805)	0.1467 (0.2917)	-0.0279 (0.8638)	1.3335 (0.7212)

Notes: p-values are shown in ( )

In order to investigate leverage effects (asymmetric effects) in the Iran stock return series, we use also the Enders (2010) procedure. Table 5.11 displays the results from regressing the squared standardised residuals on the lagged levels of error terms from fitted GARCH model. According to reported results in table 5.11, the sample F-statistic for the null hypothesis is 0.2420 and less than the critical value obtained from an F table, we can conclude that there is not asymmetric effect in the volatility dynamic of Iran stock market. In other words, in Iran stock return data generating process the squared standardized residuals are not predictable on the basis of observed variables.

Table5.11. Test for leverage effect

intercept	ε_{t-1}	ε_{t-2}	F-statistics
1.1686 (0.0000)	0.0583 (0.5377)	0.0307 (0.7456)	0.2420 (0.7850)

Notes: p-values are shown in brackets

In spite of the results from the Engle and Ng (1993) and Enders (2010) asymmetric tests indicating lack of asymmetric effect in data generating process of Iran stock returns, we apply three asymmetric GARCH models (TGARCH(1,1),EGARCH(1,1),PARCH(1,1)). Table 5.12 displays the results of the application of these nonlinear GARCH models to the Iran stock return series.

Table5.12.The estimation results of asymmetric GARCH models

Coefficient	ARIMA (9 1, 8)-TGARCH(1,1)		ARIMA (9, 1, 8)-EGARCH(1,1)		ARIMA (9, 1, 8)-PARCH(1,1)	
		P_value		P_value		P_value
μ	0.0007	0.0000	0.0006	0.0000	0.0007	0.0000
ϕ_1	0.7348	0.0000	0.6807	0.0000	0.7401	0.0000
ϕ_9	0.0431	0.0000	0.0462	0.0000	0.0413	0.0000
MA (1)	-0.2839	0.0000	-0.1836	0.0000	-0.2941	0.0000
MA (3)	-0.0543	0.0026	-0.0361	0.0275	-0.0554	0.0020
MA (8)	0.0214	0.0258	0.0308	0.0018	0.0210	0.0304
ω	2.38E-06	0.0000	-2.4996	0.0000	0.0001	0.3382
α	0.5307	0.0000	0.5721	0.0000	0.4068	0.0000
β	0.4811	0.0000	0.8130	0.0000	0.5739	0.0000
γ	-0.0719	0.4929	0.0237	0.4460	-0.0247	0.6834

Note: ϕ, α, β, γ are the AR, ARCH, GARCH and asymmetry parameters respectively.

According to the reported results in table 5.12, since the probabilities are greater than the conventional 5% level of significance, the asymmetry term (γ) in three models is statistically insignificant. In other words, there is no significant asymmetric effect in Iran stock market. As such, it can be noted that these empirical findings are in contrast with the third hypothesis of this chapter and there is no asymmetric volatility in the Iran stock return series. In view of this finding, it can be highlighted that in Iran stock market investors do not overreact (underreact) to bad news and underreact (overreact) to good news. Therefore, we conclude that the response to the stock returns shocks is not asymmetrical in the Iran stock market and the variance equation of GARCH (1,1)-M model is well specified. In other words, the conditional variance is a symmetric function of past innovations. Hence it is clear that the symmetric GARCH models can be applied for modelling the stock return series of the Iran stock market. In this sense, it can be noted that there is no nonlinear behaviour in dynamic of conditional volatility in Iran stock market.

An important implication of these findings is that the good news and bad news have the same effects on stock prices in the Iran stock market. In this sense, stock prices reflect symmetrically new information. It can be noted that in the Iran stock market correlation between changes in stock prices (unexpected returns) and changes in stock returns volatility is not negative. Under these circumstances, there is a tendency for stock returns volatility to increase when stock returns rise and to decline when stock returns fall. It can be noted that in this market bad news (negative shocks) increase volatility the same extent as good news (positive shocks). In view of the more popular reason (leverage effect) for the presence of asymmetric effect, the potential explanation derives from “inflation advantage”. In inflationary conditions (specifically in developing countries) the long term debts are considered an advantage for the firms. Under this circumstance, increasing debt to assets ratio (leverage) does not lead to higher stock volatility (risk) in stock market. In other words, in an inflationary economy an increase in the leverage ratio is not considered a risk criterion for firms. Additionally, the “price limit[1]” which is introduced especially in emerging markets to control market volatility can be another reason for the lack of asymmetric effect. It seems that in this circumstance the reaction amplitude of stock prices to new information is reduced.

This finding is in contrast to results from other studies for emerging or developed stock markets. For instance, Liu et al. (2009) for Chains, Nowbutsing and Naregadu (2009) for Mauritius, Hung (2009) for Taiwan, Charles (2010) for France, Germany, US and Japan, Cheng et al. (2010) for Bahrain, Kuwait, Oman, Saudi Arabia, Egypt, Jordan and Turkey, Krishnan and Mukherjee (2010) for India , Sabiruzzaman et al. (2010) for Hong Kong and Tan and Islam Khan (2010) for Malaysia stock markets find the existence of leverage effects in volatility modelling. On the other hand, this finding is not unique to our study as many other studies have reached similar conclusions (Rousan and Al-khouri (2005) for Amman, Brooks (2007) for Chilli, Saudi Arabia and Bahrain, Mun et al (2008) for Malaysia, Bahadur

1 . Nowadays in Iran stock market the daily price fluctuation (price limit) is fixed to a maximum of 4% either way from the last closing. Restriction on Rights is 8%.

(2008) for Nepal, Alagidede and Panagiotidis (2009) for Tunisia and Zimbabwe, Jayasuriya et al. (2009) for Brazil, Chile, Indonesia, Pakistan and Taiwan, Saeidi and Koohsarian (2010) for Iran, Cheng et al (2010) for Morocco, Charles (2010) for the UK stock markets). On the whole, it can be noted that the asymmetric volatility (negative relationship between stock returns movements and future volatility) may not be applicable to emerging stock markets. In other words, positive and negative shocks (good and bad news) of the same magnitude have the same impact and effect on the future volatility level. Since the asymmetric volatility is one of the effective factors in portfolio selection, asset pricing, option pricing and hedging strategies, this finding has important implications for investment process in specifically the Iranian stock market as an emerging market.

5.6. Concluding remarks

In this chapter we have examined empirically stock return dynamics and the implication of conditional volatility models in daily index returns for Iran stock market. With regards to the importance of identifying the underlying data generating process in analysing the behaviour of stock prices in stock market, firstly the special distribution properties of Iran stock return series have been investigated. Empirical analysis has indicated that Iran stock returns distribution function departs from normal distribution. Furthermore, like other stock market the stylized facts (fat-tailed, asymmetric and volatility clustering) appear in Iran stock returns data generating process. In this regard, it can be noted that Iran stock return series are not independent and identically distributed (i.i.d.). The existence of volatility clustering has important implications for portfolio risk measurement, option pricing and hedging. In this circumstance, due to a big shock to stock market, volatility changes and the probability of another big shock is significantly increased. To put it another way, the implication of volatility clustering is that today's volatility shocks will affect the expectation of stock market volatility in the future. Volatility clustering implies that there will be periods of high volatility, periods of low volatility and periods of normal levels of volatility in the stock market. Volatility clustering as a characteristic of stock returns which mirrors the leptokurtosis (fat tails) in the returns' distribution may be induced by the autocorrelation in information arrivals (Goodhart et al., 1993, Bollerslev and Domowitz, 1993). In this regard, Engle (2003) argues that since news is typically clustered in time, volatility clustering is simply clustering of information arrivals.

Ngugi et.al (2005) argued that the appearance of volatility clustering in distribution characterises of stock returns in emerging and developed stock markets can be as a result of various factors such as trade volumes, nominal interest rate, dividend yield, money supply and other external shocks including oil price rises and political events. It is generally believed that emerging stock markets tend to be more volatile than the highly-liquid developed markets. The macroeconomic volatility (e.g. inflation, money and industrial production growth), policy uncertainties and structural and institutional factors namely speculative investors (noisy traders), trading mechanism, inexperienced regulators, inside trading and manipulation, limited investment products and instruments contribute to high volatility of emerging stock market (see Ng and Wu, 2005; Miao and Peng, 2007). In the same way, Shiller (1990, 2000) argues that part of stock volatility is created by investors' psychological and judgment biases such as overconfidence, overvaluation, undervaluation, mimetic behaviour, and irrational behaviour. It seems that these factors are more likely to appear in emerging stock market due to the existence of uninformed and unqualified investors.

In view of the role of the information arrival in causing volatility clustering in the behaviour of stock returns, it seems that this stylized fact of distribution characteristics of returns may not be a sign of inefficiency of the market in weak form. Schwaiger (1995); Millionis, and Moschos (2000) and Alagidede and Panagiotidis (2009) argue that time varying volatility in stock returns can be seen as a result of rational and hence efficient equilibrium pricing and suggest that presence of volatility clustering does not indicate market inefficiency in weak form. In the related argument, Aggarwal et al. (1999) ; Panagiotidis (2005) and Filis (2006) suggest that the presence of the volatility clustering result in inefficient stock market in semi-strong form. On the whole, based on theoretical and empirical literature, we shall argue here that the presence of volatility clustering is not inconsistent with the weak form efficiency of Iran stock market.

In order to analyse the behaviour of stock return series in Iran stock market, the two moments- the mean and the variance- of stock return series have been simultaneously examined. After pre-whitening (removal of linear dependencies) the data fitting ARIMA (9, 1, 8) model, according to diagnostic tests (McL and BDS) high moment dependencies or time-varying variance (heteroscedasticity) in the residual series of the mean equation have been observed. Accordingly, the univariate autoregreressive conditional heteroskedasticity models have applied to model the conditional variance of the Iran stock return series. Based on diagnostic tests and model selection criteria (AIC and BIC) we have concluded that the ARIMA-GARCH (1, 1)-M model well specifies the dynamic volatility of Iran stock market. Empirical findings have shown the presence of significant autoregressive conditional heteroscdasticity in the underlying data generating process of Iran stock return series. In this sense, high degree of persistence and long memory in the conditional variance has been another property of Iran stock return volatility. In other words, the volatility of Iran stock market is persistent (nevertheless stationary conditions are satisfied because the sum of ARCH and GARCH coefficient is smaller than one), hence shocks to volatility continue for a long period. In this sense, the fitted GARCH model is integrated in variance and is analogous to a unit root in conditional mean (see Poshakwale and Murinde, 2001). In this condition, the future discount rate may be adjusted and as a consequence the asset pricing mechanism can be affected (see Choudhry, 1996). Furthermore, the long term volatility of Iran stock market has important implications in for the process of option pricing.

Another interesting finding is the magnitude of ARCH parameter (α) in the estimated ARIMA-GARCH (1, 1)-M model. In this sense, the estimated ARCH coefficient is 0.52 whereas the coefficient of GARCH is 0.44. Since ARCH parameter measures the reaction of the conditional volatility to market shocks and GARCH parameter determines the persistence in conditional volatility, the magnitude of ARCH coefficient implies the significant role of news effect in dynamic of Iran stock market volatility. In fact, the volatility of Iran stock market is very sensitive to market event. On the other hand, based on yield GARCH coefficient it can be noted that market volatility takes short time to die out following a big shock in the market. In other words, the influence of past volatility on the current stock market volatility is slight. These findings have the determinant implications in portfolio management and policymaking process in Iran stock market.

The empirical results also support the existence of the risk-return trade-off (risk premium) parameter in the volatility dynamics of Iran stock market. This means that conditional volatility is priced in Iran stock market. As a consequence, in Iran stock market investors are compensated with higher returns for bearing higher levels of risk. The implication of the existence positive risk premium is investors with long horizon will gain excess returns. Since investment in stock market with long horizon is accompanied with higher risk (in particular political risk) due to instability in economic and political conditions, investors especially in emerging stock market are less interested in long run investment. Political risk is also known as geopolitical risk which appears more as the time horizon of an investment gets longer and affects investment returns. In this sense, the presence of risk premium parameter encourages participants in stock market to undertake investment with long horizon and as a result the volatility of stock market decreases. From the economic development prospective, the long horizon investment enhances the role of stock market in mobilizing of savings and providing of equity capital to the corporate sector. As a result, the capacity of stock market in allocating financial resources and its contribution to economic growth increases.

On the other hand, our examination has led to another interesting result. In contrast with numerous empirical studies (i.e. Liu et al. 2009, Nowbutsing and Naregadu 2009, Charles 2010, Cheng et al. 2010, Krishnan and Mukherjee 2010, Sabiruzzaman et al. 2010 and Islam Khan 2010) the asymmetric effect (negative relationship between stock returns movements and future volatility) in Iran stock has not been proven. In this sense, positive and negative shocks (good and bad news) of the same magnitude have the same impact and effect on the future volatility level. Since the asymmetric volatility is one of the effective factors in portfolio selection, asset pricing, option pricing and hedging strategies, this finding has important implications for investment process in Iran stock market. In short, the symmetric GARCH models have been found to be adequate to model of volatility dynamic of Iran stock return series.

Generally speaking, the empirical results of this study provide clear evidence of time varying volatility in the Iran stock market as an emerging stock market. It should be emphasized that differences in stages of market development (emerging or developed stock markets) do not influence characterises of stock return volatility (see Ngugi et.al. 2005). From a policymaking point of view, since sock returns volatility implies high cost of capital and is a determinant factor in investment process, the Iran stock market reforms should be designed and implemented with the objective of reducing market volatility. In the same way, volatility of stock market through increasing risk premium (of interest to risk-averse investors) leads to a rise in the cost of financial resources and reduction in the level of investment. In this sense, reforms of the institutional framework (in particular improving the mechanism of information disclosure and introducing new financial instruments) would be effective in the reduction of Iran stock market volatility.

Chapter 6

The effects of oil price shocks on the behaviour of stock prices in Iran stock market

6.1. Introduction

In line with the fifth main objectives of the thesis, this chapter examines empirically the relationship between the behaviour of stock prices and international oil prices in Iranian economy in order to provide better explanation of the dynamic of stock prices movements. Identifying the factors that drive the equity returns of companies and/or portfolios is of utmost relevance and importance to investors and policy makers. In financial economics literature, stock market is known as a barometer of economic conditions of a given country. In this sense, the behaviour of stock prices is formed on the basis of economic performance and political environment. Since Iran is one of the biggest producers and exporters of crude oil in the world, as noted in the chapter two, oil exports largely determine foreign earnings and government's revenues and expenditures. As a result Iran stock market is affected by the changes in the world oil prices. In view of the dominant role of oil revenue in economic activity of Iranian economy the investigation of the effects of oil price fluctuations on the behaviour of stock prices has important implications for the process of investment in stock market. To be precise, the implications of identifying the effects of oil price shocks on the stock prices movements can be helpful in portfolio construction and risk management in Iranian stock market for both domestic and international investors. Generally speaking, investigating the impacts of oil price shocks on Iran stock market would be useful in decision- making process for investors (specifically hedging strategy) and in regulating or monitoring effectively stock market for policymakers.

In Iranian economy as an oil exporting country the mechanism of oil shock effects may be significantly different from oil importing countries. Indeed, oil revenues affect the main economic variables in Iranian economy: earnings, government budget revenues, expenditures and aggregate demand. Therefore, oil price fluctuations affect corporate performance, output and earnings, and thus stock returns in this country. In particular, higher oil prices provide additional income and wealth to oil producer countries. If this surplus income is transmitted back to the economy, then higher oil prices would be expected to lead to higher levels of economic activity. In this sense, effects of the changes in oil price are transmitted to economic activity through the macroeconomic factors. Rising (falling) oil prices lead to increase (decrease) in the level of aggregate demand through rising (decreasing) national income or per capita income. From macroeconomic point of view, changes in the level of aggregate demand as a sign of economic improvement will alter expectations of economic trends and consequently stock prices will be affected. In the case of the listed companies in stock market influences will be different depending on the dependency rate of a given company to oil or oil products. For instance, the effects of oil price shocks on companies which use oil as input will be significantly bigger than other companies.

In view of the dominant role of oil revenues in the Iranian economy, the current chapter attempts to investigate the effects of the fluctuations of international oil prices on the behaviour of the Iran stock returns. The rest of this chapter is organized as follows. Section 2 reviews the existing literature and empirical studies on the relationship between stock prices movements and oil price. Section 3 presents the methodological approach used in the analysis i.e. the symmetric and asymmetric multivariate GARCH model. The data and preliminary analysis are presented in section 4. Section 5 discusses the empirical results and main findings. The chapter ends up with concluding remarks in section 6.

6.2. Literature review

Research into indentifying influencing factors on stock prices movements or stock returns has been one the main subjects in theoretical and empirical financial economics literature. In this context, in addition to company- specific factors (financial conditions of company), the economic activity and political environment at macroeconomic level also are significant in determining the price of a given company's share and predicting the future of company's performance. One of the main lines of enquiry has been investigation of the impacts of oil price shocks on stock prices movements, given the undeniable role of energy in the world economy.

It is important to point out that from the perspective of investment decision making, understanding the mechanism of volatility transmission and time-varying covariance between stock and oil market plays a crucial role in asset pricing, risk management or diversification, portfolio allocation, option trading and hedging strategy. Shock effects and volatility spillover through changes in common information may simultaneously alter expectations across markets. In this sense, identifying direct and indirect effects of movements in stock and oil prices on each other and detecting the influences of the returns and volatility of both markets would be useful in investment decision making and designing policy tools.

Oil price fluctuations may affect stock returns through various transmission channels. In this respect, relationship between oil price changes and stock prices movements (stock returns) can be explained using an equity pricing model. According to this model, the price (value) of equity (share) at any point of time equals present value of discounted sum of expected future cash-flows (see Huang et al., 1996). Accordingly, the oil shocks can affect the value of given share through affecting expected cash flows and/or discount rates. By influencing macroeconomic variables (e.g., inflation, interest rates, economic growth, and investor and consumer confidence) oil price shocks affect the discount rates and as a consequence the price of given equity changes owing to adjustments in cash flows of company (see Huang et al., 1996; IMF, 2000; Jones et al., 2004; Park and Ratti, 2008; Nandha and Faff, 2008). For instance, since an increase in oil prices has often been considered as an indicator of inflationary pressures, central banks within the framework of monetary policy have decided to raise interest rates.

In these circumstances, the increased interest rate reduces the value of stock.

From macroeconomic point of view, the transmission mechanisms of oil price changes to stock returns can be explained through influence of oil prices fluctuations on real economic activity in view of both supply and demand channels. The supply side effects of oil price shocks are due to the fact that crude oil is a basic input in the production function, and for instance an increase in oil price, through rising production costs, reduces the output of firm, (see Nandha and Faff, 2008; Kilian, 2009). In this case, oil price shocks can affect corporate cash flow through production costs. In the same way, oil price changes through influencing the demand for output of a company at industry and national levels, affect the expected revenues of company and then the expected cash flows. It is important to emphasize that the overall impact of changes in oil prices on stock prices depends on whether a company is a consumer or producer of oil and oil related products. Oil prices changes by affecting both consumption and investment decisions lead to the demand side effect. Consumption is adversely affected because increase in oil prices fluctuations affects consumption by influencing national income (as a consequence disposable income) and the domestic price of tradable goods and services. Investment is affected by changes in inputs costs and in general the cost of production. It is worthwhile pointing out that the supply side and demand side effect on oil producer or exporter can vary with the degree of dependence of national economy on oil revenues.

In the case of oil producing and exporting countries, change in oil prices may affect the economy through two channels. In the first stage, positive income and wealth effects can be consequences of an increase in oil prices (see Bjørnland, 2009). In this case, higher oil prices lead to an immediate transfer of wealth from oil importers to oil exporters. These effects would be different in the medium term and long term. This differential effect depends on how the additional income by the oil producer countries (in particular governments) is used. If this surplus income is used to purchase goods and services in their own country, higher oil prices through increasing the level of aggregate demand lead to a higher level of activity in the domestic economy. In general, owing to an increase in oil prices national wealth and aggregate demand rise. At the same time, huge investment and business opportunities in the national economy are created due to development in potential capacities of profitable investments in oil or oil-related sectors with increased demand for others inputs (e.g. labour and capital). It should be noted that the high level of aggregate demand may put upward pressures on price level and lead to inflation and depreciation of the domestic currency (crowding out effect). Because of this, the competitive advantage of the country suffers in export markets.

Secondly, an increase in oil prices may result in a negative international trade effect. In this case, the demand of oil importing countries for non-oil exports (goods and services) of oil exporting countries will fall due to oil induced recession (because of increasing oil prices). It is clear that this effect and the extent of it depend on the volume of non-oil exports and type of exported goods and services. It is necessary to point out that in most cases the oil producing or exporting countries are importers of manufactured goods or engineering and technical services. In these circumstances, the effects of oil fluctuations come back to oil exporting countries through increased the prices of imported goods and services. This transmission process may lead to inflationary pressure and increase the level of prices and as a consequence cash flows of firms are affected in view of the changes in interest rates and investment opportunities. On the whole, the final effect of increasing oil revenue on real economic activity in oil producing countries depends on the role of foreign trade sector in the national economy and dependence rate of economy on foreign economic activity (degree of openness of economy). According to transmission channels discussed above, it can be noted that the relationship between oil price shocks and stock market returns in oil producing or exporting countries is ambiguous and the total impact of oil price fluctuations on the behaviour of stock returns depends on which of the positive and negative effects offset the other (see Arouri et al., 2009 and Arouri et al., 2010b).

The linkages between oil prices and economic activity have been studied by numerous researches. The significant effects of oil price fluctuations on economic activity have been investigated for several developed and developing countries by the majority of these studies (Hamilton, 1983, 1996, 2003, 2010; Burbidge and Harrison, 1984; Bohi (1989); Mork (1989), Mork et al. (1994), Lee et al. (1995); Gisser and Goodwin (1986), Bjørnland (2000), IMF ,2000; Balke et al., 2002; Cunado and Gracia, 2003; Bjørnland 1998, 2000; Davis and Haltiwanger (2001); Hamilton and Herrera (2004); Jones et al. 2004; Jiménez-Rodríguez and Sánchez, 2005; Balaz and Londarev, 2006; Gronwald, 2008; Cologni and Manera,2008; Baumeister and Peersman ,2008; Kilian ,2008; Jin, 2008; Lardic and Mignon, 2008; Kim, 2009, Kilian,2009; Engemann et al., 2010; Herrera et al., 2010; Elder and Serletis, 2010; Ravazzolo and Rothman, 2010; Ramey and Vine, 2010; Carlton, 2010).

In contrast, there have been relatively few analyses in investigation of the dynamic relationship between oil price fluctuations and the behaviour of stock markets. In view of the key role of oil in world economy, a growing interest in examining the behaviour of stock prices in terms of oil price fluctuations has been established in financial economic studies. On this subject, the pioneering study was conducted by Al-Mudhaf and Goodwin (1993). In a firm- specific study they analyse the behaviour of the returns from 29 oil companies listed on the New York Stock Exchange. Employing the arbitrage pricing theory they find a positive impact of oil price shocks on ex post returns for firms with significant assets in domestic oil production. In the same way, using the standard cash-flow dividend valuation model Jones and Kaul (1996) provide support for the proposition that aggregate stock market returns in the USA, Canada, Japan and the UK are negatively sensitive to impact of oil price shocks on the economies of these countries. While in the case of the S&P500 market index, using an unrestricted vector autoregressive (VAR) model, Huang et al. (1996) find no evidence of oil shock's impact on stock returns. On the other hand, Sadorsky (1999) applying unrestricted VAR model with GARCH effects to American monthly data shows a significant relationship between oil price changes and US aggregate stock returns. In the case of oil and gas companies, Sadorsky (2001), applying a multifactor market model documents the positive sensitiveness of these companies to oil price increases. In the same year, Papapetrou (2001) employing impulse response functions emphasises the oil price role as an important factor in explaining the stock price movements in Greece stock market.

Hammoudeh and Aleisa (2004) find remarkable results in the case of the oil sensitivity of the stock markets in some oil exporting countries namely Bahrain, Kuwait and Oman except Saudi Arabia. Based on their study the stock returns of these oil exporter countries except for Saudi Arabia have no causal relationships with oil price changes. In the same way, using a generalised VAR approach and utilizing variance decomposition and impulse response analysis Maghyereh (2004) finds out that oil price shocks have no impact on stock market returns in 22 emerging markets. By contrast, employing the vector error–correction (VEC) model Hammoudeh and Li (2005) find that the oil price growth leads the stock returns of the oil-exporting countries (Mexico and Norway) and the US oil-sensitive industries.

The impact of oil price shocks on the returns of the oil and gas in the UK stock market is investigated by El-Sharif et al. (2005). Using the multifactor model they demonstrate that oil price has a significant positive impact on oil and gas returns, however, the evidence for the oil price sensitivity of non-oil and gas sectors is weak. Basher and Sadorsky (2006) investigate the behaviour of 21 emerging stock markets regarding oil price variations. Based on an international multi-factor Arbitrage Pricing Theory (APT) model they conclude that oil price risk has a strong impact on stock market returns.

In an industry focused study, Nandha and Faff (2008) investigate the short-term link between oil prices and thirty-five Data Stream global industries and show that the increase in oil prices has a negative impact on all industries, except for oil and gas. Kilian and Park (2008) use the structural VAR model and find that the response of aggregate US real stock returns may differ greatly depending on whether the increase in the price of crude oil is driven by demand or supply shocks in the crude oil market. Cong et al. (2008) investigate the interactive relationships between oil price shocks and Chinese stock market. Using multivariate vector auto-regression, they conclude that oil price shocks do not have statistically significant impact on the real stock returns of most Chinese stock market indices, except for manufacturing index and some oil companies. Employing vector error-correction model Apergis and Miller (2009) examine whether structural oil-market shocks affect stock returns in eight developed countries, and show no significant responses of international stock market returns to oil price shocks. In a seminal study, Nandha and Brooks (2009) examine the reaction of the transport sector to oil price fluctuations in thirty-eight countries and document the influence of oil prices on the stock returns in this sector in developed economies. Arouri and Rault (2009) investigate the effects of oil shocks on the stock market of GCC region (oil exporting) countries applying linear and nonlinear model. Using data from 7 June 2005 to 21 October 2008 they show that stock market returns significantly react to oil price changes in Qatar, Oman, Saudi Arabia and UAE except Bahrain and Kuwait. In the case of Norway as an oil exporting country, Bjørnland (2009) employs the structural VAR model to examine the effects of oil price movements on stock prices behaviour. Using monthly data from 1993 to 2005, findings suggest that the Norwegian economy responds to higher oil prices by increasing aggregate wealth and demand and in the short term stock prices fluctuate owing to the monetary policy shocks.

More recently, Arouri and Nguyen (2010) in a comprehensive study, investigate sector return sensitivities to oil price shocks in European stock markets. Using a conditional version of two-factor market model and Granger causality test they find that reactions of stock returns to oil price fluctuations differ greatly among different sectors. To examine the impact of oil price fluctuations on macro-economy and stock market simultaneously in Greece, Filis (2010) employs vector error-correction and multivariate VAR models. His findings imply that the cyclical components of oil prices lead the Greek stock market. Chen (2010) employs the time varying transition-probability Markov-switching models to examine the impact of oil price changes on the behaviour of the Standard & Poor's S&P 500 price index and find evidence that higher oil price does push the stock market into bear territory. In order to examine the relationship between oil price shocks and stock returns in oil exporting countries Arouri et al. (2010b) employ the cointegration and SUR regression methods. Using two different (weekly and monthly) datasets covering respectively the periods from 7 June 2005 to 21 October 2008, and from January 1996 to December 2007, they find that there is evidence for cointegration of oil prices and stock markets in GCC countries, while the SUR results indicate that oil price increases have a positive impact on stock prices, in all member countries with the exception of Saudi Arabia.

In recent years, in view of well-documented typical characteristics or stylised facts (e.g. non-normality, skewness, leptokurtosis, highly significant linear and nonlinear serial correlation and volatility clustering) of stock returns and changes in oil prices series, studies on the relationship between stock market and oil market have turned to apply GARCH modelling approach. Using a trivariate GARCH_M model Hammoudeh et al. (2004) show that there are two way interactions between S&P oil composite index, oil spot and futures prices over the period July 17, 1995 to October 10, 2001. In order to examine crude oil shoks and stock markets Aloui and Jammazi (2009) apply the Markov- switching EGARCH model. Using data over the period December 1987 to January 2007 they find that the net oil price (the WTI and Brent oil) variable plays a notable role in determining both the volatility of real returns and the probability of transition across regimes in developed stock markets namely France, UK and Japan. In a sector focused study, Malik and Ewing (2009) employ a bivariate GARCH model to search volatility transmission between oil prices and equity sector returns in the US stock market by using weekly data from January 1, 1992 to April 30, 2008. Their estimation results indicate evidence of significant transmission of shocks and volatility between oil prices and some of the examined market sectors.

To the best of our knowledge, there is only one empirical study of the impact of oil price on the Iran stock market. In this regard, Keshavarzhadad and Maanavi (2008) examine short run dynamic linkages between exchange rates and stock prices in relation to oil price shocks in Iran stock market. Employing a VAR model and the Granger causality tests and using the data over the 1999 to 2006 period they show that there is a significant causal effect from oil prices to stock prices and then from stock prices to exchange rates during the periods of increasing oil prices.

The reported results in the above surveyed literature suggest that although higher oil price is generally a deterrent factor for economic growth specifically in oil-importing countries, the direction of the impact of oil price shocks on stock market returns depends on various factors. In terms of direct impact, the final influence of an oil shock would depend on whether oil is an input or an output for a company or industry in the market. In addition, the position or ability of companies in passing the cost of oil prices to its customers to minimize the negative impact of oil prices on its profitability is also relevant. In this regard, the degree of competition or concentration within an industry as well as the degree of price elasticity of demand has a significant role in the final effect of oil shocks on listed companies. It is worth mentioning that the size and efficiency of stock market are also determinant factors in the impacts of oil price variations. On the other hand, the stock markets are indirectly affected by changes in monetary and fiscal policies, consumers' confidence, inflation rate and in general economic environmental owing to oil price fluctuations.

In the light of the mixed results of investigation on the impact of oil price shocks on the behaviour of stock returns especially in oil exporting countries and in view of lack of sufficient number of empirical examinations in this field, this study seeks to analysis the impact of oil price fluctuations on the dynamic of stock prices in a main oil-exporting country (Iran) using a novel and compatible (with distribution characteristics of stock returns and oil price changes data) empirical methodology and relatively long term sample data.

6.3. Empirical methodology

In this subsection, we attempt to identify the interaction between the oil price changes and stock returns in Iran stock market. Based on theoretical and empirical literature we define the following hypotheses to investigate the possible relationship between Iran stock market and international oil market:

H_1: There is return spillover between the Iran stock market and international oil market

H_2: The volatility of the international oil market is transmitted to the volatility of the Iran stock market

In order to analysis the dynamic relationship between two markets in view of the frequently documented nonlinear behaviour in financial time series we apply a bivariate GARCH model which simultaneously estimates the mean and conditional variance of stock and oil returns. Specifically, the following model is used to examine the time varying interdependence across the two markets.

In the first stage we define the mean equation as a VAR specification to each series:

$$Y_t = E(Y_t | I_{t-1})$$

$$Y_t = \alpha + \Gamma Y_{t-n} + \varepsilon_t, \qquad \varepsilon_t | I_{t-1} \approx N(0, H) \quad (1)$$

Where Y_t is a 2X1 vector of two markets returns at time t and α as a 2X1 vector represents constants. ε_t is a 2X1 vector of random errors for each market at time t and has a 2X2 conditional variance-covariance matrix, H_t. This is a general VAR for the mean equation where one variable is a function of its own lagged values, and lagged values of all the other variables, from time *t -1*, to time *t - n.*

Since the accurate mean specification is crucial in unbiased estimation of conditional variance-covariance matrix (H_t), based on ACF analysis in order to remove any existing serial correlation in the series under study mean equations in the more parsimonious specifications are defined specifically to each market as follow:

$$Y_{1t} = \mu_{11} + \beta_{11} Y_{1t-1} + \beta_{12} Y_{2t-1} + \delta_{11} Y_{1t-2} + \varepsilon_{1t}$$
$$Y_{2t} = \mu_{22} + \beta_{22} Y_{2t-1} + \beta_{21} Y_{1t-1} + \varepsilon_{2t} \quad (2)$$

Note that Iran stock market and oil market are respectively indexed as 1 and 2.

To reduce the number of estimated parameters and ensure the positivity of the conditional variance matrix, based on Engle and Korner (1995) specification we adopt following BEKK parameterisation for H_t:

$$H_t = C'C + A'\varepsilon'_{t-1}\varepsilon_{t-1}A + G'H_{t-1}G \qquad (3)$$

Where C is defined as a 2X2 lower triangular matrix of constants while A and G are2X2 matrices. In matrix A the diagonal parameters (a_{ii}) measure the effects of own past shocks on its conditional variance, while the off-diagonal parameters (a_{ij}) measure the cross-market effects of shock. The diagonal parameters (g_{ii}) in matrix G determine the effect of past volatility of each market on its conditional variance, while the off-diagonal parameters (g_{ij}) measure the cross-market effects of volatility (as known volatility spillover). In this sense, the shocks and volatility spillovers among two markets can be examined by the significance of the a_{ij} and g_{ij}, respectively (see Li and Majerowska (2008)). The explicit format of conditional variance and covariance for the Bi-variate GARCH model can be expressed as follows:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

$$+ \begin{bmatrix} a_{11} & a_{21} \\ a_{12} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \qquad (4)$$

$$+ \begin{bmatrix} g_{11} & g_{21} \\ g_{12} & g_{22} \end{bmatrix} \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}$$

In the same way the expanded form of conditional variance and covariance for the Bi-variate GARCH model can be written as follows:

$$\begin{aligned}
h_{11,t} &= c_{11}^2 + g_{11}^2 h_{11,t-1} + g_{21}^2 h_{22,t-1} + 2 g_{11} g_{21} h_{12,t-1} + a_{11}^2 \varepsilon_{1,t-1}^2 + a_{21}^2 \varepsilon_{2,t-1}^2 \\
&\quad + 2 a_{11} a_{21} \varepsilon_{1,t-1} \varepsilon_{2,t-1} \\
h_{22,t} &= c_{21}^2 + g_{12}^2 h_{11,t-1} + g_{22}^2 h_{22,t-1} + 2 g_{12} g_{22} h_{12,t-1} + a_{12}^2 \varepsilon_{1,t-1}^2 + a_{22}^2 \varepsilon_{2,t-1}^2 \\
&\quad + 2 a_{12} a_{22} \varepsilon_{1,t-1} \varepsilon_{2,t-1} \\
h_{12,t} &= c_{11} c_{21} + g_{11} g_{12} h_{11,t-1} + g_{21} g_{22} h_{22,t-1} + (g_{11} g_{22} + g_{21} g_{12}) h_{21,t-1} \\
&\quad + a_{11} a_{21} \varepsilon_{1,t-1}^2 + a_{22} a_{12} \varepsilon_{2,t-1}^2 + (a_{11} a_{22} + a_{21} a_{12}) \varepsilon_{1,t-1} \varepsilon_{2,t-1}
\end{aligned} \tag{5}$$

Since it is widely believed that the bad news (negative shocks) tends to increase volatility more than good news (positive shocks), we also employ the asymmetric BEKK (ABEKK) model to identify the dynamic relationship between two markets. The ABEKK model which was proposed by Kroner and Ng (1998) allows for the asymmetric response of volatility. In this sense, it is assumed that volatility tends to rise more in response to negative shocks (bad news) than positive shocks (good news), in the variances and covariances:

$$H_t = C'C + A' \varepsilon'_{t-1} \varepsilon_{t-1} A + G' H_{t-1} G + D' u'_{t-1} u_{t-1} D \tag{6}$$

The expanded form of conditional variance and covariance for the asymmetric Bi-variate GARCH model is written as follows:

$$h_{11,t} = c_{11}^2 + g_{11}^2 h_{11,t-1} + g_{21}^2 h_{22,t-1} + 2 g_{11} g_{21} h_{12,t-1} + a_{11}^2 \varepsilon_{1,t-1}^2 + a_{21}^2 \varepsilon_{2,t-1}^2$$
$$+ 2 a_{11} a_{21} \varepsilon_{1,t-1} \varepsilon_{2,t-1} + d_{11}^2 u_{1,t-1}^2 + d_{21}^2 u_{2,t-1}^2 + 2 d_{11} d_{21} u_{1,t-1} u_{2,t-1}$$

$$h_{22,t} = c_{21}^2 + g_{12}^2 h_{11,t-1} + g_{22}^2 h_{22,t-1} + 2 g_{12} g_{22} h_{12,t-1} + a_{12}^2 \varepsilon_{1,t-1}^2 + a_{22}^2 \varepsilon_{2,t-1}^2$$
$$+ 2 a_{12} a_{22} \varepsilon_{1,t-1} \varepsilon_{2,t-1} + d_{12}^2 u_{1,t-1}^2 + d_{22}^2 u_{2,t-1}^2 + 2 d_{12} d_{22} u_{1,t-1} u_{2,t-1} \quad (7)$$

$$h_{12,t} = c_{11} c_{21} + g_{11} g_{12} h_{11,t-1} + g_{21} g_{22} h_{22,t-1} + (g_{11} g_{22} + g_{21} g_{12}) h_{21,t-1}$$
$$+ a_{11} a_{21} \varepsilon_{1,t-1}^2 + a_{22} a_{12} \varepsilon_{2,t-1}^2 + (a_{11} a_{22} + a_{21} a_{12}) \varepsilon_{1,t-1} \varepsilon_{2,t-1}$$
$$+ d_{11} d_{21} u_{1,t-1}^2 + d_{22} d_{12} u_{2,t-1}^2 + (d_{11} d_{22} + d_{21} d_{12}) u_{1,t-1} u_{2,t-1}$$

The last item on the right-hand side of equation (6) captures the asymmetric property of the time-varying variance–covariance. u_t is defined as one if ε_t is negative and zero otherwise. D is a 2$\times$2 matrix and the diagonal parameters in this matrix measure the response of market *i* to its own past negative shocks. However, the off-diagonal parameters, u_t in matrix D measures the response of market *i* to the negative shocks, i.e., bad news, of other markets, to be called the cross-market asymmetric responses. In particular, the d_{11} represents the asymmetric effect in Iran stock market while the d_{12} measures the asymmetric response of Iran stock returns volatility to negative shocks (decline of oil price) in international oil market and vice versa.

In order to identify possible simultaneous shocks and volatility spillovers among Iran stock market and international oil market, the Wald test can be carried out. In this regard, we impose in the estimated symmetric and asymmetric bivariate GARCH models the restrictions that all the coefficients of the off-diagonal parameters are zero. In this respect we also carry out the likelihood ratio test to establish the validity of simultaneous estimation of the two series by the BEKK approach.

It can be pointed out that the BEKK model makes possible the analysis of cross-market effect in the variance equation parsimoniously. Since the BEKK specification of the multivariate GARCH model is specified using quadratic forms, the positive definiteness of the variance equation is guaranteed. Furthermore in the BEKK model the restriction of constant correlation across variables over time is not imposed. In sum, the BEKK specification apart from allowing for time-varying variance and covariance through the cross-market effects, capturing returns linkage and transmission of shocks and volatility from one market to another.

In order to estimate efficiently and consistently the BEKK specification we use the full information maximum likelihood method. Specifically, the log likelihood function of the joint distribution is defined as the sum of all the log likelihood functions of the conditional distributions, i.e., the sum of the logs of the multivariate-normal distribution. In this sense, supposing that L_t is the log likelihood of observation *t*, and *n* is the number of markets, the joint log likelihood L can be defined as:

$$L = \sum_{t=1}^{T} L_t, \quad L_t = \frac{n}{2}\ln(2\Pi) - \frac{1}{2}\ln|H_t| - \frac{1}{2}\varepsilon'_t H_t^{-1} \varepsilon_t \quad (6)$$

In order to maximise the log-likelihood function a numerical procedure, e.g., BHHH algorithm is usually employed, by searching for optimal estimates of the unknown parameters. In this study, we use the first derivative method of Marquardt as the optimisation algorithm. The Marquardt algorithm is a modification of BHHH that incorporates a 'correction', the effect of which is to push the coefficient estimates more quickly to their optimal values. In the framework of two-step estimation approach, the estimated corresponding coefficients in the univariate GARCH models are used to refine the starting values of the parameters in the mean equations and constants in the conditional variance–covariance equations[1].

6.4. Data and preliminary analysis

Since in Iran stock market trading days (according to Persian calendar) are Saturday to Wednesday, in order to analysis relationship between oil price changes which are determined in international market with trading days (based on Gregorian calendar) Monday to Friday, we can't use the daily data because of heterogeneity. To circumvent this problem, we employ weekly data from Jan, 2, 1999 to 31 Dec, 2010, which consists of 622 observations. We constructed the weekly data by matching the average corresponding oil price data to the last trading day in the week in Iran stock market. The data for oil prices are Oklahoma crude oil future contract prices and comprise from Energy Information Administration (EIA) site. The futures prices are

1. I would like to thank Dr. Hong Li for providing basic bivariate GARCH programme.

selected instead of spot prices because the futures are more heavily traded than the commodity itself and also are more sensitive to the arrival of new information. Iran stock market prices index (TEPIX) are transformed to weekly returns **R**= ***Ln*** (P_t / P_{t-1}) where P_t and P_{t-1} are stock prices index prices at date *t* and *t* − 1 respectively. In the same way percentage change in Oklahoma crude oil future prices is calculated as: **dop**= ***Ln*** (op_t / op_{t-1})

Figures 6.1 and 6.2 display the time plot of the logarithm of Iran weekly stock prices index and stock returns and the logarithm of weekly oil prices and percentage changes in oil prices series respectively. It can be seen that both Iran weekly stock prices index and oil prices series follow random walk theory (stochastic trend). Although each series is non-stationary, it can be seen that they follow a similar trend. At the first glance, since both series move together over time, it can be noted that there is a positive relationship between the two. At the same time based on the figure of Iran stock returns and percentage changes in oil prices it can be seen that two markets have experienced high volatility over the period of study. As we can see from figure 6.1, the volatility of Iran stock market in the early study period has been relatively small. Since July week3, 2008 the volatility of oil market in line with the decline in international oil prices has been significantly increased (see figure 6.2).

In order to obtain insight into the unconditional distribution, table 6.1 reports the descriptive statistics of the weekly Iran stock return series and international oil prices changes. The sample mean for stock return series and oil prices changes per week are 0.4047 and 0.3218 respectively. In view of the maximum and minimum values of both series it can be noted that fluctuations in oil prices have been greater than that of Iran stock prices over the period of study. In the same way, the value of standard deviation (an indication of unconditional variance in return series) given the value of mean is another proof for high volatility and risky nature of oil market in comparison with Iran stock market. The significance of sample skewness and kurtosis criteria coupled with the Jarque–Bera normality statistics show that the distribution of monthly stock returns and oil price changes are non-normal. The positive value of skewness suggests that large positive returns are more frequent than large negative returns when investing in Iran stock market. In the same way, the presence of positive kurtosis indicates a higher probability of getting positive returns (or large price movement) for investors in Iran stock market. The Ljung–Box Q-Statistics for the first six and twelve lags in stock return and oil price changes levels indicate the existence of serial correlations in the raw data of both series. However, nonlinear dependencies are more important than the linear ones because the value of the Ljung–Box Q-Statistics for squared returns is generally higher than for the raw returns. For both series, the Engle (1982)'s test for conditional heteroscedasticity rejects the null hypothesis of no ARCH effects, and thus justifies the existence of ARCH effect in the dynamic of Iran stock returns and oil price changes.

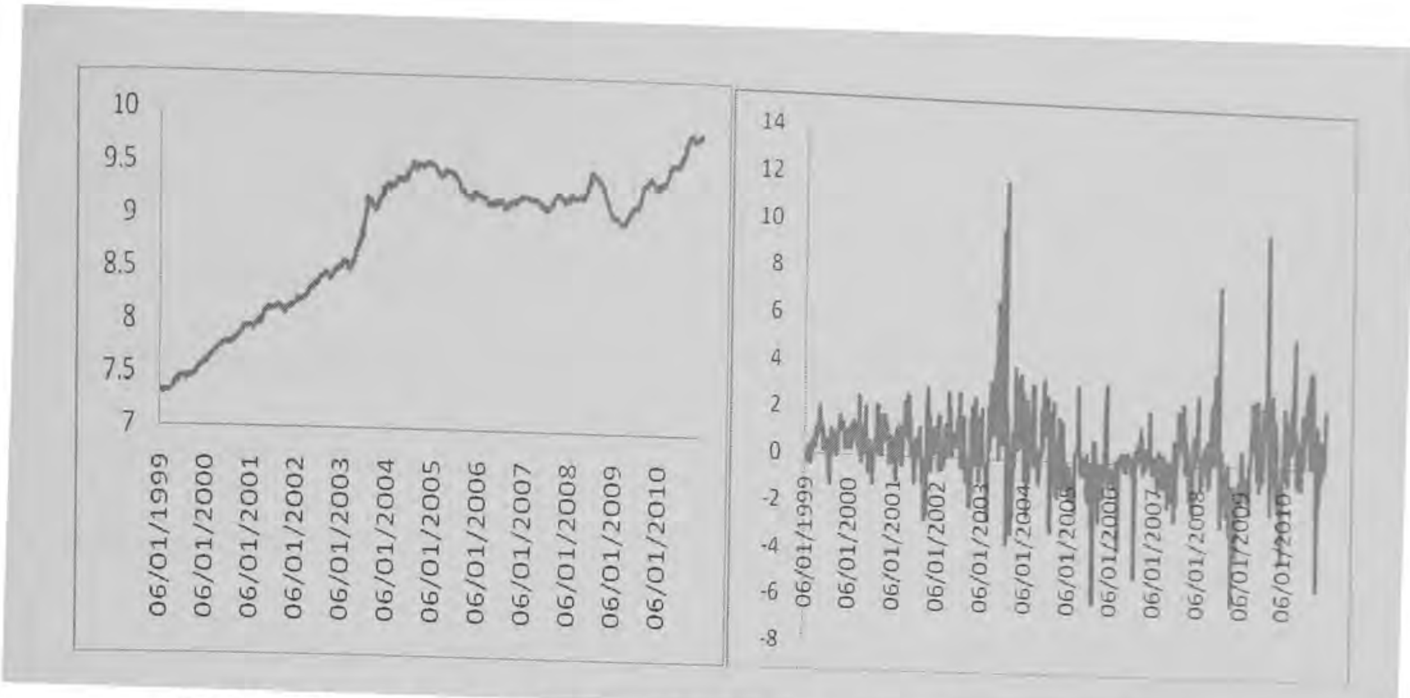


Fig6.1.The time plot of Iran weekly stock prices index and stock returns

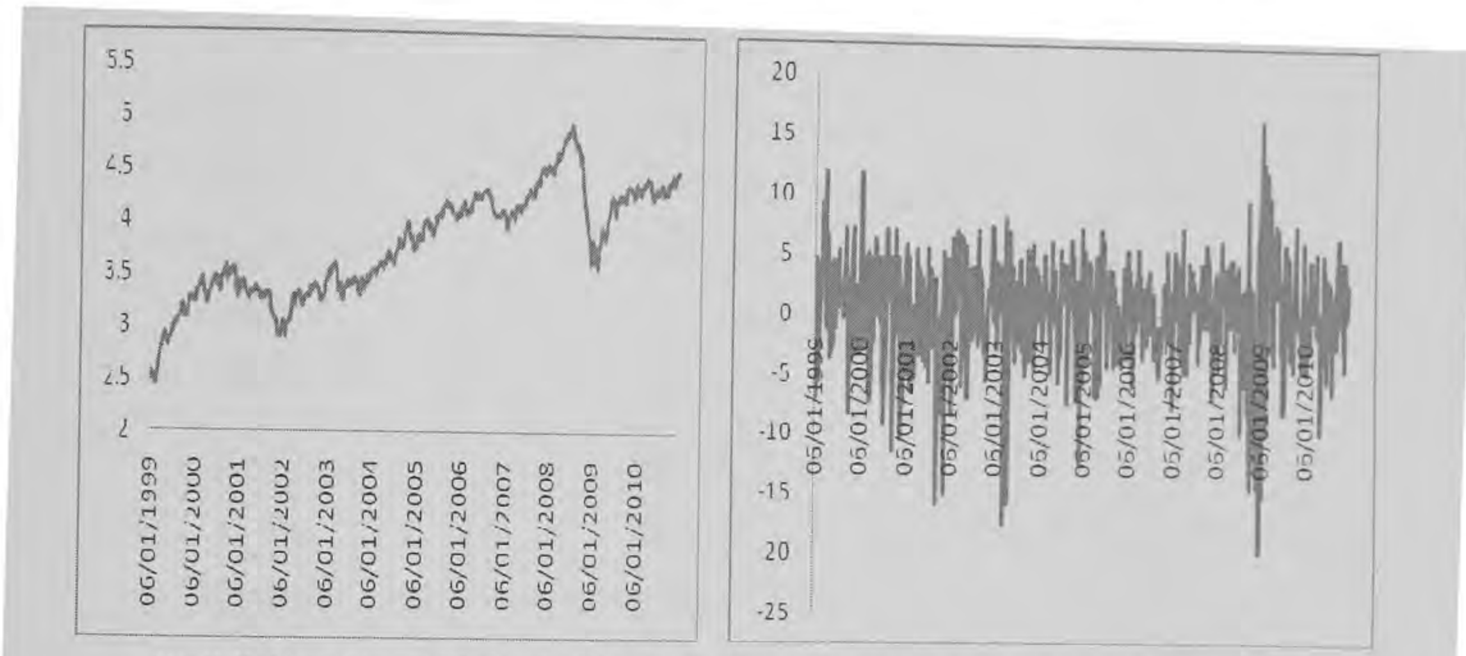


Fig6.2.The time plot of weekly oil prices and percentage changes in oil prices

The unconditional correlation between the Iran weekly stock returns and percentage changes in oil prices can be used as a preliminarily tool to analyse possible relationship among these series. In this regard, there is a positive weak correlation (0.094) between Iran stock returns and fluctuations in oil price.

It is worth noting that in analysing the dynamic of relationship between stock market returns and oil prices fluctuations we should take into account the stochastic features of both series. In view of the unconditional distribution, attention to existence of nonlinear dynamic in Iran stock returns and oil price changes series is crucial in building a suitable model of the effects of oil price variations on the behaviour of Iran stock market.

Tabl6.1. Stochastic properties of stock returns and oil price changes

	Stock returns	Oil price changes
Mean	0.4047	0.3218
Maximum	11.8339	16.4859
Minimum	-6.0927	-19.8017
Std.Dev.	1.6641	4.4958
Skewness	1.1640	-0.6917
Kurtosis	11.1835	4.7462
Q(6)	248.36***	17.47***
Q(12)	265.50***	31.61***
$Q^2(6)$	118.63***	227.72***
$Q^2(12)$	133.09***	358.41***
JB	1873.09***	128.43***
ARCH(6)	71.69***	108.13***
ARCH(12)	79.05***	121.45***

*Notes: Q(6), Q(12) ,$Q^2(6)$ and $Q^2(12)$ are the Ljung–Box tests for serial correlation in levels and squares of both series. JB is the Jarque–Bera test for normality. ARCH (6) and ARCH (12) are Engle (1982)'s tests for conditional heteroscedasticity in both seires. Notice that skewness is equal to zero in a normal distribution while excess kurtosis is three if series are normally distributed. The superscripts *** indicate that coefficients are significant at 1% level of significance.*

6.5. Empirical results

In order to examine the dynamic relationship between Iran stock market behaviour and oil price movements, we estimate simultaneously the mean Eq. (2) and time-varying variance–covariance Eq. (3) by the maximum log likelihood method. The estimation results of the mean equation and bivariate BEKK model are reported in table 6.2. In the estimation process, the specified bivariate GARCH model converges after 202 iterations. We are interested specifically in the analysis of cross-market parameters to identify the possible evidence of linkage between Iran stock market and oil market.

Firstly, in order to identify the relationship in terms of returns across the markets we look at matrix Γ in the mean equation, Eq. (1), captured by the parameters β_{ij} in Table 2. As can be seen from the table 6.2, the diagonal parameters β_{11} and β_{22}, are statistically significant, thus the returns of Iran stock market and oil market depend on their first lag, respectively. In the same way, the coefficient of second lag in Iran stock market is statistically significant. In this case, it can be noted that the stock returns of Iran stock market in the current week is influenced by the stock returns of two weeks ago. In contrast, the cross-market returns linkages which are represented by the off-diagonal parameters β_{12} and β_{21} are statistically insignificant. More precisely, while the percentage changes in oil price has a negative (-0.0049) impact on the stock returns in Iran stock market, it is statistically insignificant. These imply that there is no returns spillover among the Iran stock market and oil market. In other words, the information about oil price movements is not transmitted into the pricing process of the Iran stock market. The statistical insignificance of the off-diagonal parameters β_{12} and β_{21} contrary to the first hypothesis (H_1) indicates lack of returns spillover between two markets. In order to check the adequacy of specified mean equations the diagnostic tests namely Ljung–Box Q statistics for the 12th and 24th orders in the standardised residuals are reported in table 6.2. The represented results indicate that the mean equations are specified appropriately and any linear dependences in both series are removed.

In the second step in order to identify the structure of variance-covariance matrix we examine the results of estimation of the time-varying variance–covariance Eq. (3) in the specified model. As stated above, the matrices A and G in equation 3 are estimated to examine the relationship of two markets in terms of shocks and volatility. While the diagonal elements in matrix A capture the own ARCH effect, the diagonal elements in matrix G verify the own GARCH effect. As it can be seen from table 5.2, the estimated diagonal parameters a_{11} and a_{22} and; g_{11} and g_{22} are all statistically significant, indicating a GARCH (1, 1) model well specifies the conditional variances of the two series (Iran stock returns and percentage changes in oil price). In this sense it can be mentioned that the own past shocks and volatility affect the conditional variance of each series. The volatility (as a measure of market risk) of each market is considerably influenced by the past realized unexpected shocks and volatility in each market.

At the same time, the off-diagonal elements of matrices *A* and *G* measure the cross-market effects namely shock and volatility spillovers among the two markets. Based on reported results in table 6.2, the off-diagonal parameters a_{12} and a_{21} are statistically insignificant indicating there is not shocks spillovers across the Iran stock market and oil market. In other words, the unexpected shock owing to realized new information in each market does not affect the volatility of another market. The conditional variance of Iran stock market and oil stock market are not influenced by the unexpected shocks in other market. Specifically, unexpected shocks do not spill over from oil market to Iran stock market and vice versa. In the same way, the off-diagonal parameters g_{12} and g_{21} in the matrix G according to represented results in table 6.2 are statistically insignificant. These mean that the conditional variance of each market is not affected by the information about risk in the other market. To put it another way, the risk of each market is not transmitted to other market. More precisely, the volatility of oil market does not spill over to Iran stock market .In sum; the empirical results contrary to the second designed hypothesis in this chapter do not provide evidence of contemporaneous shock and volatility spillovers between Iran stock market and international oil market.

In the case of well- specifying the time-varying variance–covariance, the reported Ljung–Box Q statistics for the 12th and 24th orders in squared standardised residuals indicate that there is no series dependence in the squared standardised residuals of the series at the level of significance of 5% (indicating the lack of ARCH effects). This means that the fitted symmetric bivariate GARCH model (BEEK model) captures well the dynamic behaviour of the two series specifically in second moment. Generally speaking, empirical results show the lack of cross-market effects between Iran stock market and oil market indicating the independence of the pricing process and dynamic behaviour of each market.

Table6.2. Empirical results of the estimation of symmetric bivariate GARCH model

Coefficient	R(*i*=1)	Prob.	Dop (*i*=2)	Prob.
μ_{i1}	0.0016*	0.0076	-	-
μ_{i2}	-	-	0.0022	0.1892
β_{i1}	0.2746***	0.0000	-0.0049	0.6939
β_{i2}	0.1347	0.1855	0.1735***	0.0000
δ_{i1}	0.2914***	0.0000	-	-
C_{i1}	0.0037***	0.0000	-	-
C_{i2}	-	-	0.0129***	0.0000
a_{i1}	0.3678***	0.0000	0.0093	0.3184
a_{i2}	-0.0489	0.4251	0.2859***	0.0000
g_{i1}	0.8978***	0.0000	0.0002	0.9812
g_{i2}	0.1258	0.1774	0.9054***	0.0000
LB-Q(12)	12.74	0.388	14.64	0.262
LB-Q(24)	22.26	0.563	41.10	0.016
LB-Qs(12)	4.09	0.982	14.80	0.252
LB-Qs(24)	13.41	0.959	18.34	0.786
LLR	2881.805			
AIC	-9.267978			
SC	-9.139051			

*Note: * and *** represent the levels of significance of 10% and 1%, respectively. LB-Q (12) and (24) stand for the Ljung–Box Q-statistic for the standardised residuals up to 12 lags and 24 lags, while LB-Qs (12) and (24) for the Ljung–Box Q-statistic for the squared standardised residuals. LLR, AIC and SC represent the lag likelihood ratio, Akaike information criterion and Schwarz criterion, respectively.*

In order to identify the possible asymmetric response the volatility of one market to bad news in other market, table 6.3 shows the empirical results of estimated ABEKK (asymmetric bivariate GARCH) model when negative shock in oil market is assumed to be reduction in oil price. In the estimation process, the specified asymmetric bivariate GARCH model converges after 131 iterations. As has been noted above, the diagonal parameters (d_{11} and d_{22}) measure the asymmetric effect in Iran stock market and oil market, respectively. As it can be seen from table 3, the coefficient of asymmetric effect (d_{11}) in Iran stock market is statistically insignificant implying that good news and bad news have the same effects on stock returns in the Iran stock market (this finding confirms to the results of univariate nonlinear GARCH model in chapter four). At the same time, since the probabilities is smaller than the conventional level of significance 5%, the asymmetry term (d_{22}) in oil market is statistically significant indicating the bad news affect the oil price movements more than good news in international oil market. This means that the sign of the own past shocks affects the conditional variance of the oil price movements. However, the given empirical results in table 6.3 suggest that there is no evidence of cross-market asymmetric response. More precisely, the cross-market asymmetric parameters (d_{12} and d_{21}) are statistically insignificant. The volatility of Iran stock returns and international oil market do not response asymmetrically to negative shocks in other market.

As far as matrix A is concerned, we find no evidence of bidirectional shocks and volatility spillover between two markets. Since the off-diagonal parameters (a_{12} and a_{21}) are statistically insignificant, news about shocks in the each market does not affect the conditional variance of other market. At the same way, the coefficients of off-diagonal elements of matrix G namely g_{12} and g_{21} are statistically insignificant. This means that the conditional variance of Iran stock returns and percentage changes in oil prices are not influenced by the conditional variance of other market. In general, it can be highlighted that even with discriminating between positive and negative shocks; the empirical results imply that there are not cross-market effects between Iran stock market and oil market. The dynamic behaviour of Iran stock prices and oil prices are independent of information related to other market. The empirical results do not provide evidence of contemporaneous shock and volatility spillovers between Iran stock market and international oil market.

Table6.3. Empirical results of the estimation of ABEKK model

Coefficient	R(*i*=1)	Prob.	Dop (*i*=2)	Prob.
μ_{i1}	0.0016	0.0122**	-	-
μ_{i2}	-	-	0.0017	0.3072
β_{i1}	0.2867***	0.0000	-0.0061	0.6405
β_{i2}	0.1559	0.1459	0.1803***	0.0000
δ_{i1}	0.2899***	0.0000	-	-
C_{i1}	-0.0041***	0.0000	-	-
C_{i2}	-	-	0.0121***	0.0000
a_{i1}	0.4181***	0.0000	0.0153	0.3690
a_{i2}	0.0310***	0.7471	0.1294*	0.0771
g_{i1}	0.8660***	0.0000	0.0037	0.9115
g_{i2}	0.0439	0.7967	0.9098***	0.0000
d_{i1}	0.0246	0.8987	-0.0042	0.8182
d_{i2}	-0.2512	0.2487	0.3542***	0.0000
LB-Q(12)	11.78	0.463	13.76	0.316
LB-Q(24)	21.35	0.618	39.76	0.023
LB-Qs(12)	4.83	0.963	10.48	0.573
LB-Qs(24)	15.21	0.914	13.79	0.951
LLR	2888.381			
AIC	-9.276315			
SC	-9.118738			

*Note: *, ** and *** represent the levels of significance of 10%, 5% and 1%, respectively. LB-Q (12) and (24) stand for the Ljung–Box Q-statistic for the standardised residuals up to 12 lags and 24 lags, while LB-Qs (12) and (24) for the Ljung–Box Q-statistic for the squared standardised residuals. LLR, AIC and SC represent the lag likelihood ratio, Akaike information criterion and Schwarz criterion, respectively.*

Table 6.4 provides the empirical results from conducting the Wald and Likelihood ratio tests to identify existence of the joint shock and volatility spillover effect between two markets. The reported Wald test statistic in table 5.4 suggests that we cannot reject the null hypothesis that there is no return spillover between Iran stock market and international oil market. In the same way, according to the conducted Wald statistics from symmetric BEKK model we cannot reject the null hypothesis of the lack of shocks and volatility spillover between two markets. In the same way, according to the carried out Wald test statistics (1.87 and 1.94) on the coefficient of asymmetric BEKK model we cannot reject the null hypothesis of jointly insignificant of the effects of shock and volatility spillover between two markets. In general, it can be noted that the shock and volatility of international oil market do not transmit to the volatility of Iran stock market, through either of the following three channels; the symmetric shock a_{12}, the asymmetric shock d_{12} or conditional variance (volatility) g_{12}. At the same time, based on reported likelihood test statistics (82.96 and 96.11) we can reject the null hypothesis that all the cross products of the diagonal parameters are zero. This means that symmetric and asymmetric bivariate GARCH model are appropriate and the modelling simultaneously dynamic volatility of Iran stock returns and oil price movements is correct. Finally, the reported likelihood test statistic (13.15) rejects the symmetric BEKK modelling of the relationship between two markets. This means that in view of underlying data generating process of two series, the asymmetric bivariate GARCH model best fit the possible dynamic relationship between markets.

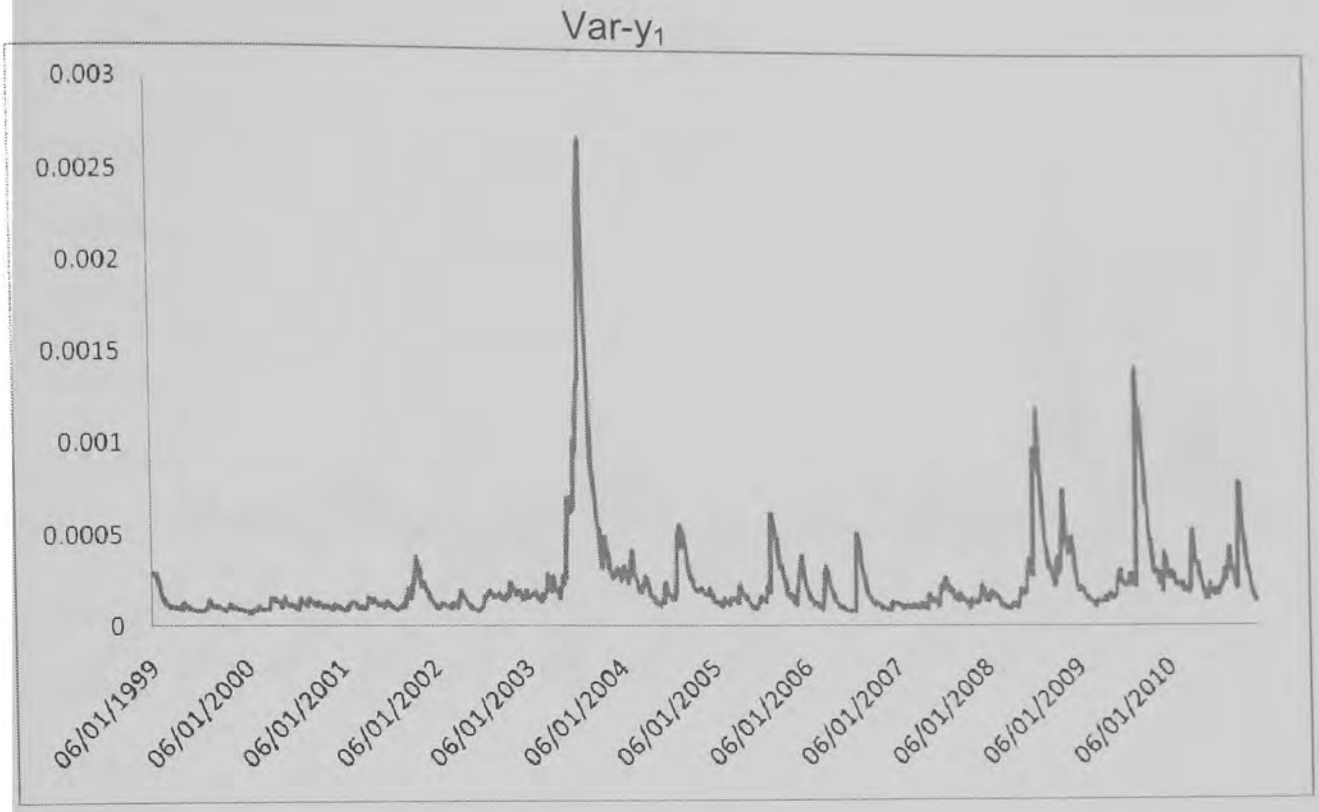
Table6.4. Restriction tests concerning the symmetric and asymmetric bivariate GARCH model

Null hypothesis	Wald test statistic	Degree of freedom
Symmetric BEKK model:		
$H_0: \beta_{12} = \beta_{21} = 0$	2.095 (0.3508)	2
$H_0: a_{12} = g_{12} = 0$	1.037 (0.5954)	2
$H_0: a_{21} = g_{21} = 0$	2.018 (0.3645)	2
Asymmetric BEKK model:		
$H_0: \beta_{12} = \beta_{21} = 0$	2.36 (0.3072)	2
$H_0: a_{12} = g_{12} = d_{12} = 0$	1.87 (0.5998)	3
$H_0: a_{21} = g_{21} = d_{21} = 0$	1.94 (05849)	3
	Likelihood ratio test statistic	**Degree of freedom**
Symmetric BEKK model vs. symmetric univariate model: $H_0: a_{ij} a_{ji} = g_{ij} g_{ji} = 0, i \neq j$	82.96 (0.0000)	4
Asymmetric BEKK model vs. asymmetric univariate model: $H_0: a_{ij} a_{ji} = g_{ij} g_{ji} = d_{ij} d_{ji} = 0, i \neq j$	96.11 (0.0000)	6
Asymmetric BEKK model vs. symmetric BEKK model: $H_0: D = 0$	13.15 (0.0106)	4

In order to understand the structure of volatility dynamic we plot the estimated conditional variance (from asymmetric bivariate GARCH model) of

Iran stock returns and percentage changes in oil price series. It is clear from figure 5.3 that the conditional variance of both series is time- varying. The time- varying volatility of Iran stock market has experienced the most fluctuations during 2004 simultaneous with the start of political challenges concerning Iranian nuclear programme. Indeed, the rise in the conditional variance of Iran stock returns coincides with the decline in oil prices and world financial crises in 2008. On the other hand, most of variation in the conditional variance of international oil market is related to the significant reduction in oil prices in 2008.

In line with empirical results, the represented conditional covariance and correlation among the Iran stock returns and percentage changes in oil price series in figure 6.4 indicate the dynamic relationship between Iran stock market and oil market in terms of analysis of the first and second moment market's returns. As it can be seen from figure 6.4, the estimated conditional covariance testifies to the limited interaction between Iran stock market and oil market. It seems that after the notable decline in oil prices and world financial crises in 2008, the relation between two markets has slightly increased.



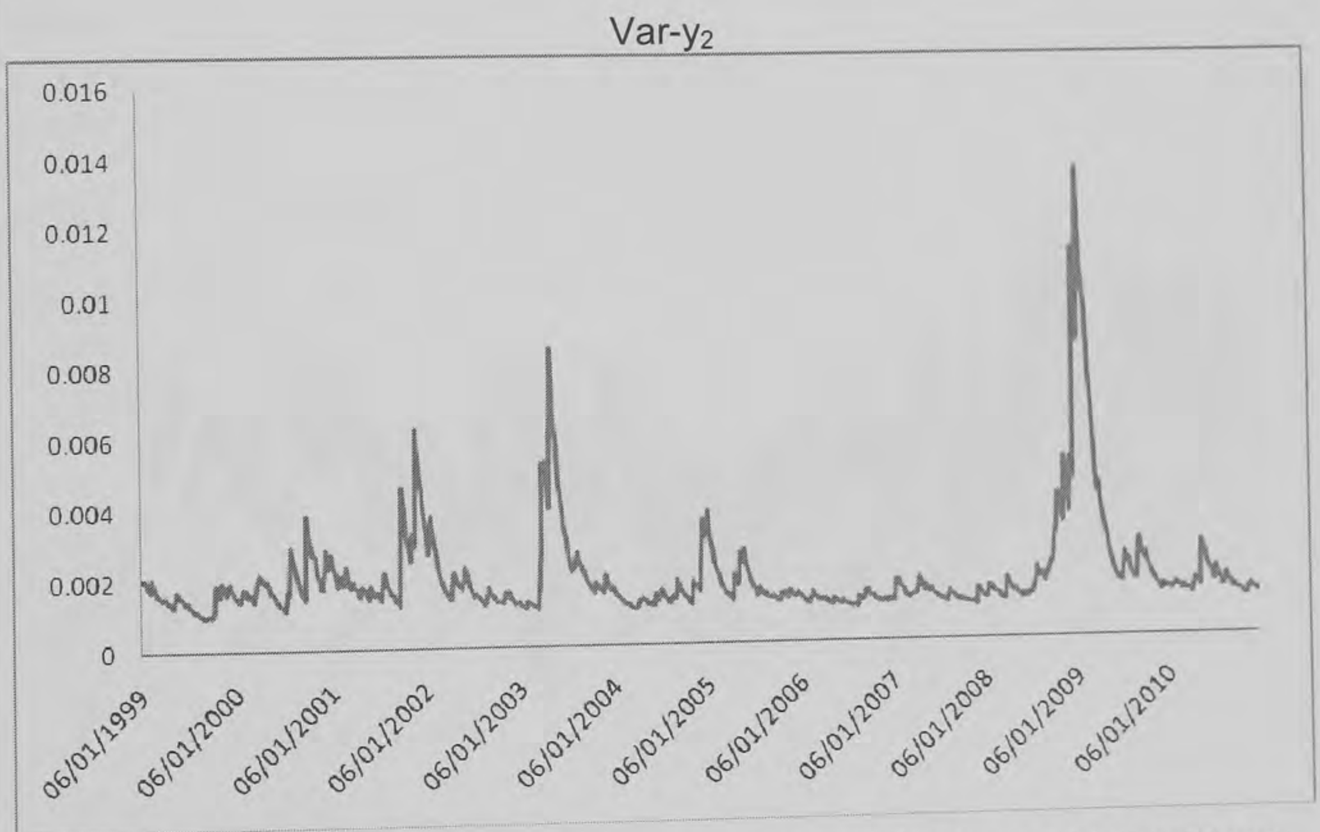
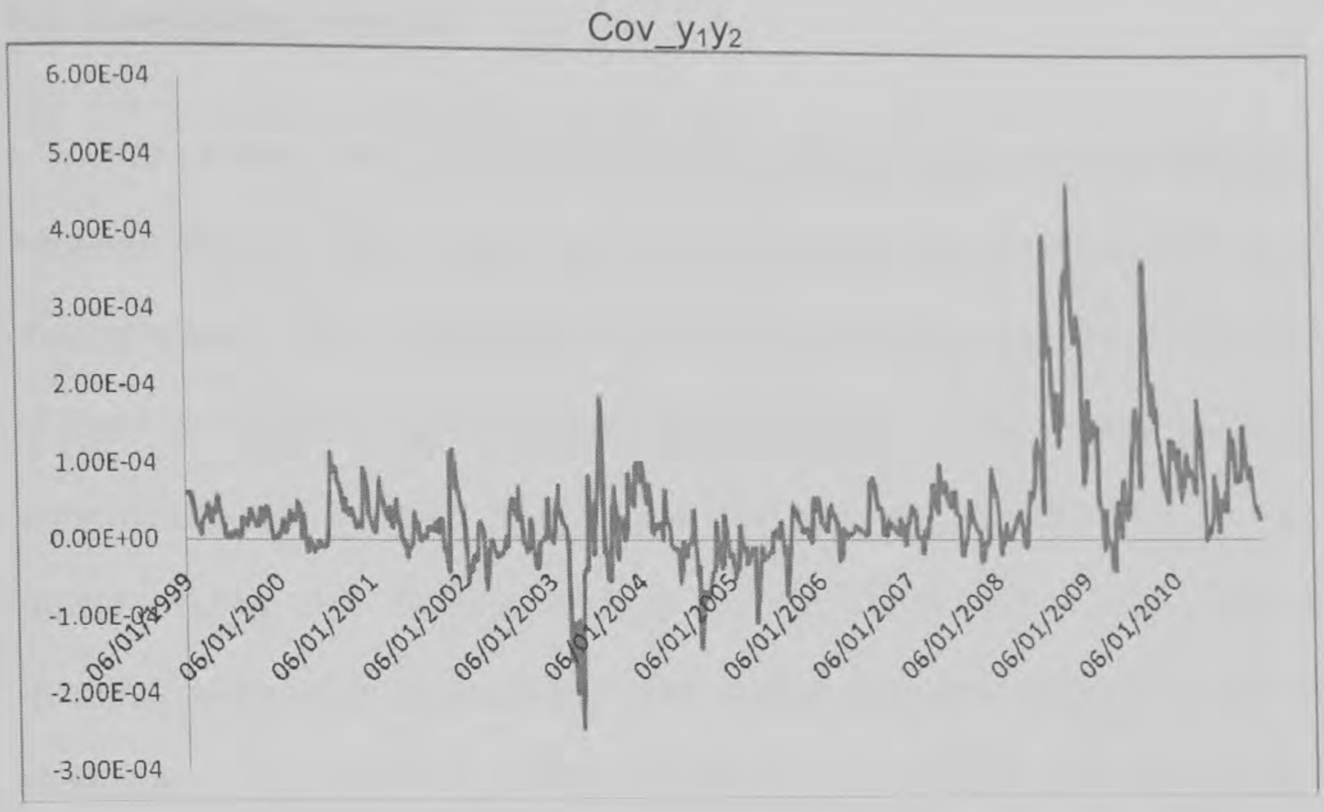


Figure6.3. Estimated conditional variance for Iran stock returns and percentage changes in oil price



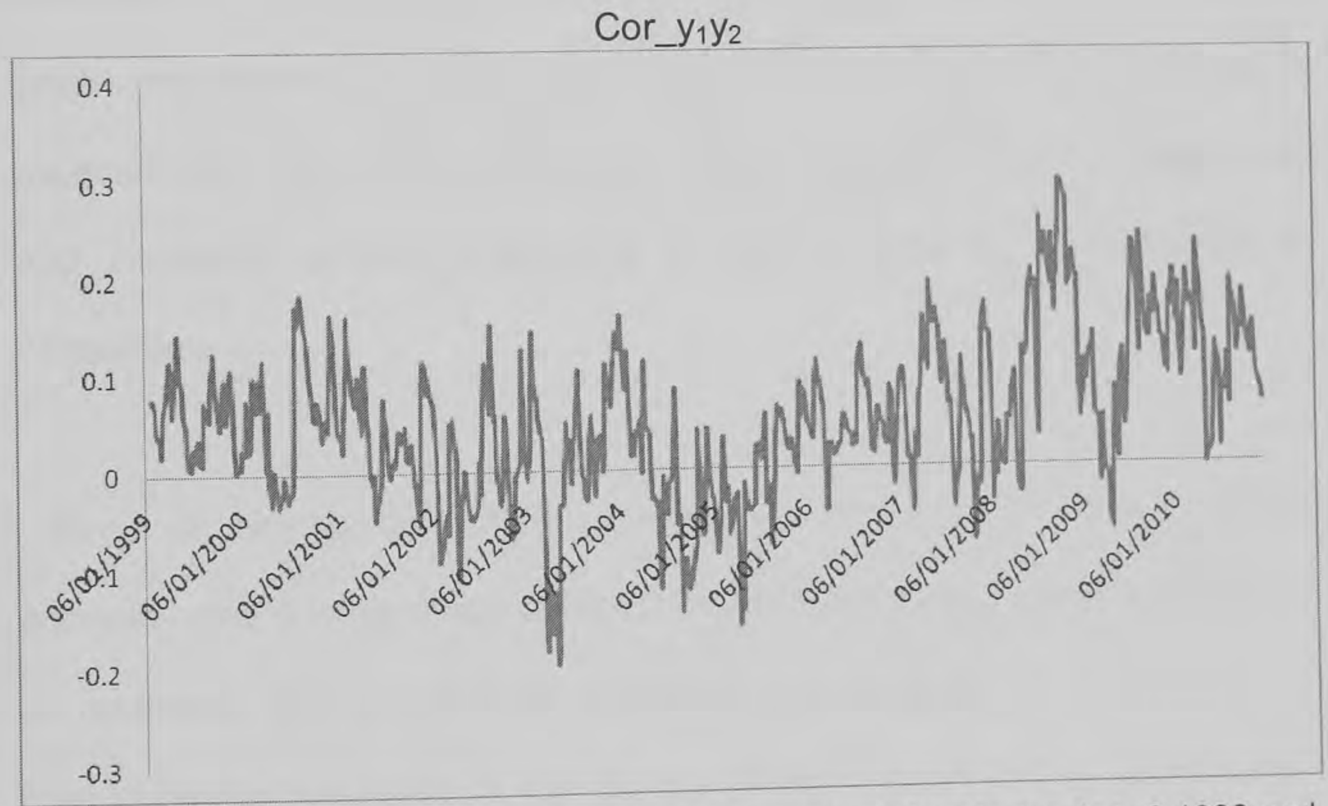


Figure6.4. Estimated conditional covariance and correlation during Jan, 2 1999 and Dec, 31 2010

6.6. Concluding remarks

In this chapter, we have tried to identify the possible dynamic linkages between the Iran stock market and international oil market in terms of cross-market effects. The identification of the factors affecting the pricing process of listed companies or tradable financial instruments in stock markets plays a determinant role in asset pricing, risk management, portfolio construction, option trading and hedging strategy. In this sense, the investigation of dynamic relationship between the stock market and international markets (in particular oil market) in view of the crucial role of oil in world economy seems very important. Since in theory the price (value) of equity (share) is determined based on present value of discounted sum of expected future company's cash-flows, the fluctuations in oil prices can influence the stock prices and their movements through inter firm level (expected revenues or expenditures) and macroeconomics variables (e.g. interest rate, inflation rate and economic growth) depending on the degree of oil sensitivity of companies.

Since oil exports and obtained revenues play a crucial role in Iranian economy and it is generally believed that Iranian economy is dominated by oil revenues, the examination of effects of fluctuations in international oil market on the behaviour of Iran stock market as an emerging stock market has useful implications for domestic and international individual or institutional investors. In this way, since the cross-effects or correlation between tradable financial instruments (e.g. shares, options) are very important in effective portfolio construction and hedging strategy, identifying the dynamic correlation or covariance between stock prices movements (stock returns) and changes in oil price would be helpful.

In order to examine the possible dynamic relationship between Iran stock market and international oil market in view of the typical distribution characteristics of the weekly Iran stock returns and percentage changes in oil price series a bivariate GARCH model (VAR-BEKK) was adopted. This method allows for time-varying variance and covariance through the cross-market effects and measures returns linkage and transmission of shocks and volatility from one market to another market. More precisely, this multivariate GARCH model captures simultaneous volatility interactions between two markets.

By specifying an appropriate model (bivariate GARCH model) the time varying conditional variance and covariance and cross-market effects (shock and volatility spillover effects) were identified in view of the data generating process of Iran stock returns and percentage changes in oil price series. Our findings of symmetric BEKK model suggest that there is no relationship between Iran stock market and international oil futures market in terms of returns and volatility. This means that, there is no evidence of direct effects (through mean equation) and indirect effects (through variance and covariance equations). The return and volatility of each market are influenced by its past realized returns, shocks and volatility as evidenced by the significant coefficients of ARCH (news effect) and GARCH terms. In other words, the conditional variance in each market is specified well by generalized autoregressive conditional heteroskedasticiy model namely GARCH (1, 1). The estimation results reveal the lack of spillovers effect in terms of shocks and volatility among two markets under study. Specifically, the realized unexpected shocks (new information) in international oil futures market does not spill over to Iran stock market. In the same way, the volatility (fluctuations in oil futures prices) does not transmit to the volatility of Iran stock returns. More precisely, the risk of Iran stock market is not influenced by the unexpected oil price movements in international oil market. Overall, we found that there is no transmission of volatility and shocks between Iran stock market and oil market. It can be noted that Iran stock market is more influenced by its own domestic stochastic environment and that the asset pricing process in this market is not affected by originating information from oil market. In other words, non-fundamental factors play a more important role in shaping stock price dynamics and the effect of the unobservable speculative factors is the dominant driving force determining short-term stock price movements in Iran stock market. It should be noted that oil price fluctuations through transmitting to macroeconomic factors (e.g., per capita income, inflation and interest rates, economic growth, and investor and consumer confidence) may influence liquidity of Iran stock market.

Moreover, in view of well documented asymmetric effect in stock markets, the asymmetric bivariate GARCH model (ABEKK) has been adopted to distinguish different effects of bad and good news on the volatility of Iran stock market and international oil market. The estimation results from specified model suggest no evidence of cross-market asymmetric responses.

In this sense, Iran stock market does not response asymmetrically towards shocks of oil prices. In other words, Iran stock prices do not respond asymmetrically to negative shocks in international oil market. On the whole, it can be noted that even with distinguishing bad and good news there is no shock transmission from international oil market towards Iran stock market and vice versa.

With respect to dominant role of oil earnings in Iranian economy (as has been analysed in chapter 2) a potential explanation for lack of effect of oil price fluctuations on the volatility of Iran stock market may be the small size of Iran stock market in relation to GDP (as has been discussed in chapter 2, the market capitalization of Iran stock market is 18 percent). Since we have used the weekly Iran stock prices index in this study, possible positive (negative) effects of oil price fluctuations on different sectors or companies may be offset by each other producing an overall effect is zero. At the same time, the existence of implicit and explicit energy subsidies in particular in industry and services sectors in Iranian economy can be another reason for the lack of spillover effect between Iran stock market and international oil market. In addition, offsetting the positive and negative impacts of oil price shocks on the individual listed companies can be another reason for the lack of shock and volatility transmission from international oil market to Iran stock market. In this sense, the positive effects of an increase in oil prices on economic activity, government expenditure and generally companies output may be offset by the negative impacts through inflationary pressure (by increasing the price of imported manufactories products) and raising the cost of production.

Since the volatility of stock returns is crucial in pricing of shares, options, futures and hedging strategies, the findings of this study have important implications for domestic and international individual and institutional investors and portfolio managers. In order to make optimal portfolio allocation decisions and effective risk management, understanding the volatility transmission mechanism over time and across markets is very important. The lack of dynamic linkage between Iran stock market and international oil market in terms of shocks and volatility transmission can provide important and useful information for portfolio managers specifically in international level. In the same way, the empirical results of this study can present information for policy makers to better understand the behaviour of Iran stock market.

CHAPTER 7

CONCLUSION

7.1. Summary of results

This study is an attempt to analyse the Iranian stock market as an emerging market in oil exporting middle income developing countries. It has investigated the subject from various points of view, based on the research problems stated in Chapter One. To reiterate, efficiency, volatility and the link between the stock market and international oil market are three of the main topics analysed using various time-series models and econometric techniques.

Iran stock market has experienced remarkable development over the last decade after implementation of institutional reforms, including reorganization of market, changes in the regulatory regime, reforms in information disclosure procedures, modernization of trading system, relaxation of foreign investment restrictions (as part of market liberalization) and the expansion of market by creating regional stock markets. Like other emerging stock markets, Iran stock market has faced various challenges such as market domination by state-owned or semi state-owned investment companies, political and liquidity risk, lack of reliable infrastructure (embryonic private sector, small number of financial instruments, specialized portfolio management institutions and unqualified investors) and the absence of international accounting standards and appropriate laws to protect minority shareholders.

Although each of the chapters in the thesis has an extensive conclusion, in this final chapter we briefly summarise the results. We have in the first stage examined the contribution of Iran stock market to the development process of Iranian economy in terms of market's performance indicators (market value of the listed shares, total value of traded shares and stock prices Index), market's size and market's liquidity.

Since the efficiency of the stock market in mobilizing and channelling domestic savings and absorbing foreign financial resources is crucial, the weak form efficiency of Iran stock market using various conventional linear (ADF, PP and KPPS) and nonlinear (SETAR and Fourier) unit root tests has been investigated. The empirical results are consistent with the defined hypothesis in chapter three and confirm that Iran stock prices index follows random walk hypothesis even in the presence of endogenous and exogenous break points, and considering possible nonlinear dynamics in the data generating process of Iran stock prices index series. This means that successive price changes in individual securities in this market are independent and the stock price fluctuations are unpredictable.

It is evident that understanding and determination of stock market volatility plays a critical role in portfolio construction, risk management, hedging and the pricing of financial derivatives such as options and futures. For this reason we have modelled the dynamic volatility of Iran stock market in view of underlying data generating process. The examination of distributional characteristics of Iran stock returns series has revealed that the stylized facts (non-normality, fat-tailed, asymmetric and volatility clustering) appear in Iran stock returns data generating process. Confirming the first hypothesis in chapter four, empirical findings have provided the evidence of significant autoregressive conditional heteroscdasticity (volatility clustering) in the underlying data generating process of Iran stock return series. At the same time, empirical results confirm the second hypothesis in chapter four and show the existence of risk-return trade-off (risk premium) parameter in the volatility dynamics of Iran stock market. On the other hand, in contrast with the third hypothesis in chapter four the estimation results and diagnostic tests have shown lack of the asymmetric effect (negative relationship between stock returns movements and future volatility) in Iran stock market.

In view of the dominant role of oil revenues in Iranian economy, it may seem obvious that there should be a significant link between international oil prices and Iran stock market. Consequently, this thesis has examined the effect of fluctuations in oil prices on the behaviour of Iran stock prices. The empirical findings from employing symmetric and asymmetric multivariate GARCH models, contrary to the developed hypotheses in chapter five, have demonstrated the lack of shock and volatility spillover effect from international oil market to Iran stock market. Thus, contrary to intuitive expectation of a significant link between two markets, our results show that Iran stock prices index is not affected by oil price shocks and it is more influenced by its own domestic stochastic environment and the asset pricing process in this market is not affected by originating information from oil market.

7.2. Policy implications

The weak form efficiency of the Iran stock market has important policymaking implications. Since in an efficient stock market equities or other financial instruments are priced fairly and the signalling function of market is reliable, government should consider this market as a main venue for implementing the economic privatization programmes. At the same time, since the stock prices in an efficient market accurately reflect the underlying fundamentals and expectations about future economic environment, policymakers should employ the stock prices as leading indicators of future economic activity in designing economic development plans. In these circumstances, the role of government in the stock market should be very limited.

Since the risk premium is caused by political risk, ambiguousness of economic policy, unstable macroeconomic environments and uncertainty about future, developing public confidence and improving the transparency of national economic situation should be considered in policymaking process of the Iranian economy. At the same time, increasing the liquidity of the Iran stock market would be useful in reducing high risk premium. In view of the existence of volatility clustering phenomenon in Iran stock market, the authorities of this market should pay attention to improve information disclosure system, develop the knowledge level of investors and provide the possibility of creation specialized portfolio management institutions (fund investment) in this market. In this way, discouraging the herding behaviour in stock transactions should be targeted.

The policy implication of the lack of return and volatility spillover effect between Iran stock market and international oil market is that government should pay special attention to the Iran stock market in promoting economic growth programmes, considering this market as a section of the Iranian economy which is independent of the fluctuations in oil prices.

7.3. Future research

This study may be extended in the following ways. First, this study has investigated the weak form efficiency of Iran stock market applying unit root tests and using daily Iran stock prices index. It may be extended by employing other methods or using weekly and monthly data. For instance, using case-study or sub-section (certain companies or particular industries) sample data can be another direction of future studies. Second, another extension can be made by investigating the effects of micro structural or institutional reforms in market on the volatility dynamic of Iran stock return series.

Finally another promising area for future research would be to investigate the effects of fluctuations in international oil prices on the behaviour of stock prices at industry level of Iran stock market.

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