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International interdependence of an emerging market: the case of Iran

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In this study the interdependence between Iran, its major trading partners and the United States is investigated using vector autoregression, generalized impulse response function and generalized variance decomposition techniques, introduced by Pesaran and Shin (1998). These techniques have an advantage over the commonly used impulse response and variance decomposition procedures in that they are insensitive to the ordering of the countries considered and hence, they produce more reliable results. The countries included in the sample, besides Iran are, France, Germany, Spain, Japan, South Korea, Brazil, Italy and the United States. The direction, strength, durability and stability of the effect of shocks in one market on the return patterns of the other markets are examined. The findings are 4-fold. First, the effect of past own market shocks on current behaviour is significant, beyond the first month, in most cases. Second, the own effect is stronger for the emerging markets such as Iran and Brazil, than the industrialized countries. Third, cross-country effects are short-lived for Brazil, Korea and Japan, but durable in the case of Iran, Germany, Spain and the United States. Fourth, in terms of breadth and strength, cross-country effects exhibit differential degrees of interdependence and asymmetry. The observed lack of integration between the Iranian market and the industrialized world makes it less vulnerable to the effect of shocks in the latter countries but it also deprives it from the flow of funds that could spur economic development and growth.

I. Introduction

In the recent decades, the equity markets of the industrial countries have moved toward integration, resulting in an increase in the extent and the speed of spillover of shocks across these markets. The sources of this change include advancement in the information technology, market deregulation, formation of regional trading blocks and policy coordination. In the case of emerging markets, however, this phenomenon is lacking. Indeed, there is evidence that many emerging markets continue to operate in a good degree of isolation, driven largely by own internal dynamics and domestic, political and regulatory forces (Park and Fatemi, 1993; Niarchos *et al.*, 1999).

Determination of the degree of interdependence across markets is important because it provides a measure of sensitivity of the markets considered to the shocks originating from outside, as well as the power of internal forces, in shaping the dynamics of change. Three points are especially noteworthy in this regard. First, it is essential that policy makers account

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for these interdependencies in formulation of their policies in order to shelter their countries from external harm. Second, investors can benefit from knowledge of the character of market interdependence from the viewpoint of diversification in the international market arena (reduction in risk), as well as availability and the cost of capital. In particular, the faster the speed of the spillover of shocks, the smaller the reduction in risk due to diversification and the more isolated the market, the more intense the scarcity of capital will be. Third, the trading partners of each country would want to learn about the outside influences on that country's market, as well as their own sensitivity to shocks originated there.

Assessment of market interdependence is particularly important for the emerging markets, such as Iran, for at least three reasons. First, these markets are highly vulnerable to the effects of shocks in general; in the sense that the extent of the resulting impairment can be substantial. Second, these markets are governed by unstable equilibria that often dominate their dynamics. If these markets are driven to unstable equilibria because of some outside shocks, the impairment may linger on. Third, research on Iran is of interest because this country is highly rich in natural resources, it has a tremendous potential for growth and it plays a strategic role in the Middle-East economic dynamics and world politics. In spite of this, there has been no study about this country's stock market or its interdependence with the rest of the world.

In this study, vector auto regression (VAR), generalized impulse response function (GIRF) and generalized variance decomposition (GVD) techniques are employed to determine the degree of interdependence and the speed of spillover of shocks between Iran, its major trading partners and the United States, as the hub of the world financial markets. The VAR framework can reveal the prevalence of comovement across markets. The GIRF analysis portrays the time pattern of the inter-market effects, determines the speed of transmission of the spillover effects and delineates the points at which inter-market effects will die down to insignificance. The GVD analysis derives the shares of innovations in each country in the system in the overall variation of the Iranian stock market.

The Tehran Stock Exchange (TSE) is a small market operating in a developing country. It is subject to inadequate transparency, poor information dissemination, government ownership, lack, or infrequent, trading of a large number of companies, considerable regulatory restrictions and lack of competition.[1] These features make the market inefficient. Hence, models based on the efficient market assumption, such as the capital asset pricing model (CAPM), are less than adequate for analysis of the TSE data and should be eschewed in favour of data-driven procedures, e.g. VAR and variance decomposition (VD).

In what follows, Section II reviews the literature, Section III discusses the methodology and Section IV describes the data and diagnostics. Section V presents the empirical results and Section VI concludes. The contribution of this article includes investigation of an important emerging market, which has been overlooked in the literature and employment of some newly developed techniques; Generalised Vector Autoregression (GVAR), GIRF and GVD.[2] These techniques have an advantage over the traditional impulse response function (IRF) and VD in that their results are insensitive to the ordering of the countries examined in the model.[3] The main findings in the GVAR context are that monthly own lagged effects are statistically significant for all but two of the countries in the sample (France, Italy) and the extent of interdependence between Iran and its trading partners is quite limited. In the GIRF framework, we find the effect of the shocks to be short-lived (one month) in some cases and enduring (lasting several months) in some other cases, including Iran. According to the GVD analysis, domestic shares are considerable for all countries and remain steady even 2 years after the shocks are introduced. Moreover, domestic shares are much larger for Brazil, Iran, Korea and Japan, than the industrialized countries in the sample. The domestic share figures for the former countries range from

[1] Detailed description of the TSE is available from the authors. Related matters are also discussed in different issues of 'Iran International', 2004 and earlier. The Iranian market is considered to be an emerging market because it is relatively small in size and the Iranian economy is still in the stage of development. Less than 1% of the Iranians actively participate in the stock exchange while the figure is close to 60% in Europe (Payvand's Iran News, 12/22/03). Baier *et al*. (2003) show that opening a stock exchange increases economic growth. However, they find Iran to be an outlier in this regard, possibly because the Iranian revolution, which followed the opening of the stock exchange, led to a major decline in output. They argue that the revolution may be interpreted as a consequence of the opening of the stock exchange.

[2] It is notable that few studies have used the GVAR, GIRF and GVD techniques to examine the issue of interdependence across any set of markets. The few studies using them have not used stock market data. The sensitivity of the results to the variable ordering is briefly discussed is the methodology section.

[3] The results of many studies based on the traditional IRF and VD change substantially in response to changes in ordering of the countries and are, therefore, suspect.

60% to more than 90% while the range for the latter group is around 30–40%. Lack of strong interdependence between the stock market of Iran with other markets protects it from shocks originating in other countries, but also deprives it from international sources of capital, badly needed for its development. This finding also has implications for international portfolio diversification. This issue will be examined in the Results section.

II. Review of Literature

Several channels may lead to interdependence and comovement of stock markets in different countries. It is well-known that trade in capital goods leads to equality of marginal product of capital across trading countries. Given the relationship between stock prices and real marginal product of capital, this in turn results in interdependence of their stock markets. Policy coordination between countries can also indirectly create a comovement between their stock markets. Moreover, speculative activities in currency markets, contagion among financial institutions and portfolio rebalancing across markets, often serve as channels for transmission of idiosyncratic shocks from one market to another.[4] King and Wadhwani (1990) offer the 'private market' hypothesis as an explanation for the comovements across markets. According to this view, players in one market try to extract information privately held by participants in other markets by observing their trade patterns. This results in interdependence across markets, as mistakes in one market get transmitted to others. Harvey and Huang (1991) theorize that it is the 'public announcement' of the news, including policy announcements, rather than 'private information' that brings about comovement across markets. Kodres and Pritsker (2002) focus on portfolio rebalancing as the main mechanism for shock transmission. According to this view, investors respond to shocks in one market by adjusting their portfolio positions in all markets, engendering a comovement across those markets. The pattern and the severity of the shock transmission depend on the level of information asymmetry and sensitivities to macroeconomic risk in each market. The Kodres–Pritsker model can generate contagion even in the absence of news and across markets that do not share macroeconomic risks.

The phenomenon of interdependence across international financial markets has been the subject of extensive empirical investigation both in the short-run and long-run settings. Short-run spillover is examined using techniques such as correlation, VAR, IRF and VD. Examples of studies using simple correlation include Panton *et al*. (1976) and Hilliard (1979). Eun and Shim (1989) use VAR to study the transmission of shocks across nine major stock markets. They find spillover effects to be substantial, multilateral and dominated by the United States[5] Park and Fatemi (1993) report that the stock markets of Pacific-Basin countries show only a small degree of interdependence to those of the United States, the United Kingdom and Japan. Similarly, Elyasiani *et al*. (1998), based on VAR analysis, find little evidence of linkages among the small Sri Lankan equity market and the United States and Asian markets considered in their study. Horvath *et al*. (1998) use a structural VAR model to examine the German disinflationary spillover to France and Italy, all of whom belong to the European Monetary System. They find that the German price shocks did have a spillover effect on the rates of inflation in France and Italy. Fry (2004) has also adopted a structural VAR system to examine the US and Japan impact on Australian economy.

Long-term market interdependence is generally examined within the context of cointegration analysis. Examples include Chan *et al*. (1992), Arshanapalli *et al*. (1995), Ghosh *et al*. (1999) and Chen *et al*. (2002). The first three studies examine the linkages between the United States and the Asian markets. Chen *et al*. (2002) examine the linkages across six Latin American stock markets, including Argentina, Brazil, Chile, Colombia, Mexico and Venezuela. They find that stock prices in the six countries they consider are cointegrated, indicating the prevalence of a stable long-run relationship and conclude that the potential for risk diversification, by investing in these markets is limited.[6] Fernández-Serrano and

[4] Kodres and Pritsker (2002) provide a good review of this literature.
[5] The markets examined are Australia, Canada, France, Germany, Hong Kong, Japan, Switzerland, the United Kingdom and the United States.
[6] A number of studies focus on the effect of crises and turbulence on the interdependence across markets. Some examples are Malliaris and Urrutia (1992), Arshanapalli and Doukas (1993), Arshanapalli *et al*. (1995), Hassan and Naka (1996), Choudhry (1996) and Masih and Masih (1997). The findings of these studies generally denote an increase in interdependence under crisis condition, and significance of interdependence in the post-crisis era. For Iran, it would be interesting to examine the effect of the Iranian–Iraqi war on market interdependence. However, the Iranian market was closed during the war and even for the early post-war period. Hence, the data necessary for this purpose are not available.

Sosvilla-Rivero (2003) examine the relationship between the US and Latin American country stock indices. They find that several cointegrating relationships exist between the Dow–Jones and/or S&P 500 index and the Brazilian, Mexican, Argentine, Chilean and Venezuelan indices, especially once the structural breaks induced by financial crises are taken into consideration.

Another strand of the literature uses the ARCH methodology to investigate contagion across markets. King and Wadhwani (1990) employ an ARCH model and find spillover to be in effect between London, New York and Tokyo equity markets and the private information hypothesis to be operational.[7] Niarchos *et al.* (1999) employ ARCH to examine the relationship between the United States (a large, well-developed market) and Greece (a small emerging market). They find that no spillover exists between the mean and variance of returns of the two markets, either in the short-term, or the long-term. They conclude that the Greek market is segregated. They contend that this lack of inter-market relationship may be due to differences in economic, political and social structures.

Studies of linkages among industrialized country markets do not produce consistent results. Moreover, although the literature in this area is vast, emerging markets continue to receive less than adequate attention. Chen *et al.* (2002) have argued that the investigation of emerging markets may shed new light on market linkages because they provide a separate source of data, which has a low correlation with those of the developed markets and, hence, it can lessen data-snooping biases. No study has examined the interdependence of the Iranian stock market with the rest of the world. This study intends to fill this void.[8]

III. Methodology

A VAR model of order p, or VAR(p), can be presented as:

$$R_{t,k} = C_0 + \sum_{i=1}^{p} \gamma_i R_{t-i,k} + u_t T, \quad t = 1, 2, \ldots, T, \quad k = 1, 2, \ldots, K \tag{1}$$

In this model, R_t is a $m \times 1$ column vector of market returns, C_0 is $1 \times m$ row vector, γ_i $(i = 1, 2, \ldots, p)$ is a $m \times m$ coefficient matrix, m is the lag length and u_t is the $m \times 1$ column vector of independently and identically distributed disturbances with mean zero and covariance matrix Ω for all t. The model has K equations, one for each market. If R_t is covariance stationary, Equation 1 can be rewritten as an infinite moving average process, where R_t is a linear combination of the current and past one step-ahead forecast errors:

$$R_{t,k} = \sum_{i=0}^{\infty} A_i u_{t-I,k}, \quad t = 1, 2, \ldots, T, \; k = 1, 2, \ldots, K \tag{2}$$

The VAR procedure allows the dynamic responses of the markets included in the model to the shocks generated in a given market in the group to be investigated, without imposing any theoretical restrictions (Sims, 1980). In other words, in this framework, the data identify the relationship among the variables, if such relationships do exist. VD and IRF are obtained from the same VAR system. VD analysis explains the forecast error variance of returns in a given market, in response to an innovation in own or a foreign market within the group of markets considered, over a specific time horizon. The response patterns are simulated

[7] Elyasiani and Mansur (2003) examine spillover across the banking markets of the United States, Japan and Germany. The finding is that the spillover effects of volatility in interest rate between the United States and Japan (Germany) are asymmetric, with the United States manifesting itself as a leader. Moreover, unsystematic shocks that harm the banking sector of the country they originate from, are beneficial to the others, namely that banks of different countries act as competitors.

[8] The literature on the TSE is seriously limited and published outside the mainstream journals. A search of the literature using the common search engines produces only one article, Sadeghi (1997). Sadeghi investigates whether the Iranian stock market serves as a hedge against inflation within a regression model, using monthly data over the 1991–1995 period. The findings based on regression analysis indicate that the Iranian stock market does not serve as a good hedge for inflation. Results are also drawn using t-tests for significance of mean monthly, annual and 5-year real returns on gold, foreign currency and equity shares. None of the tests is found to be significant, indicating that these investment vehicles produced zero real returns during the sample period (Table 2). Even the cumulative returns on these investment vehicles are most often insignificantly different from zero. Specifically, the cumulative real returns on gold and foreign exchange never become significant and the cumulative real returns on shares is insignificant, except for a brief period, May 1991 to December 1992 (Table 4). There are also some studies of the Iranian currency and money markets, e.g. Bahmani-Oskooee (1996a, b, 2002) and Bahmani-Oskooee and Shiva (1998).

by introducing one SD shocks to each of the markets in the model and tracing out the normalized responses of these markets over different time horizons. These responses identify the proportions of the overall forecast error variance of a given market return, which can be attributed to shocks in other market returns, as well as its own.

Similarly, an IRF traces the effect of a one-time shock (innovation) to one of the markets on current and future values of all markets, through a dynamic (lag) structure. If innovations are contemporaneously uncorrelated, interpretation of the impulse response is straightforward. Innovations, however, are usually correlated and may be viewed as having a common component, which cannot be associated with a specific variable. Under this condition, a shock in one market will work through the system jointly with the innovations in the other markets, with which it is contemporaneously correlated. It is customary to transform the correlation coefficients among the innovations in the VAR system by orthogonalizing these innovations according to a pre-specified causal ordering. Specifically, the innovations are orthogonalized using a Cholesky decomposition so that the resulting covariance matrix is diagonal.[9] This essentially assumes that the first market in a pre-specified ordering has an immediate impact on all other markets in the VAR system. A shock in the second market in the system has an immediate impact on all markets, excluding the first market and so on. Clearly, the pre-specified ordering of markets is important and can alter the dynamics of the VAR system. This is a major disadvantage of this method and can result in unreliable and nonunique outcomes. To overcome the ordering obstacle, many authors rely on some theoretical argument about the causality relationship between the endogenous variables, i.e. a structural VAR system.[10] Essentially, the structural VAR attempts to identify the VD and impulse responses by imposing *a priori* restrictions on the covariance matrix of the structural errors and the contemporaneous and/or long-run impulse responses themselves. The structural approach has its own problems; not the least of which is the imposition of *a priori* assumptions. As the model gets larger, the number of restrictions gets larger as well. Further, in the case of linkages between equity markets, it would be very difficult to impose a set of sound *a priori* assumptions and to postulate theoretical relationships to cover all the endogenous variables.

The generalized approach to the VAR was developed because of the limitations and problems with both the orthogonalized approach to the VAR and the structural VAR. The concept of generalized IRF was advanced in Koop *et al.* (1996) for nonlinear dynamic systems and applied to linear systems by Pesaran and Shin (1998). The major advantage of this approach is that it does not require orthogonalization of the shocks and it is immune from the problems of variable ordering in the VAR system. In other words, the generalized approach to VD and impulse response analysis are invariant to the ordering of the variables in the VAR model and, therefore, result in a unique solution. We use this generalized framework to carry out the estimation of the model. Given that inefficiencies in the stock markets of emerging markets make the theoretical models based on the assumption of market efficiency inadequate and the fact that no theoretical models concerning the functional form of market interdependence is generally accepted, the data driven VAR methodology is the appropriate framework for the analysis of these interdependencies.[11] An example of the advantage of GVAR is given by Ewing *et al.* (2003), who use it to examine the impact of macroeconomic shocks on the S&P sector indices.

[9] See Hurley and Santos (2001) for an example of application of such orthogonalization.

[10] See Bernanke (1986), Blanchard and Watson (1986), Sims (1986), Shapiro and Watson (1988) and Blanchard and Quah (1989).

[11] Since the details of traditional VAR, GIRF and GVD analysis are available in the literature, they are not repeated here. See Koop *et al.* (1996), Pesaran and Shin (1998) and Potter (2000) for full description of these techniques. See Dekker *et al.* (2001), and Elyasiani *et al.* (2004) for applications of these techniques to financial markets. To select the number of lags, several lag selection criteria including the sequential modified likelihood ratio (LR) test statistic, final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan–Quinn (HQ) information criterion are used. The results of these procedures are found to be inconsistent. Since none of the procedures is clearly superior to the rest, it is desirable to err on the side of a larger, rather than a smaller, number of lags because omitted variable problems due to exclusion of relevant lags would be much more serious than inclusion of possibly redundant ones (Kmenta, 1986). Following this principle, we choose three monthly lags for each country in the model.

Table 1. Market index summary statistics: monthly data May 1991–December 2002

	Brazil	France	Germany	Iran	Italy	Japan	Korea	Spain	USA
Mean	0.097	0.006	0.003	0.024	0.006	−0.005	0.004	0.008	0.007
Median	0.054	0.010	0.005	0.014	0.002	−0.008	−0.004	0.008	0.006
Maximum	1.000	0.134	0.139	0.279	0.166	0.143	0.230	0.153	0.108
Minimum	−0.396	−0.175	−0.239	−0.087	−0.180	−0.118	−0.210	−0.194	−0.113
SD	0.213	0.060	0.058	0.048	0.060	0.046	0.084	0.060	0.035
Skewness	1.354**	−0.295	−0.756**	1.654**	0.173	0.634**	0.299	−0.156	−0.421**
Kurtosis	6.200**	2.855	4.939**	8.833**	3.321	3.721*	3.131*	3.250	4.712**
Skewness/Kurtosis Joint test	33.25**	2.20	17.4*	47.21**	1.80	10.23**	2.61	1.37	10.83**
Jarque–Bera	99.577	2.148	35.265	262.285	1.302	12.397	2.182	0.931	21.219
Probability	0.000	0.342	0.000	0.000	0.522	0.002	0.336	0.628	0.000

Source: IFS.
Notes: The return is the monthly return of each country index. Brazil has a large monthly average return during the sample period (9.7%) but also shows a much larger variation (SD of 21.3%).
The Jarque–Bera procedure tests the null hypothesis of normality.
IFS stands for the International Financial Statistics data series.
*Denotes significance level of 10%.
**Denotes significance level of 5%.

IV. Data and Diagnostics

Monthly share price index data are extracted from the International Financial Statistics (IFS) data series for Iran, its major trading partners and the United States for the period May 1991 to December 2002.[12] Seven major trading partners of Iran with nonmissing/not-reported stock market data are included in the model; France, Germany, Spain, Japan, South Korea, Brazil and Italy. The United States was also included because of its well-recognized leadership in the world financial markets and the fact that Iran's major trading partners are also important trade partners of the United States.

The sample period is chosen to start from May 1991 because data on Iran on the IFS data set begin from that month. This period begins after the era of Iranian–Iraqi war and avoids the subsequent conditions of turmoil in the Iranian market. After adding the United States, the sample includes nine countries and 140 monthly observations for each country. The monthly data is the highest frequency data available from the IFS. Monthly data is also much less subject to noise than higher frequency observations, such as daily and weekly and is expected to produce more reliable results. The possible draw back is that some of the interaction effects may be completed within the month and, hence, may be masked.[13] Thus, the dynamics observed with monthly data frequency may under represent the interdependencies among the countries considered. Table 1 presents the general characteristics of the time series for each country.

Data series are tested for stationarity before the VAR technique is applied. The augmented Dickey–Fuller test (ADF), the modified Dickey–Fuller *t*-test (MADF) and the Phillips–Perron test (PP) are utilized for this purpose.[14] Between ADF and PP, the latter tends to be more reliable in cases of serial correlation. The MADF test, proposed by Elliot *et al.* (1996), also known as the DF-GLS test, is essentially similar to the ADF, except that the time-series is

[12] TSE produces an aggregate index called the All Share Index (TEPIX). This index is not considered to be a true representative of the current state of the market due to changes in the mix of the relevant and highly traded stocks. The IFS indices generally relate to common shares of companies traded on national or foreign stock exchanges. Monthly indices are obtained as simple arithmetic averages of the daily or weekly indices, although in some cases mid-month or end-of-month quotations are used. All reported indices are adjusted for changes in quoted nominal capital of companies. Indices are in general base-weighted arithmetic averages with market value of outstanding shares as weights.
[13] We also obtained daily data on individual firms from the TSE to investigate the interdependence across the markets in the sample. Several problems led us to abandon this effort. First, and most importantly, many listed firms exhibited highly infrequent trading. Indeed, stocks of a large number of firms were not traded for months. As a result, dependable daily data could not be constructed for firms, and even portfolios of firms. Second, daily data for the TSE stocks are subject to a considerable degree of noise. This produces unreliable estimates of measures of market interdependence. Third, the speed of reactions in emerging markets such as the TSE to the world events is small, making lower frequency data suitable for analysis.
[14] See Phillips and Perron (1988).

transformed via a generalized least squares (GLS) regression prior to performing the test.[15] All three procedures are found to strongly reject the null hypothesis that the return series show a unit root, at 1% significance level.[16]

V. Empirical Results

Dependence or interdependence across markets may be due to trade relationship, coordination of policies by respective governments and/or financial flows due to speculative currency activities, contagion among financial intermediaries and international portfolio rebalancing (Kodres and Pritsker, 2002). In the recent decades, these factors have mostly moved in the direction of increasing integration in the industrialized world, leaving most of the developing economies segregated and operating in solitude. Market integration and rapid and substantial spillover of shocks from one country to another implies that there is a strong comovement between the two markets. As a consequence, each market is exposed to the effects of shocks emanating from the other and little is gained from diversification across the two countries. On the other hand, if markets are isolated and, hence, uncorrelated, each market is immune from the spillover of shocks originating in the other but also deprived from capital flows from the latter. In this case, diversification can be fruitful in terms of risk reduction, but only if not undermined by other obstacles. To investigate the degree of interdependence between Iran and its major trading partners, the VAR, GVD and GIRF procedures are applied to the monthly data of these countries over the 1991–2002 period.

Several interesting questions can be asked and answered in the context of VAR and GVD. The first question concerns the relative strength of internal vs. external forces in determination of the changes in market returns. At one extreme, internal forces determine the changes in the market return entirely and the market is segregated from other markets. Most commonly, however, return changes are contributed to by a varying combination of internal and external forces. In this scenario, spillover effects from one market to another engender a comovement between the two, demonstrating interdependence.[17]

The second question concerns the symmetry of the interaction effects across markets. Specifically, the issue is whether the spillover effects are mutual and of equal force (symmetry), or lop-sided and unidirectional, depicting a leadership–followership pattern (dominance). In general, larger, well-developed markets tend to lead the smaller markets, in their region or worldwide and to put forth an asymmetric dominant influence on the latter. Emerging markets tend to be followers and incapable of exerting a considerable impact, except on their own future performance.

The third question concerns the duration of the spillover effects. Do shocks in one market exert a transient (short-lived) effect on other markets such that the inter-market effects are demonstrated merely when the shocks are triggered, or do the effects sustain themselves over a window of time. To investigate this issue, the patterns of the net inter-market effects are examined at several monthly lags, from $t-1$ to $t-24$ (2 years), in order to determine the time-profile of these effects. The fourth question concerns the stability of the effects. Specifically, the question is whether the relative shares of the internal and external forces remain stable over time or do they change from one period to another. These issues will be examined subsequently.

Results based on the VAR model

The VAR results are displayed in Table 2. According to the estimated VAR coefficients, own monthly lagged effects are statistically significant for most of the countries in the sample including Brazil, Iran, South Korea, Japan, Germany and the United States. In all of these cases, internal forces play a significant role in determining the country's stock market returns. With regards to durability, for Brazil, Korea and Japan, the effects of the shocks are

[15] Elliot *et al*. (1996), and subsequent studies have shown that the DF-GLS test has a significantly higher power than the previous versions of the ADF test. The PP test performs a regression of the variable on its lags. The lag number is determined by the procedure as $4*(N/100)^{(2/9)}$, where N is the number of observations in the series. This test tends to be robust to a wide range of serial correlation patterns and heteroskedasticity.

[16] The test-statistics for the test results are not reported here to save space. Country return autocorrelation, partial autocorrelation, and cross-market correlations are also calculated (not reported). According to these figures, autocorrelations for France, Germany and Spain are not significant at any lag, they are significant at 5% level for a few months in the case of Japan, Italy and the United States, and they persist up to 2 years for Iran, Brazil and Korea. Pair-wise correlations are small and insignificant in many cases.

[17] Own market forces include e.g. shocks to the underlying economy, domestic speculation about the stock market and government interest rate and exchange rate policy decisions. Given that only one value is generated for VD shares, a formal test of hypothesis of segregation against the alternative of interdependence is not possible in the VD framework.

Table 2. VAR model of market interdependence

	Brazil		Iran		France		Germany		Italy		Korea		Spain		Japan		USA	
Brazil (-1)	0.327	(3.086)***	0.010	(0.538)	0.016	(0.453)	0.061	(1.856)*	0.088	(2.990)***	0.047	(1.046)	0.044	(1.233)	0.041	(1.666)*	0.033	(1.867)*
Brazil (-2)	0.276	(2.550)*	−0.003	(−0.153)	0.015	(0.436)	0.008	(0.233)	−0.044	(−1.460)	0.020	(0.435)	−0.016	(−0.429)	0.011	(0.435)	−0.022	(−1.252)
Brazil (-3)	0.086	(0.777)	−0.027	(−1.399)	−0.033	(−0.923)	−0.032	(−0.937)	−0.028	(−0.898)	−0.047	(−1.000)	−0.029	(−0.785)	−0.046	(−1.776)*	−0.020	(−1.099)
Iran (-1)	−0.737	(−1.410)	0.373	(4.023)***	−0.058	(−0.345)	−0.065	(−0.402)	−0.109	(−0.753)	−0.360	(−1.632)	−0.086	(−0.482)	−0.202	(−1.659)	−0.088	(−1.017)
Iran (-2)	0.141	(0.241)	0.032	(0.308)	−0.036	(−0.190)	0.113	(0.625)	0.020	(0.126)	0.171	(0.696)	0.017	(0.088)	0.398	(2.929)***	0.157	(1.619)
Iran (-3)	−0.088	(−0.158)	0.275	(2.807)***	−0.113	(−0.634)	−0.143	(−0.835)	−0.072	(−0.469)	−0.134	(−0.576)	−0.140	(−0.747)	−0.187	(−1.456)	−0.097	(−1.058)
France (-1)	0.256	(0.420)	−0.023	(−0.217)	−0.076	(−0.386)	0.093	(0.492)	0.140	(0.827)	0.133	(0.520)	−0.001	(−0.003)	0.257	(1.816)*	0.159	(1.574)
France (-2)	−0.631	(−1.037)	0.023	(0.216)	−0.193	(−0.979)	−0.163	(−0.865)	0.033	(0.193)	−0.171	(−0.665)	−0.121	(−0.587)	−0.120	(−0.845)	−0.126	(−1.244)
France (-3)	0.511	(0.881)	−0.029	(−0.282)	0.101	(0.537)	0.280	(1.557)	0.138	(0.855)	0.174	(0.713)	0.139	(0.708)	0.011	(0.081)	0.054	(0.559)
Germany (-1)	−0.626	(−0.986)	0.146	(1.292)	−0.214	(−1.043)	−0.277	(−1.409)	0.052	(0.293)	0.460	(1.717)*	0.047	(0.218)	−0.075	(−0.509)	−0.042	(−0.399)
Germany (-2)	1.031	(1.630)	−0.065	(−0.583)	−0.066	(−0.321)	0.014	(0.071)	−0.037	(−0.209)	0.210	(0.789)	0.112	(0.523)	0.218	(1.479)	−0.002	(−0.016)
Germany (-3)	−0.781	(−1.250)	−0.032	(−0.291)	−0.312	(−1.539)	−0.580	(−2.991)***	−0.476	(−2.740)***	−0.074	(−0.280)	−0.488	(−2.301)**	0.094	(0.643)	−0.062	(−0.595)
Italy (-1)	0.075	(0.174)	−0.022	(−0.294)	−0.201	(−1.443)	−0.158	(−1.187)	−0.089	(−0.742)	−0.277	(−1.533)	−0.119	(−0.816)	−0.064	(−0.643)	−0.069	(−0.970)
Italy (-2)	−0.214	(−0.508)	0.053	(0.712)	0.036	(0.263)	−0.048	(−0.368)	−0.100	(−0.859)	−0.119	(−0.670)	−0.013	(−0.089)	−0.026	(−0.268)	−0.044	(−0.628)
Italy (-3)	0.246	(0.654)	−0.061	(−0.910)	−0.018	(−0.144)	0.033	(0.282)	0.034	(0.325)	−0.168	(−1.058)	0.045	(0.349)	−0.022	(−0.251)	−0.084	(−1.351)
Korea (-1)	0.113	(0.451)	0.000	(−0.002)	0.077	(0.947)	0.070	(0.896)	0.010	(0.139)	0.340	(3.209)***	0.107	(1.260)	0.089	(1.524)	0.078	(1.861)*
Korea (-2)	0.270	(1.055)	0.004	(0.081)	−0.126	(−1.527)	−0.109	(−1.369)	−0.031	(−0.429)	−0.028	(−0.263)	0.029	(0.338)	−0.061	(−1.019)	−0.095	(−2.239)**
Korea (-3)	−0.137	(−0.541)	0.032	(0.715)	0.020	(0.244)	−0.012	(−0.152)	−0.025	(−0.351)	0.042	(0.393)	−0.100	(−1.169)	0.140	(2.364)**	−0.009	(−0.210)
Spain (-1)	0.157	(0.315)	−0.034	(−0.380)	0.318	(1.971)**	0.222	(1.438)	0.339	(2.445)**	−0.178	(−0.846)	0.045	(0.264)	0.036	(0.313)	0.162	(1.959)*
Spain (-2)	−0.544	(−1.059)	−0.039	(−0.430)	0.114	(0.683)	0.197	(1.233)	0.132	(0.922)	−0.072	(−0.332)	0.025	(0.142)	−0.005	(−0.043)	0.085	(0.992)
Spain (-3)	0.392	(0.784)	0.011	(0.119)	0.294	(1.815)*	0.427	(2.757)***	0.265	(1.912)*	−0.264	(−1.252)	0.323	(1.907)*	−0.026	(−0.225)	0.027	(0.328)
Japan (-1)	−0.558	(−1.269)	0.106	(1.355)	−0.111	(−0.778)	0.028	(0.208)	0.191	(1.560)	0.141	(0.759)	−0.003	(−0.023)	0.228	(2.226)**	−0.088	(−1.213)
Japan (-2)	0.352	(0.755)	0.038	(0.463)	0.022	(0.145)	0.000	(−0.003)	−0.019	(−0.150)	0.205	(1.040)	−0.127	(−0.804)	0.071	(0.652)	0.169	(2.188)**
Japan (-3)	−0.213	(−0.473)	−0.112	(−1.396)	0.071	(0.488)	−0.006	(−0.044)	−0.070	(−0.561)	−0.264	(−1.388)	−0.038	(−0.250)	−0.100	(−0.954)	−0.093	(−1.238)
USA (-1)	−0.166	(−0.221)	−0.247	(−1.856)*	0.345	(1.418)	0.034	(0.147)	−0.448	(−2.149)**	−0.251	(−0.794)	−0.166	(−0.651)	−0.331	(−1.895)*	0.009	(0.068)
USA (-2)	−0.878	(−1.112)	0.019	(0.136)	0.333	(1.300)	0.305	(1.244)	0.417	(1.899)*	−0.311	(−0.933)	0.177	(0.662)	−0.119	(−0.647)	0.065	(0.498)
USA (-3)	0.180	(0.244)	0.161	(1.234)	0.140	(0.588)	0.166	(0.725)	0.254	(1.244)	0.289	(0.932)	0.260	(1.044)	0.121	(0.708)	0.302	(2.478)**
C	0.047	(1.813)*	0.010	(2.086)**	0.003	(0.390)	−0.005	(−0.614)	0.003	(0.444)	0.014	(1.303)	0.009	(1.016)	−0.004	(−0.590)	0.005	(1.112)
R-squared	0.387		0.422		0.181		0.234		0.407		0.305		0.129		0.300		0.373	
Adj. *R*-squared	0.229		0.273		−0.029		0.036		0.254		0.126		−0.094		0.120		0.212	

Notes: Rows represent sources of the shock. Columns show the markets affected.
t-statistic are in brackets.
*Indicates 10% significant level.
**Indicates 5% significant level.
***Indicates 1% significance level.

short-lived; they last only 1 to 2 months (one to two lags), while for Iran, Germany, Spain and the United States, the effects are more durable; they remain potent even after 3 months.

In terms of breadth and strength, cross-country effects are dissimilar across different countries indicating differential degrees of interdependence and asymmetry. Specifically, the United States, Japan and Italy demonstrate significant relationships with several other countries, while the developing countries such as Iran and Korea show a relationship with only one other country. One explanation for this finding is that the developing markets considered here are not strongly linked in terms of information transmission, nor very suitable outlets for liquidation of assets in portfolio rebalancing actions. Hence, shock transmission across these markets remains limited. The policy implication to be drawn here is that the governments in the emerging markets need to take steps to ameliorate the liquidity of their markets and to improve the quality of the information transmission mechanism between their countries and others, in order to further the integration of their economies with those of their trading partners.

This finding also shows a contrast between industrialized and developing countries in regards to degree of isolation vs. integration. Moreover, this result is intriguing because it contradicts the common finding that the United States market exerts a considerable influence on other markets. The results in Table 2 suggest that the United States influence is somewhat limited to the industrialized world and its leadership role does not always extend to developing countries. It must be pointed out, however, that during this period, the United States and Iran lacked political and trade relationships. This may be a major factor leading to the lack of a considerable interdependence between their stock markets. Moreover, it is unlikely that investors choose Iran, as an alternative to the United States, for the purpose of portfolio rebalancing, in response to shocks in the latter market. The explanatory power of the model is dissimilar for different countries and weak in the cases of France and Spain. This is an indication that factors other than lagged own- and cross-returns (e.g. structural factors) do play a role in describing market return performance and their inclusion may improve the model fit.

The duality in market integration between the industrialized and emerging markets is worth emphasizing; while the former markets may indeed be moving toward increased integration, most of the latter continue to remain in isolation with little movement toward the same end. This is unsurprising and very consistent with the existing literature (Park and Fatemi, 1993, Elyasiani *et al*., 1998 and Niarchos *et al*., 1999). The possibility should not be ruled out, that these markets may have actually moved towards increased segregation because they remain behind in terms of acquiring the new trading technology, deregulation of foreign client investment, privatization of government-owned companies, etc.[18] Political tensions exacerbate this trend. Certain developing countries occasionally choose, for political and religious reasons, to limit their trade with the industrialized countries in favour of other developing nations, or at least they avoid trade partners such as the United States or the United Kingdom. For example, Arab countries and Iran have at times limited their trade with the United States and the United Kingdom in response to the United States and the United Kingdom positions on the Arab–Israeli conflict (Habibi, 2003).[19] These moves have deepened the isolation and segmentation of their economies from those of the latter countries.

Findings on asymmetry of the effects have implications on the leadership–followership issue. The relationships estimated here are in some cases unidirectional and in all cases asymmetric. This indicates that the spillover effects from one country to another are dissimilar to those in the reverse direction. It is noteworthy, however, that the monthly data frequency used here is likely to have impacted the results. In particular, for the more developed countries, it is likely that much of the spillover effects occur within the month and, hence, with a good probability, monthly data fail to capture them.[20]

Results based on GIRF and GVD

The IRF trace the dynamic responses of the markets in the model to innovations in a given market, where innovations are introduced as one-SD shocks.

[18] In a similar vein, Klaassen (2000) has found that, since the 1980s, currency markets in the western world have moved toward increased segregation (looser links), rather than further integration, due to increased volatility in these markets.
[19] As a recent example of religious forces driving political and economic actions on the part of Iran, the Iranian president, Ahmadinejad, called for Israel to be wiped out from the face of the earth (CNN.Com, 27 October 2005). The president then added: 'And God willing, with the force of God behind it, we shall soon experience a world without the United States and Zionism,' according to a quote published by IRNA. One million Iranians marched in support of Ahmadenejad's position the same week. Iran has also barred trade with Israel since the Iranian revolution of 1979.
[20] This loss in information has to be balanced against the noisiness of the data in higher frequency sampling.

IRF responses delineate the speed of adjustment of the markets in the model to the shocks and the points at which the effects die down. This allows the direction and the speed of the effects to be marked out and the extent of persistence (durability) of the impact to be determined. VD analysis shows how the forecast error for each series at a given horizon is decomposed into shocks in each of the variables in the VAR model.

The patterns of the GIRF effects are examined over 24 lags (months). This period is long enough for the shocks to be absorbed even for some less-developed economies included in the current sample. The GIRF results for the model used here are graphed in Fig. 1. The GVD results are presented in Table 3.

A few interesting results emerge. First, for the more developed countries (United States, Japan, Germany, France, Spain and Italy), all GIRF shock effects are absorbed within a short period of time. More specifically, the shock effects for most of these countries die down within the first 2 to 3 months after the shock is introduced, with a few lingering on for a while longer. In no case, however, do these effects persist beyond 5 months. Second, for developing economies in the sample (Brazil, Iran) the GIRF effects of the shocks persist much longer, lasting up to 2 years. The effect of a Korean shock seems to be closer to those of the developed countries, rather than those of the developing economies, namely, Iran and Brazil.

Third, for all the countries included in the sample, self-shocks have the largest effects. In other words, shocks to a country will have the biggest influences on future returns of the same country and smaller effects on other countries. Moreover, in no case the effect of shocks from another country has a bigger effect than those of the own shocks, for either the developed or developing countries.

In brief, a main difference between the industrialized and developing economy markets is the endurance of the shock effects on market returns. The effects for the former group are smaller and short-lived, while for the latter group, the effects are long lasting, with the effects failing to taper off or die down. Outside shocks on the Iranian market are found to have little effect both in the short- and the long-term. This result indicates that transfer of information from other markets to Iran is rather inefficient. These properties can be best illustrated by the graphs in Fig. 1.[21]

The findings here are in accord with Harvey (1995) who finds that the performance of emerging markets is more likely to be influenced by local information, than those of their developed market counterparts. He concludes that inclusion of assets from emerging markets will significantly reduce portfolio volatility and increase expected returns. Our findings also support Harvey's position that standard global asset pricing models, based on the assumption of complete integration of markets, cannot explain the cross-section of returns in emerging markets. Prevalence of regulatory restrictions on stock ownership by foreign residents, exchange rate regulation, opaqueness and inadequate information transmission lead to further deviation of the portfolio effects from those prescribed by the established asset pricing theories. Active oversight and promotion of competition on the part of these emerging countries is a remedial step in this regard.

The GVD results are presented for four different lags; 1-month, 3-month, 6-month and 12-months (Table 3).[22] The GVD results confirm the findings based on the GIRF. The figures in Table 3 clearly show that own effects or internal forces are considerable in magnitude for all countries at all lags considered. A clear distinction, however, does present itself when results are contrasted across the countries in the model. According to the figures in Table 3, internal forces are much stronger for Iran and Brazil, than for the other countries considered. Indeed, for Iran, between 83 and 95% (depending on the number of lags chosen) of the total variance is contributed to by the internal factors. This leaves around 5–17% of the total variation in the Iranian market to be explained by all other countries in the sample. The own-share for industrialized countries such as the United States, Germany, France, Italy and Spain, is much lower (30–40%). Even Korea, which is not highly industrialized, demonstrates a much smaller own-effect than Iran and Brazil, while its effect is much larger than those of the industrialized countries. Japan, though highly industrialized, is still largely driven by domestic forces, with those forces constituting more than half of the total variance.

These results suggest that the stock markets of Brazil and Iran are much more segregated (isolated) from the world markets, than those of the developed countries. Hence, these markets may be classified as almost exogenous or autonomous. In contrast, all the developed countries show significant effects from shocks emanated in other countries, demonstrating a

[21] GIRF table is too long and not included here.
[22] The values for other lags are left out to make the table more readable.

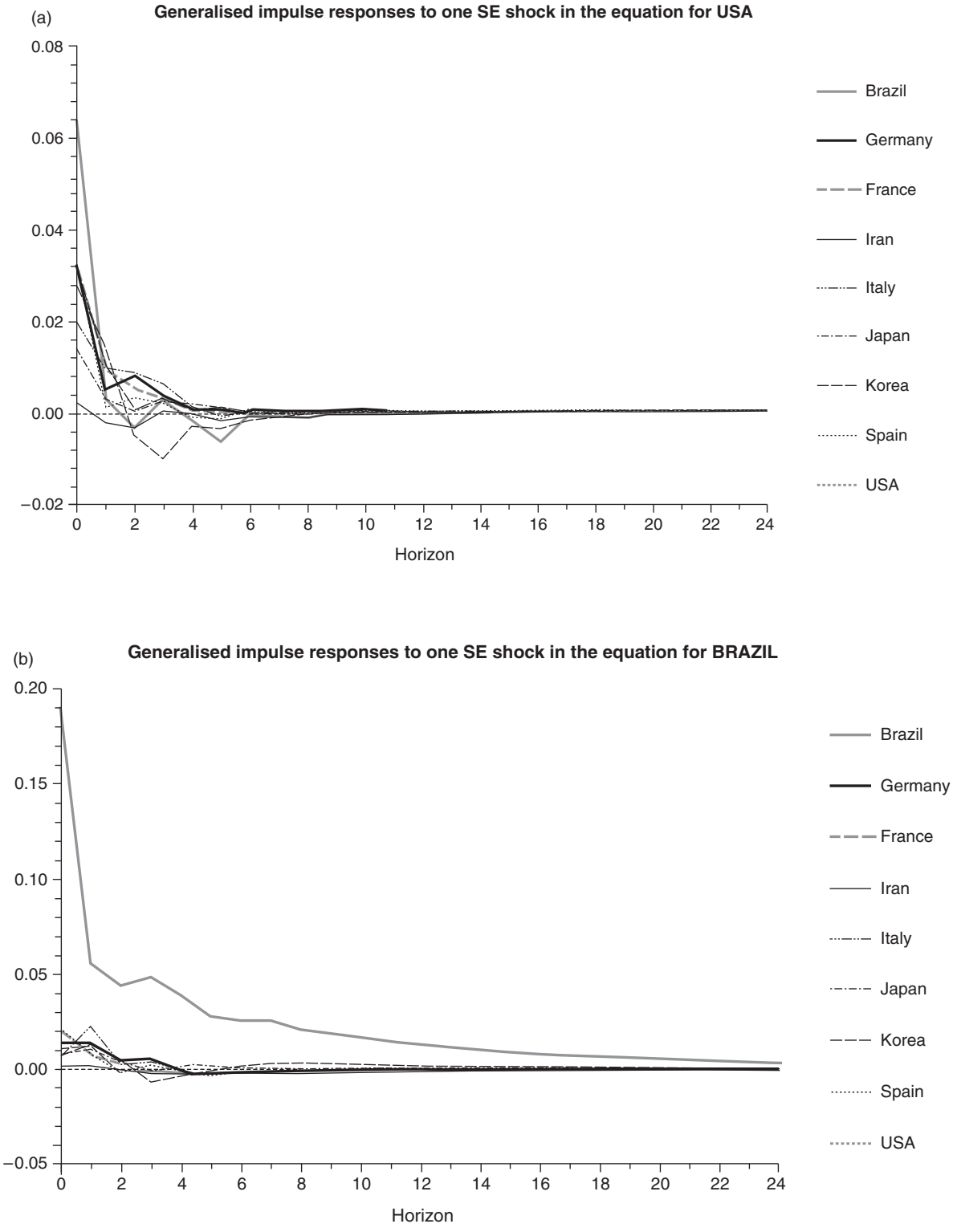


Fig. 1. Generalized impulse response function result

higher degree of openness and exposure. One explanation for the largely autonomous dynamics of the Iranian stock market is that outside investment in Iran is still subject to many restrictions as well as serious political risk. Exchange rate risk engendered by government's control of the foreign currency values during the sample period only adds to these impediments.

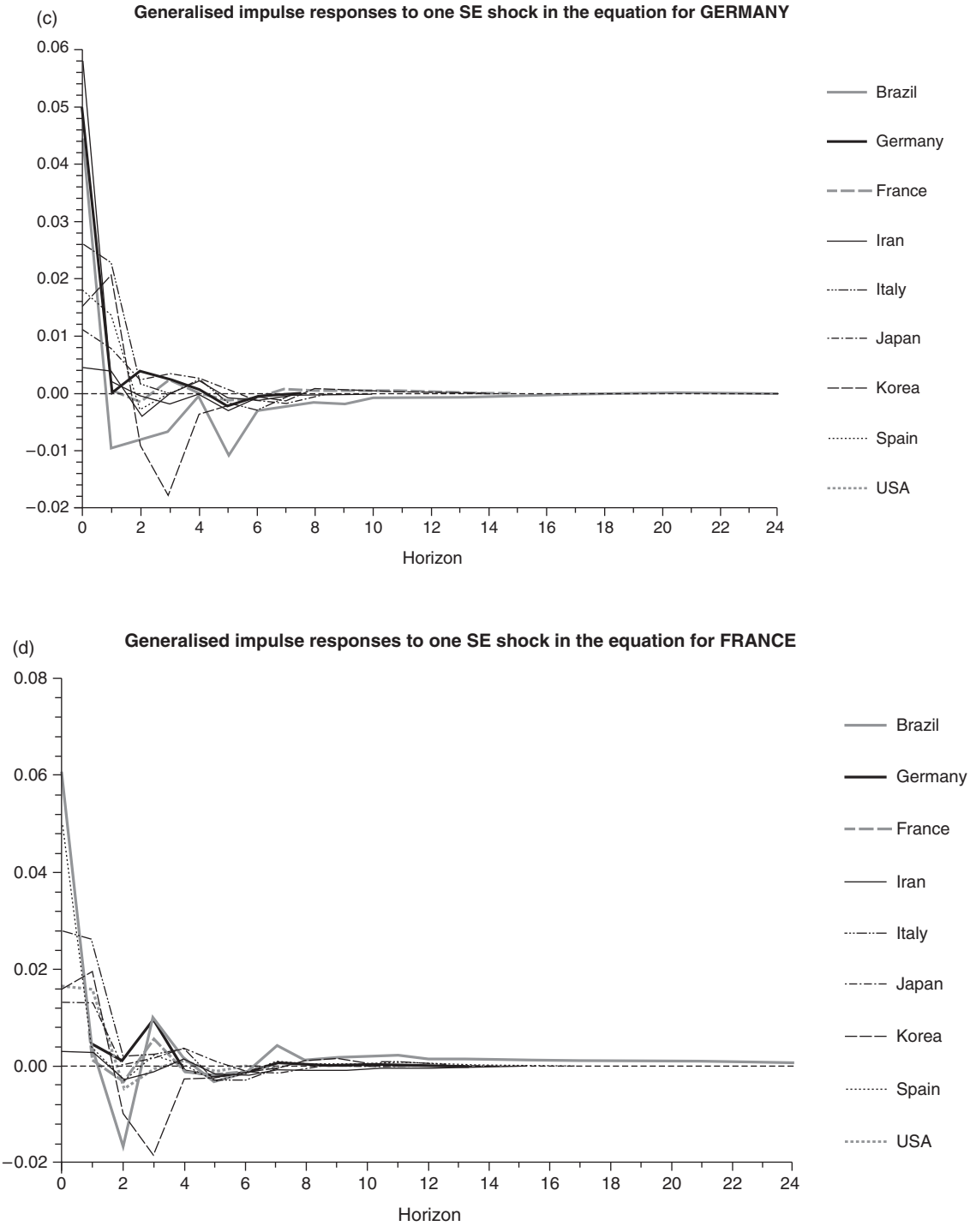
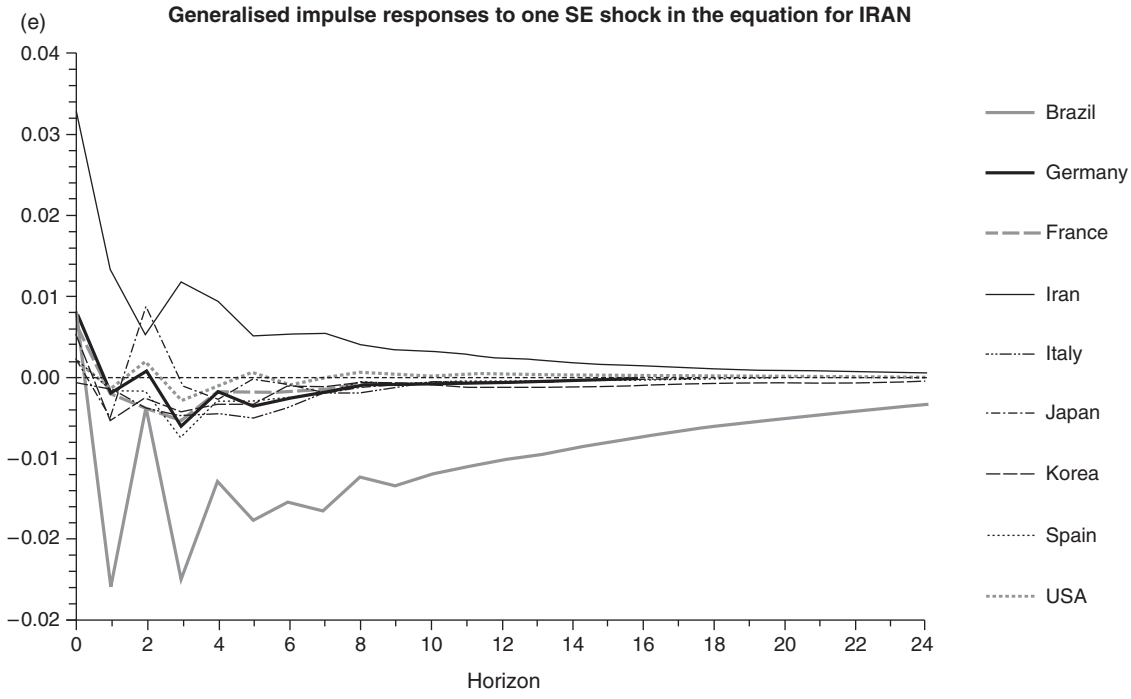


Fig. 1. Continued

The inter-market effects vary across countries, with some countries exerting a dominant influence on others and some wielding little impact. Moreover, the effects from some countries are unidirectional while the relationship between some others shows a mutual or bi-directional impact. Countries with strong and unidirectional impact may be classified as 'leaders' in the sense that the effect between them and other countries is asymmetric; their impact on others is much stronger than the impact they receive from the latter markets. Among the countries included in the sample, Brazil and Japan show bi-directional effects



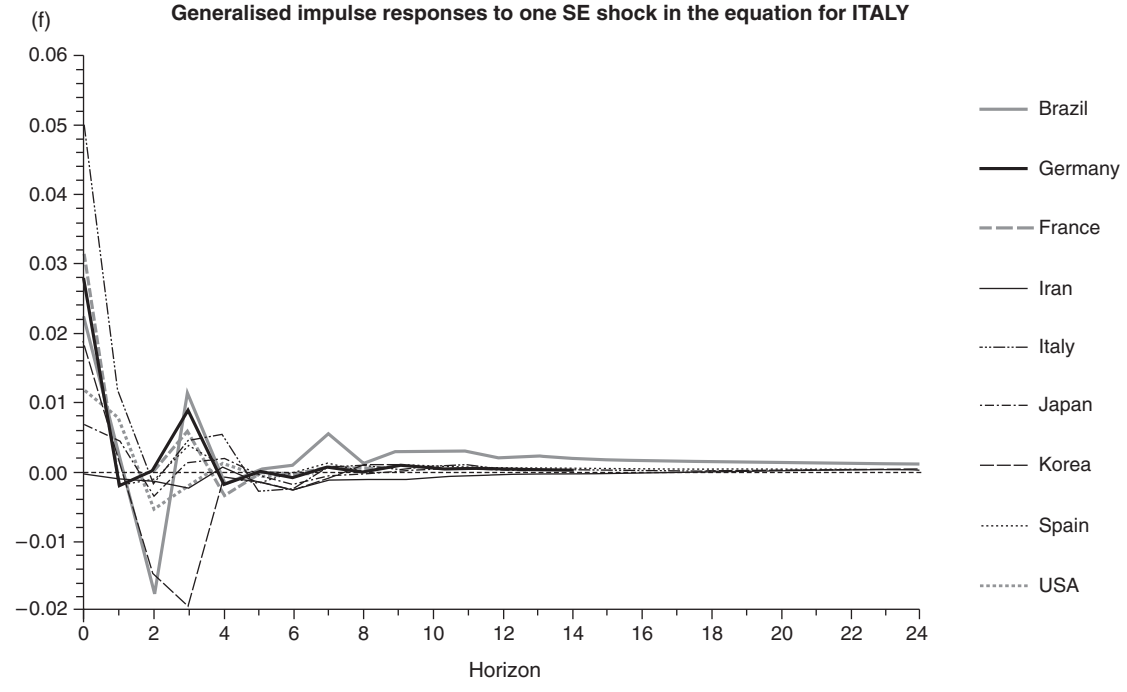
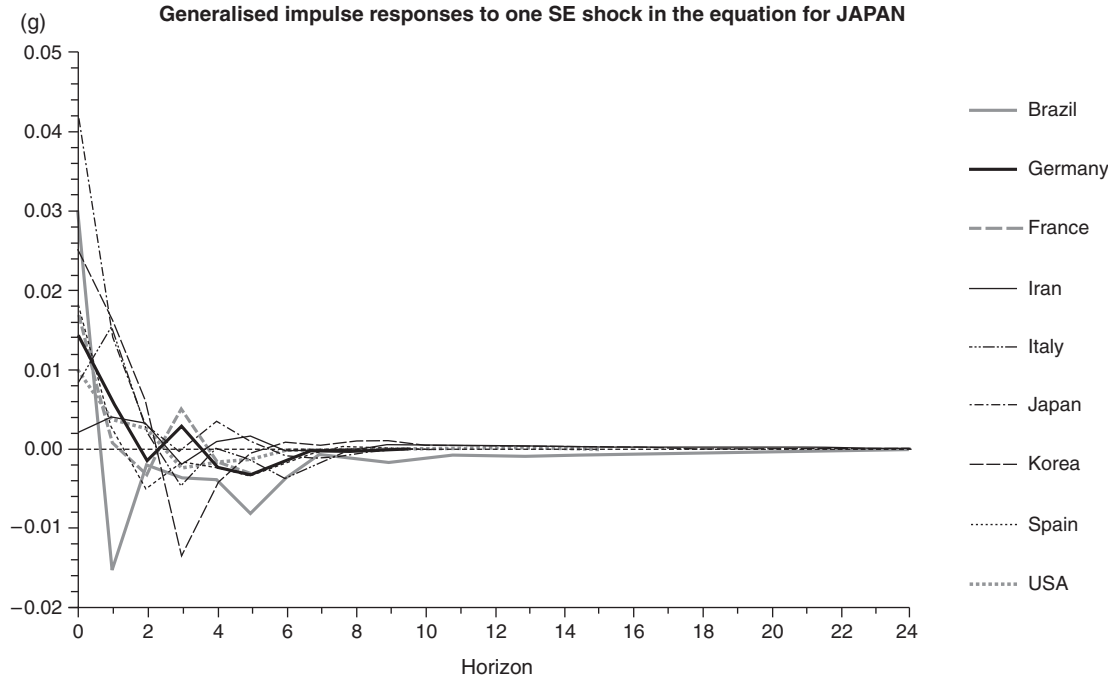


Fig. 1. Continued

of similar force with Iran. The magnitude of these effects is small (less than 5%) but these are still the strongest effects exerted on Iran from any of its trading partners. There is no single country in the sample that exerts a strong effect on Iran, or receives one from it. The external effects on the industrialized countries are stronger than those observed in the developing economies. However, no clear pattern of dominance or leadership is observed.

The isolation of the Iranian economy and lack of strong interdependence between the stock market of this country with other markets implies that it is



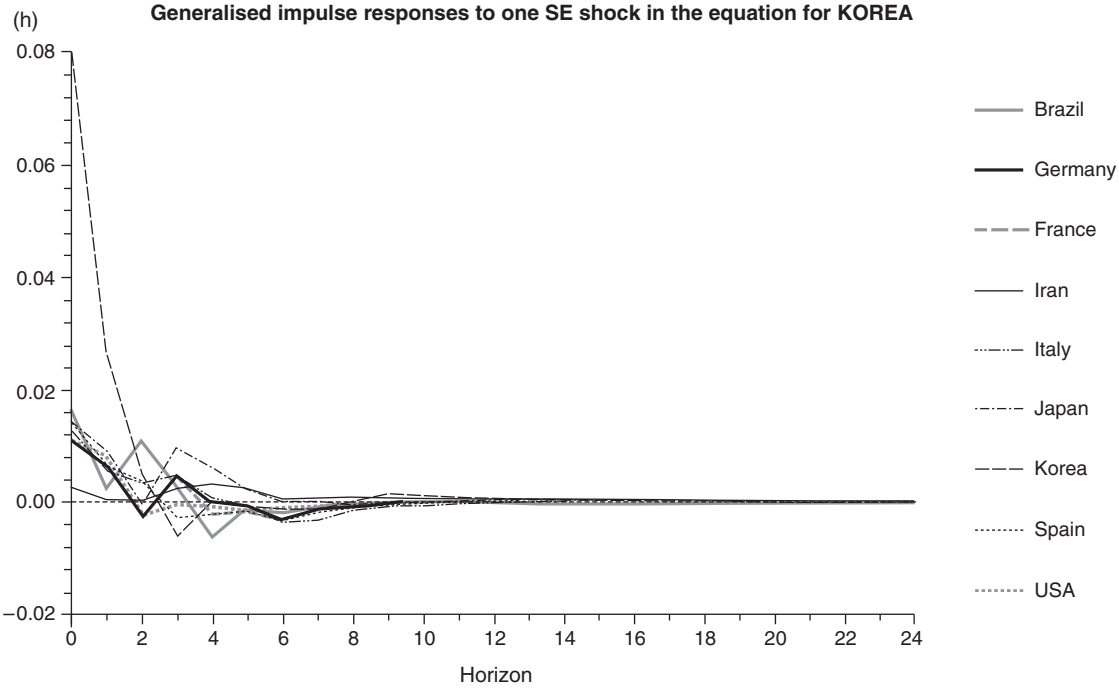


Fig. 1. Continued

not directly and immediately affected by the crises in world financial markets such as the Asian or the Russian crises. The negative side of this phenomenon, however, is that the cost of capital in this country is higher than it would have been if it were integrated with other markets and more easily accessible to outside investors. Given the political, regulatory and technological obstacles, the Iranian

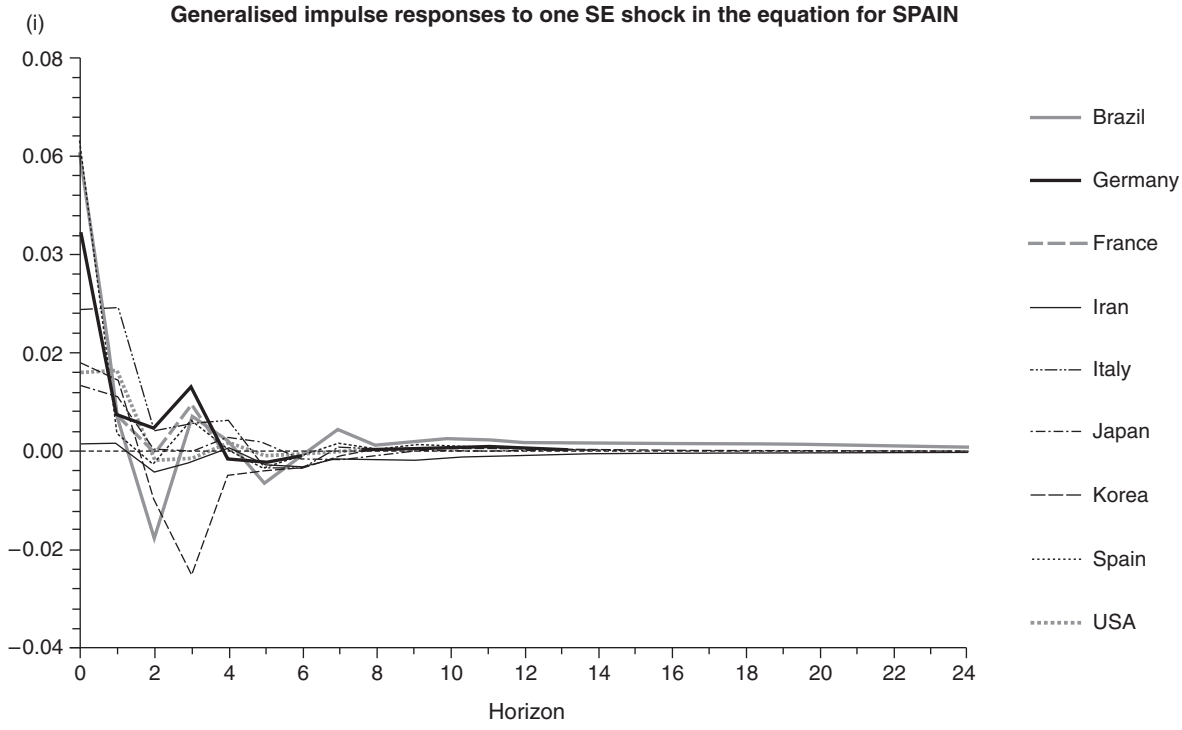


Fig. 1. Continued

Table 3. Generalized Forecast Error Variance Decomposition (GVD) Results

Market	Horizon	Brazil (%)	France (%)	Germany (%)	Iran (%)	Italy (%)	Japan (%)	Korea (%)	Spain (%)	USA (%)
Brazil	1	**69.71**	7.20	4.10	0.17	1.03	2.00	0.53	7.06	8.19
	3	**69.67**	6.82	3.86	1.33	1.44	2.16	0.68	6.81	7.22
	6	**69.89**	6.32	3.74	2.90	1.50	2.10	0.68	6.28	6.58
	12	**69.71**	6.01	3.57	4.34	1.50	2.01	0.65	5.98	6.22
	24	**69.37**	5.92	3.51	5.07	1.51	1.98	0.65	5.90	6.11
France	1	3.30	**31.94**	23.24	0.27	9.06	2.75	1.32	19.52	8.60
	3	3.65	**31.16**	22.59	0.41	8.87	2.78	1.84	19.43	9.26
	6	3.66	**30.64**	22.05	0.72	9.01	3.03	2.05	19.75	9.09
	12	3.71	**30.58**	22.00	0.77	9.00	3.04	2.13	19.72	9.07
	24	3.71	**30.57**	22.00	0.77	9.00	3.04	2.13	19.72	9.07
Germany	1	1.91	23.57	**32.39**	0.59	8.06	2.06	1.12	19.68	10.62
	3	3.75	22.66	**31.06**	0.60	7.74	2.28	1.51	19.46	10.93
	6	3.87	22.46	**29.79**	1.04	8.12	2.39	1.64	20.13	10.55
	12	3.88	22.41	**29.69**	1.14	8.11	2.41	1.78	20.08	10.51
	24	3.88	22.41	**29.68**	1.14	8.11	2.41	1.78	20.08	10.51
Iran	1	0.24	0.80	1.73	**95.76**	0.01	0.33	0.57	0.11	0.44
	3	0.34	1.76	3.50	**88.77**	0.21	2.10	0.47	1.46	1.39
	6	1.18	1.86	3.17	**86.33**	0.61	2.14	1.50	1.92	1.30
	12	2.46	2.09	3.02	**83.67**	1.20	1.96	1.45	2.77	1.38
	24	2.91	2.09	2.96	**83.16**	1.27	1.94	1.46	2.85	1.37
Italy	1	0.71	13.70	12.02	0.01	**48.33**	1.22	2.88	14.33	6.79
	3	6.41	16.39	13.50	0.18	**32.49**	3.60	2.34	18.81	6.27
	6	6.44	16.03	13.07	0.92	**31.85**	3.72	2.51	18.97	6.49
	12	6.44	15.94	13.01	1.14	**31.52**	3.85	2.77	18.90	6.42
	24	6.43	15.94	13.01	1.16	**31.51**	3.85	2.77	18.90	6.43

(*continued*)

Table 3. Continued

Market	Horizon	Brazil (%)	France (%)	Germany (%)	Iran (%)	Italy (%)	Japan (%)	Korea (%)	Spain (%)	USA (%)
Japan	1	1.90	5.72	4.21	0.23	1.68	**66.33**	6.96	5.94	7.03
	3	4.64	8.72	5.06	2.84	2.14	**55.84**	7.41	7.70	5.65
	6	4.65	8.55	5.22	2.90	2.16	**53.16**	10.21	7.51	5.64
	12	4.65	8.59	5.32	3.04	2.26	**52.72**	10.12	7.64	5.65
	24	4.68	8.59	5.32	3.06	2.27	**52.68**	10.12	7.64	5.65
Korea	1	0.53	2.89	2.42	0.42	4.17	7.34	**69.90**	3.48	8.85
	3	1.86	6.11	5.94	0.63	4.97	8.12	**58.65**	5.16	8.57
	6	2.00	7.75	7.40	0.81	6.91	8.29	**49.77**	9.00	8.07
	12	2.25	7.75	7.37	0.85	6.94	8.26	**49.49**	9.05	8.04
	24	2.32	7.74	7.36	0.90	6.93	8.25	**49.43**	9.04	8.03
Spain	1	3.37	20.30	20.18	0.04	9.85	2.97	1.66	**33.22**	8.40
	3	3.85	20.09	19.86	0.08	9.73	3.18	2.10	**32.77**	8.35
	6	3.94	19.84	19.60	0.65	9.68	3.28	2.18	**32.58**	8.25
	12	3.95	19.80	19.54	0.74	9.67	3.29	2.29	**32.49**	8.23
	24	3.95	19.79	19.54	0.75	9.67	3.29	2.29	**32.49**	8.23
USA	1	5.01	11.48	13.98	0.20	5.99	4.52	5.40	10.79	**42.63**
	3	7.15	15.45	14.81	0.31	6.54	3.63	5.71	14.88	**31.52**
	6	7.35	15.27	14.55	0.58	6.63	3.85	5.70	14.75	**31.32**
	12	7.47	15.23	14.51	0.62	6.62	3.83	5.76	14.73	**31.22**
	24	7.52	15.22	14.51	0.63	6.61	3.83	5.76	14.72	**31.20**

Notes: Entries in row *i* show the share of each market in the forecast error VD of the market given on the left-hand side. These shares must add up to 100. Entries in column *j* show the contribution of the market listed in the column heading to the VD of the market on the left-hand side.

market may not be a good choice for international portfolio diversification, in spite of its segregated nature.

VI. Conclusion

This article examines the interdependence between the Iranian stock market, those of its major trading partners and the United States. VAR, GVD and GIRF methodologies, are employed to investigate the nature of interdependence across these countries and to determine the direction, strength, durability and stability of the effect of shocks in one market on the return patterns of the other markets considered. The general finding is the considerable effect of the past own market shocks in determining the current behaviour of most of the countries examined. This effect is particularly strong for the emerging markets such as Iran and Brazil and to a lesser degree, Korea and even Japan. The evidence concerning Japan is consistent with the existing literature. Lack of integration between the Iranian market and the industrialized world makes it less vulnerable to the effect of shocks originating in those countries but it also deprives it from the flow of funds that could spur economic development and growth. The TSE has recently taken steps to allow more foreign investment, improve transparency, enhance supervision effectiveness, expand the range of activities and improve the organizational structure of the market. These steps are expected to advance competition, boost market efficiency and increase capital flows to the Iranian economy. A detailed study of the Iranian stock market and its interdependence with the trade relationship between this country and its trade partners are interesting subjects for future research.

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