Efficiency, Risk, and Events in the Tehran Stock Exchange

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Abstract

This paper analyzes market index returns in the Tehran stock exchange (TSE) within the context of three variants of the Capital Asset Pricing Model: the static international; the constant-parameter intertemporal; and a Markov-switching intertemporal CAPM, which allows for the degree of integration with regional and international equity markets to be time-varying. We find that TSE returns are CAPM-efficient at monthly, but not at daily, frequency. Moreover, we find evidence in support of international integration of the TSE. We conduct event studies for TSE returns to examine the impact of local, regional, and international non-market events. We find that TSE returns are sensitive to non-market factors, such as changes in administration, international events, and war.

Keywords: Emerging and frontier markets, Event study, GARCH, ICAPM, Iran, Markov switching, Volatility.

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1 Introduction

Since the mid-1990s, there has been growing interest in emerging and frontier financial markets among both financial scholars and practitioners. One of the least studied emerging or frontier markets is the Tehran Stock Exchange (TSE), the sole equity market in the Islamic Republic of Iran. Very little is known about the features of this market. In our study, we address some basic questions about market risk and index returns behavior in this under-studied market.

A study of the TSE would naturally contribute to the literature on emerging markets finance in general, and Middle East and North Africa (MENA) financial markets in particular. While emerging markets have attracted considerable attention in the finance literature since the early 1990s, for example see Bekaert and Harvey (2003); the MENA region is relatively understudied. The most comprehensive recent study is Cheng et al. (2010). We follow Cheng et al. 's methodology very closely. In this paper, we analyze Tehran stock exchange index excess returns to test for efficiency of this market, via three variants of Sharpe (1964) and Lintner (1965) capital asset pricing theory (CAPM). We first test for the static international CAPM, following Lintner (1965). The objective is to measure the ability of this classical variant of CAPM to explain the behavior of excess returns in the TSE. We find that at the monthly frequency, TSE excess returns are CAPM-efficient.

Second, following the seminal work of Merton (1973) and the voluminous literature that it generated, we test for constant-parameter intertemporal CAPM model in TSE returns. We find that using conventional measures for risk-return trade-off, we can not find a statistically significant positive market price of risk in TSE excess returns.

Third, based on the seminal work of Bekaert and Harvey (1995), we study the level of integration of the Tehran stock exchange with international financial markets, using a Markov-switching intertemporal CAPM which allows for the degree of integration international equity markets to be time-varying. Our empirical findings, surprisingly, support a considerable degree of market integration for the Tehran stock exchange. Cheng et al. (2010) find evidence of international integration for Bahrain, Israel, and Turkey, but not other MENA markets in their study. Thus, based on our empirical evidence, the Iranian market behaves more like three arguably more open markets than other neighbors in the MENA region. Finally, we conduct event studies for TSE returns data to examine the potential impact of local, regional, and international non-market events. We find statistically significant evidence in support of sensitivity of TSE excess returns to economic and non-economic events.

If investment in a frontier market such as Tehran stock exchange is an objective for investors seeking to diversify their portfolios, then some knowledge of the basic properties studied in this paper are necessary. We believe that finance research community would find some of our findings, such as the level of efficiency at monthly frequency for a market populated by naive investors and prone to insider information trading, to be pleasantly surprising. Hence, we believe that a rigorous empirical study of this virtually unknown market is interesting and informative.

Among the very few studies that look at the Iranian equity market, Foster and Kharazi (2008) study the issues of efficiency and profitability of momentum strategies in TSE returns for the 1997-2002 period. They find evidence in support of efficiency at the weekly frequency, but not at the daily frequency. Our findings are inline with their conclusion regarding efficiency at lower frequencies. Hakim and Rashidian (2009) attempt to study the impact of events on TSE returns. Their study, however, has severe methodological shortcomings. We use the standard event study methodology to address the questions that they raised.

We also briefly review other recent studies of the MENA region's financial markets. None of these studies include the TSE in their sample. Errunza (2001) focuses on the liberalization and integration of financial markets in Egypt, Israel, Jordan, Morocco, and Turkey. Ghysels and Cherkaoui (2003) study trading costs in Morocco. Lagoarde-Segot and Lucey (2008) study information efficiency in seven MENA markets and find heterogeneous levels of efficiency. Billmeier and Massa (2009) study the role of oil reserves, remittances, and institutions besides the traditional factors, and find that they appear to play a role in the determination of market capitalization in the MENA and Central Asian financial markets. Alsubaie and Najand (2009) investigate the informational role of trading volume in predicting the direction of short-term returns for the Saudi Stock Exchange. Two recent studies, Billmeier and Massa (2008) and Jahan-Parvar and Waters (2010), study formation of financial bubbles in the MENA region.

The rest of the paper proceeds as follows. In Section 2, we briefly review the history of TSE activities. We discuss the data used in this study in Section 3. In Section 4, we study the efficiency of TSE in an international CAPM and international factor model setting. Risk-return trade off and dynamics of market returns volatility are the subject of Section 5. We test whether TSE is integrated or segmented from the international financial system and report the test results in Section 6. We study the impact of several important events on TSE returns in Section 7. Section 8 concludes.

2 A Brief Introduction to the Tehran Stock Exchange

The Tehran Stock Exchange (TSE) began operation in February 1967. It experienced robust growth in its first decade of operation. The number of listed companies increased from six in 1967 to 105 in 1978. Similarly, TSE's market capitalization increased from USD 885 million to USD 3.4 billion during the same time period. A number of factors contributed to the rapid growth of the TSE during this period. In particular, relative political stability, the land reform (also known as the White Revolution), a push towards the development of manufacturing sector, rapid rise in crude oil prices, and tax exemption status of listed companies are among the most important contributing factors.[1]

The Islamic revolution of 1978 and Iraq's invasion of 1981 reduced exchange activities significantly. By 1982, market capitalization fell to about USD 149 million. Following the ceasefire of August 20, 1988 in the Iraq-Iran war, the TSE gained prominence as a mechanism for channeling savings into investment, and fostering Iran's efforts towards economic reconstruction and development.[2] As a result, the number of listed companies increased from 56 in 1982 to 306 in 2000. Since 2000, the performance of the TSE has followed two distinctive patterns Hakim and Rashidian (2009). The 2000-2004 period witnessed brisk performance in the TSE, with its market capitalization growing from USD 34 billion to USD 411.5 billion, and the Tehran Price Index (TEPIX) reaching an all time high of 13,882 on August 4, 2004. However, a severe market correction brought the index down 35% to 9069 on July 26, 2006. By 2007, the market capitalization rose above its level in 2004. However the number of listed companies was still below its 2004 values due to merger and acquisition activities.

The post-2000 Iranian economy has been subject to several internal and external shocks which may have influenced the TSE's performance. First, the economy has been subject to numerous external sanctions imposed by the United States and/or the United Nations. We discuss these sanctions in Section 7. Hakim and Rashidian (2009) provide a detailed discussion of punitive sanctions on Iranian companies and entities.

Second, a number of other external events may have also potentially affected the performance of the TSE, including (a) the sharp rise and the subsequent fall in crude oil prices in 2000-2008 period; (b) the September 11, 2001 terrorist attacks in the U.S. and (c) the subsequent U.S. war on terror in two of Iran's neighboring countries – Iraq and Afghanistan.

[1] See TSE website: http://www.iranbourse.com.

[2] Iran and Iraq have not signed a peace treaty as of September 2010.

Third, the Iranian economy has also been subject to a number of internal financial, policy, and political shocks with potential effects on the TSE performance. In particular, one may emphasize the following events. First, we note the imposition of stricter disclosure rules on the TSE in 2002 to improve transparency. Second, the tax law of 2003, which reduced marginal tax rates from 50% to 35%. Third, the 2004 amendment to the Article 44 of the Constitution which allowed privatization of 80% of the state assets. Of these, "Justice Shares" scheme gets 40% and the rest are planned to be publicly offered at the TSE.[3] The government retains ownership of the remaining 20%. Under the privatization plan, 47 oil and gas companies (including PetroIran and North Drilling companies) worth an estimated USD 90 billion are to be privatized by 2014.[4] Finally, we note the election of President Ahmadinejad in 2005 and the change in administration's attitudes towards the TSE.

3 Data

We use daily and monthly returns data from the TSE, Dow Jones, and MSCI (formerly, Morgan Stanley Capital International) in this research. The binding constraint in our study is the availability of online historical data from the TSE. We could obtain daily data from TSE web site only from March 30, 1998 to April 25, 2006. TSE provides three indices: TEPIX is the market price index. TEDPIX is a total returns index which includes dividends. There is also an Industrial Index that does not include service sector shares such as banks, investment or insurance companies. We use the *Dow Jones World Index* and *MSCI Emerging Markets Index*, (EM), available from *Thomson Reuters Datastream.* Daily data on the EM index does not cover the pre-2004 period, hence we just use this index in our study of monthly returns. There are two MSCI price indices available: the MSCI price index, which reports only changes in prices of the stocks used in the construction of the index, and the MSCI total return index, which uses paid dividends in addition to price changes to construct the index. We use both indices in this study to keep the results consistent with the construction of the data.

TSE data is expressed in Iranian Rials (IR), while the available international data is in U.S. Dollars. We transform the IR-denominated returns to USD-denominated returns, using IR-USD exchange rate data from the Central Bank of Iran. Officially, the IR-USD exchange

[3] "Justice Shares" is a plan to transfer ownership of state owned industries equitably among all Iranians, especially the poor. We do not know how successful this plan is or the state of progress of the plan.

[4] See Iran Daily newspaper: http://iran-daily.com/1387/3234/html/economy.htm.

rate was fixed at 1,750 IR per 1 USD until March 18, 2002.[5]

Since Iran follows the Persian calendar which differs substantially from the Gregorian calendar, we matched the trading day data from the TSE to Dow Jones or MSCI index data. We constructed the monthly data by matching the corresponding TSE data to the last trading day in the Gregorian calendar. Our proxy for the risk-free rate is the daily 3-month secondary market US T-bill rate from the Federal Reserve Bank of St. Louis FRED II database.[6]

Summary statistics of the data are presented in Table 1. As is immediately seen on this table, the TSE data have relatively lower returns, higher volatility, larger negative skewness, and substantially larger excess kurtosis in comparison with international and emerging market index returns.

4 Static International CAPM and Factor Models

We are interested in testing market efficiency in TSE returns. The workhorse model of modern equity pricing since the 1960s has been CAPM. It comes in many flavors and our initial choice is the Sharpe (1964) and Lintner (1965) variation. This model states that the expected excess returns of an asset are linearly dependent on excess market returns. Empirically, the systematic risk of the asset is estimated by regressing its excess returns on some measure of excess returns of a broad equity market measure. To apply the model to an international setting, we regress the TSE excess returns on excess returns of an index composite of international markets.

The Sharpe (1964) and Lintner (1965) formulation of the international CAPM is given by:

$$r_t = \alpha + \beta r_t^W + \epsilon_t \tag{1}$$

where r_t is the TSE market excess return over the 3-month T-Bill rate, r_t^W is the world market excess return over the 3-month T-Bill rate, and ϵ_t is assumed to be a white noise innovation process. As mentioned earlier, we use the *DJW* and *MSCI Emerging Markets* index returns as a proxy for world market returns and the 3-month US T-bill rate as a proxy for the global

5 Since March 2002, foreign exchange market has not been a "free floating" market. The Central Bank of Iran and other government entities routinely intervene in this market. While we admit that the exchange rate data we use may have some potential shortcomings, it is the only available data set that meets our criteria of length, frequency, and uniform method of collection.

6 Iran does not have an independent central bank. Moreover, Iranian government bonds are not risk-free due to Iran's confrontational foreign policy. Hence, we follow the long-standing tradition of using the 3-month T-Bill rate as the risk-free rate.

risk-free rate. The above variant of the international CAPM assumes there is no exchange-rate risk. Under certain conditions, exchange-rate risk is not priced independently from market risk; see, for example, Adler and Dumas (1983).

A necessary condition for a market to be CAPM efficient is $\alpha = 0$. If $\beta = 0$, then the market is segmented from the international capital market. International CAPM results are presented in Table 2. The models were estimated by OLS and Newey-West HAC standard errors were computed; see Newey and West (1987).

The empirical results show that with monthly DJW returns as a predictor, in the plain vanilla international CAPM, the monthly $\hat{\alpha}$'s are not significantly different from zero at conventional significance levels for all three index returns. Since monthly $\hat{\beta}$s are significantly different from zero at conventional significance levels across the three index returns, this implies that monthly TSE returns are CAPM efficient with respect to a broad international market index. Moreover, the estimated parameters are statistically "close". That is, they are within one standard error of each other.

Once we change the predictor from DJW returns to EM returns, this CAPM efficiency is lost. Neither the monthly $\hat{\alpha}$'s are significantly different from zero at conventional significance levels, nor are the $\hat{\beta}$s. Interestingly, estimated parameters based on daily data are not statistically significant, using DJW returns.

Based on these observations from Table 2, we conclude that there seems to be positive and statistically significant correlation between TSE and broad international market returns at the monthly frequency. Moreover, this relationship seems to be CAPM-efficient. This efficiency and statistically significant correlation is lost once we study the relationship between the TSE and other emerging or frontier markets. Even more interesting is the fact that sampling frequency seems to be quite influential on the regression results. While monthly results using DJW returns are statistically significant, daily results using the same independent variable are not. One possible explanation, based on "delayed reaction" hypothesis of Hong and Stein (1996), is that market participants in the TSE incorporate new information relatively slower than what is observed at the international level.[7] We do not address the issue of reaction to availability of new information in the TSE and leave this question for future research. Another explanation is that similar to the conclusions reached by Foster and Kharazi (2008), the Tehran stock

[7]Other studies that use empirical methodologies based on this hypothesis include Hong et al. (2007) and Fan and Jahan-Parvar (2010).

exchange may suffer from problems such as insider trading and other inefficiencies at higher sampling frequencies, such as daily frequency, but closing prices at weekly and monthly levels seem to be efficient.

There are well-documented criticisms to CAPM and two remedies are often considered. The most common approach is to use the Fama and French (1996) methodology. We can not use this method since Fama-French factors are not available for the TSE. As an alternative, we use a variant of multifactor models. A classic example is Chen et al. (1986), who link stock market performance to a set of well-known macroeconomic factors. We postulate that oil prices have an impact on market performance in the 5^{th} largest oil exporter in the world. Thus, we use the growth rate of oil prices. We also considered Hamilton (1996) net oil price increase (NOPI) over the preceding four months. Further, we allow for the possibility that there is a correlation between TSE returns and international macroeconomic factors such as changes in one of the international measures of the risk-free rate, or in case of a major commodity exporter, fluctuations in the USD exchange rate against other major international currencies. To this end, we include changes in 3-month T-Bill rates, and changes in exchange rates between the USD and the British Pound, the Japanese Yen, the Swiss Franc, and the Euro.[8] These series are all available from the Federal Reserve Bank of St. Louis FRED II data bank.

In the next step, we test whether augmenting the model with the factors discussed above affects these results on asset pricing efficiency and capital market integration obtained with the simple international CAPM; exclusion of these factors can be a source of omitted variables bias. The factor model is given by:

$$r_t = \alpha + \beta r_t^W + \sum_{j=1}^{J} \delta_j F_{t,j} + \epsilon_t, \tag{2}$$

where the factors $F_{t,j}$ are the log differences in the daily spot oil price, the squared log differences in the spot oil price, the squared world market excess returns, Hamilton (1996) "NOPI" measure, changes in 3-month T-Bill rates, and changes in exchange rates between the USD and British Pound, Japanese Yen, Swiss Franc, and the Euro.[9]

[8]In case of the Euro, we had to trim the data set since the Euro/USD exchange rate is available only since January 1999.

[9]We used West Texas Intermediate spot oil prices from the US Department of Energy's database as our oil price measure. We acknowledge the criticisms raised by Kilian (2008) about using net oil price changes as a predicting factor for both macroeconomic and financial models.

As it turns out, none of these factors help in improving the performance of the international CAPM model. In general, either their impact is not statistically significant, or their inclusion in the model is not supported based on a combination of likelihood-ratio tests, the Akaike information criteria, and the Bayesian information criteria. To save space, we do not report these results. However, they are available upon request.

5 Constant-Parameter Intertemporal CAPM

Merton (1973) extended the static CAPM of Sharpe (1964) and Lintner (1965) to an intertemporal framework which allows for a changing set of investment opportunities. In his intertemporal CAPM (ICAPM) specification, the expected conditional excess return for market i should vary positively with its conditional variance:

$$\mathbb{E}_{t-1}[r_t^i] = \mu + \lambda \mathrm{Var}_{t-1}[r_t^i], \tag{3}$$

where the parameter λ is the coefficient of relative risk aversion of the representative agent.[10] λ is also referred to as the risk premium associated with market risk. If the intertemporal CAPM holds, then $\mu = 0$.

To investigate whether there is a risk-return trade-off of the intertemporal CAPM form in TSE, we fit two specifications of GARCH-in-Mean models to the excess returns series.[11] In this case, the conditional mean for the excess returns in market is given by:

$$r_t = \mu + \lambda h_{t-1} + \varepsilon_t, \tag{4}$$

where $\varepsilon_t = \sqrt{h_t} e_t$, $e_t \sim N(0,1)$, and h_t is the conditional variance of r_t. The workhorse model in this literature is the GARCH-in-Mean (GARCH-M) which postulates that the volatility process follows the GARCH dynamics of Bollerslev (1986). In Bollerslev (1986) GARCH(1,1) formulation for conditional volatility, h_t follows:

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \tag{5}$$

[10]This conditional single-factor formulation follows under the assumption that the variance of the change in wealth is much larger than the variance of the change in the state variable with which wealth varies; see Merton (1980).

[11]We are aware of a study on the risk-return trade-off in TSE returns, Sinaee and Moradi (2010). However, the methodology of the paper does not follow the mainstream analysis of risk and returns.

We refer to equations (4), and (5) jointly as an GARCH-M model.

Bekaert and Harvey (1997) emphasize that equity returns in emerging markets exhibit substantial asymmetry in volatility, possibly due to a leverage effect in which firms' leverage increases with negative returns. Accordingly, we use the Exponential GARCH (EGARCH) model of Nelson (1991) to allow for such asymmetry.

$$\ln(h_t) = \omega + \alpha g(z_{t-1}) + \beta \ln(h_{t-1}) \tag{6}$$

$$g(z_t) = \theta z_t + \delta[|z_t| - \mathbb{E}|z_t|], \tag{7}$$

where $z_t = \varepsilon_t/\sqrt{h_t}$ and $\delta = 1$. We refer to equations (4), (6), and (7) jointly as an EGARCH-M model.

Estimation results for fitting TSE excess returns using GARCH-M and EGARCH-M formulations, are reported in Table 3. As is immediately seen in Panel A of Table 3, simple GARCH-M does not fit the data well, regardless of whether we use monthly or daily sampled data. In particular, two important GARCH parameters, $\hat{\alpha}$ and $\hat{\beta}$, are statistically not significantly different from zero. On the other hand, as is seen in Panel B of Table 3, the estimated EGARCH parameters, $\hat{\omega}$, $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\theta}$, are generally significantly different from zero at conventional confidence levels. Based on these results, there is significant asymmetry in the impact of "bad" vs. "good" news in TSE returns, based on estimated values of θ. This so-called "leverage effect" is more pronounced for daily excess TSE returns.

That said, the main parameter of interest, $\hat{\lambda}$, is either statistically not significant, is negative, or both, for all estimated models. The single instance where $\hat{\lambda}$ is significantly different from zero is for daily industrial index returns data, and even then it has a negative sign (implying a negative relationship between risk and return) and the value of the estimated parameter is close to zero. Since this parameter reflects the risk-return trade-off in TSE, these results seem disappointing at the first glance. One may interpret these results as a) no evidence of a systematic risk-return trade-off in TSE data, or b) for the single statistically significant $\hat{\gamma}$, as a counterintuitive negative relationship.

We need to emphasize that if ICAPM is the "correct" model, then intertemporal CAPM is mis-specified. Second, several new findings in the literature show that variations of GARCH-M models with symmetrically distributed innovations may not be the best way to model the risk-return trade-off. In particular, results of Rossi and Timmermann (2009) and Feunou et al. (2010) imply that there exists strong evidence of higher moments asymmetry in returns, which leads to counter intuitive empirical results like those seen here.

6 Markov-Switching Intertemporal CAPM

International finance theory includes an active line of research studying market integration versus segmentation. Some examples related to our study include Bekaert and Harvey (1995), Harvey (1995), Bekaert and Harvey (1997), and more recently Bekaert et al. (2008). The thrust of this line of research is the study of country-specific versus global pricing of risk premia. As noted by Bekaert and Harvey (1995), empirical evidence suggests that expected returns of assets with the same level of exposure to risk factors are influenced by their "nationality." Such results are consistent with incomplete equity market integration. Cheng et al. (2010) apply this methodology to Middle Eastern and North African financial markets. We follow their methodology in our study of integration vs. segmentation for TSE returns.

Bekaert and Harvey (1995) propose a conditional regime-switching model which generalizes the Sharpe (1964), Lintner (1965), and Merton (1973) asset pricing models to allow for time-varying weights on local and global pricing of an asset. We use this framework to study the extent to which the TSE degree of integration with world capital markets changes across time.

Let S_t be a latent state variable for a market which can take on two values, with $S_t = 1$ denoting that market is integrated with international equity markets in observation t and $S_t = 2$ denoting it is segmented. Define:

$$\phi_{t-1} = \text{Prob}(S_t = 1|\mathcal{F}_{t-1}), \tag{8}$$

where $\mathcal{F}_{t-1}$ is the observation $t-1$ information set. As before, let r_t and r_t^W be, respectively, the excess return for the target market and the world market. Bekaert and Harvey (1995) model r_t as:

$$r_t \quad = \quad \phi_{t-1}\lambda_{t-1}^W \text{Cov}_{t-1}[r_t, r_t^W] + (1-\phi_{t-1})\lambda_{t-1}\text{Var}_{t-1}[r_t] + \varepsilon_t, \tag{9}$$

where λ_{t-1}^W and λ_{t-1} are the time-varying risk premia associated with world market systematic risk and country-specific idiosyncratic risk.[12] While the above framework allows the probability of integration, ϕ_{t-1}, to vary across time, we assume that the transition probabilities $p_{1,1} = \text{Prob}(S_t = 1|S_{t-1} = 1)$ and $p_{2,2} = \text{Prob}(S_t = 2|S_{t-1} = 2)$ are constant. Time variation in the risk premia is allowed as follows:

$$\lambda_{t-1}^W \quad = \quad \exp(\psi_W{}' Z_{t-1}^W) \tag{10}$$

$$\lambda_{t-1} \quad = \quad \exp(\psi' Z_{t-1}), \tag{11}$$

[12]Following Bekaert and Harvey (1995), we do not include an intercept term in equation (9).

where ψ_W and ψ are parameter vectors, and Z_t^W and Z_t are vectors of state variables that capture world market information and country-specific information at time t. We also consider the case in which the risk premia λ^W and λ are constant:

$$\lambda^W = \exp(c_1) \tag{12}$$

$$\lambda = \exp(c_2). \tag{13}$$

Through use of the exponential function in (10)-(11) and (12)-(13), we constrain each risk premium to be positive.

We estimate the model, in both the constant risk premia and time-varying risk premia cases, by maximum likelihood. Estimation is carried out in two stages. First, we compute $\text{Var}_{t-1}[r_t]$ and $\text{Cov}_{t-1}[r_t, r_t^W]$ using a rolling window estimation scheme.[13] Second, we form the likelihood function according to the model in equation (9) and maximize it. To avoid local optima, we perturb our starting values and re-estimate the model 50 times for each excess returns series.

Following Bekaert and Harvey (1995), we use a set of global and local instrumental variables as components of, respectively, Z_t^W and Z_t, to study the behavior of the time-varying risk premia in TSE. The global instrumental variables we use are the log differences on the DJW market capitalization, the default spread captured by changes in the difference between Moody's Aaa and Baa bond yields, changes in the yields on US commercial paper, and the term structure spread captured by the difference between the US 10-year bond and 3-month T-bill yields.[14] These variable are designed to capture fluctuations in expectations of the world business cycle. The local instrumental variables we use include the returns on the market index, changes in market dividend payments, and changes in market valuation.

We find that including Z_t^W and Z_t, and hence allowing for time-varying premia, does not improve the estimation results significantly. As a result, we only discuss the results obtained through estimation of the constant risk premia model.

[13]We fix a sub-sample period of m days for calculating the variance of r_t and the covariance between r_t and r_t^W, and roll the sample one day forward to compute for the next pair of statistics. In order to find a sensible value for m, we look at the estimated partial autocorrelation function of the squared excess returns and include all the lags that have a significant impact on the current level.

[14]The default spreads, US commercial paper yields, and term structure data are all from the FRED II data bank maintained by the St. Louis FED. The maturity of the default spreads data is 30 years and the maturity of the commercial paper yields is 3 months.

We are interested in the behavior over time of the estimated probabilities of integration, i.e., ϕ_{t-1} for the TSE. High values of these probabilities show that pricing of assets in the TSE is done primarily with respect to the covariance of TSE returns with the world market excess return (integration), and low probabilities imply mostly local pricing of risk (segmentation).

Estimation results are reported in Table 4. We use two measures for TSE returns, TEPIX and TEDPIX, which represent the price index returns and total returns, respectively. We use TEPIX excess returns in conjunction with DJW price index returns, and TEDPIX excess returns in conjunction with DJW total returns.

The top panel in this table reports the descriptive statistics for filtered probabilities of international pricing, $\hat{\phi}_t$. As is seen, regardless of the measures of international and Iranian price index returns used, these summary statistics indicate almost equal weighting between international and local in pricing TSE returns. Transition probabilities are reported in the middle panel. We find that using TEPIX and DJW excess returns, both states are significant and persistent. On the other hand, with TEDPIX and DJW total return index excess returns, while both estimated transition probabilities are statistically significant, $\hat{p_{22}}$ is far less persistent.

Estimated values for risk premia are reported in the bottom panel. Notice that following Bekaert and Harvey (1995), we restrict the value of the risk premium to be positive. That said, the estimated values for risk premia using TEPIX and TEDPIX returns are comparable to those in neighboring countries, reported by Cheng et al. (2010). An interesting pattern is visible in this panel. If we use TEPIX excess returns, while the risk premium associated with the world market systemic risk is statistically insignificant, the estimated value of this parameter is very similar to those reported in Cheng et al. for Bahrain and Kuwait. Similarly, estimated value for local risk premium, $\hat{\lambda}$, is close to those reported by Cheng et al. for Morroco and Oman. Moreover, this parameter is statistically significant at the 5% level. Once we use the excess returns of the TEDPIX index, statistical significance results switch: now $\hat{\lambda}^W$ is statistically significant at the 1% level, but $\hat{\lambda}$ is no longer statistically significant at reasonable levels. Notice that the size of estimated parameters are still comparable to those of other MENA countries studied by Cheng et al.

7 Event Studies for TSE

In this section, we study the impact of events on the excess returns. This line of research is essentially an empirical test of the "efficient market hypothesis" (EMH) of Fama (1965). Specifically, if strong or semi-strong forms of EMH hold, then a news announcement should not have an impact on excess returns of a firm. If they do, such impact may be viewed as evidence against EMH. Usually, a sample is broken down into pre-event, event, and post-event periods, and excess returns are analyzed and compared across these periods. For an excellent overview of this methodology, refer to MacKinlay (1997) and Campbell et al. (1997).

A typical application of this methodology is concerned with market related news announcements, such as mergers and acquisitions, macroeconomic announcements, stock splits and buybacks, or financial distress news, among many others. In our study, however, we consider the impact of economic and non-economic news on aggregate market index excess returns. We provide a description of these events in Section 7.1. Hakim and Rashidian (2009) conduct a study of the impact of U.S. government sanctions on the performance of TSE-listed stocks. We incorporate the set of sanction dates from their study in ours. Their analysis, however, suffers from theoretical and empirical shortcomings documented by Doornik and Ooms (2008). Thus their results are not reliable.

In the next step, we provide a brief description of events study methodology, based on the "market model", discussed in MacKinlay (1997), among others. This method is based on the statistical analysis of residuals from regressing asset excess returns on market excess returns. Based on the results presented in Table 2 and discussed in Section 4, we use DJW index returns as the proxy for world market returns, r_t^W.

We then split the sample into three segments called estimation, event, and post-event windows, respectively. Sample size is important, since each window needs to be large enough to allow for reliable estimation. Hence, we conduct our event studies analysis using daily data only. The alternative approach of using monthly data inevitably leads to windows with very few data points.

Our estimation window has 600 data points, or approximately two and a half trading-years worth of data. This means that we use the 600 data points preceding the event window to establish the estimated parameters. We use an event window with 120 data points. That is, we choose an event window such that there are 59 trading days before and 60 trading days after the event date. This sample selection policy leads to roughly over five months of trading in this window. We then fit the following model using OLS and observations in the estimation window, and save the estimated parameters:

$$r_{i,t} = \alpha + \beta r_t^W + \epsilon_{i,t}, \tag{14}$$

where i corresponds to the estimation window and $\epsilon_{i,t} \sim (0, \sigma^2_{\epsilon_i})$. We then form the out of sample disturbances of the market model using

$$AR_\tau = r_\tau - \hat{\alpha} - \hat{\beta} r_\tau^W, \tag{15}$$

where τ belongs to the event window. Variance of AR_τ is given in Eq. (9) in MacKinlay (1997). For the interval $[\tau_1, \tau_2]$ in the event window, following MacKinlay (1997), we define the cumulative abnormal returns as

$$CAR(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_\tau. \tag{16}$$

Similarly, variance of $CAR(\tau_1, \tau_2)$ is given by

$$\sigma^2_{CAR(\tau_1,\tau_2)} = (\tau_2 - \tau_1 + 1)\sigma^2_{\epsilon_i}. \tag{17}$$

For a suitably chosen event window, under the null hypothesis of no abnormal returns, $CAR(\tau_1, \tau_2) \sim N(0, \sigma^2_{CAR(\tau_1,\tau_2)})$. We set τ_1 and τ_2 to be the start and the end point of the event windows in our study. Thus, the relevant test statistic is

$$\eta = \frac{CAR(\tau_1, \tau_2)}{\sqrt{\sigma^2_{CAR(\tau_1,\tau_2)}}}. \tag{18}$$

Under the null hypothesis of no abnormal returns, asymptotically $\eta \sim N(0, 1)$. We view the rejection of the null hypothesis as evidence in favor of the existence of abnormal returns due to the event studied.

7.1 Important Events

We now briefly discuss the important events considered for our analysis. We include two events from Hakim and Rashidian (2009), the renewal of the Iran-Libya Act of 1996 on August 5, 2001, and the U.S. Department of the Treasury's sanction against scientific exchanges with Iran on February 9, 2004. Other sanction dates used in their study are not useful due to differences in frequency and length of data sets.

Liberalization of IR exchange rate had profound effects on both TSE returns and on the Iranian economy in general. Attacks on the World Trade Center on September 11, 2001 had far-reaching political and economic effects across the world. We believe that the start dates of two wars in neighboring Afghanistan and Iraq, may have an impact on the Iranian economy and markets. Last but not least, election of president Ahmadinejad in June 2005 was as unexpected and controversial as was his re-election in June 2009. His populist and stridently fundamentalist views, at least initially, worried investors. He famously declared participation in equity markets as "gambling" and the stock market as "a tool of corruption".[15] He then engaged in a very public battle against the then chairman of the TSE, and eventually forced him out of office before his term was over, using an executive order. We thus include both Mr. Ahmadinejad's election and the inauguration of the new chairman of the TSE as important events. Table 5 reports these events.

7.2 Impact of Events on TSE Data

As is seen in Table 6, the majority of events studied seem to have induced abnormal returns, both positive and negative, in TSE returns. For the first four events in our study, the null hypothesis of no abnormal returns due to the occurrence of the event is rejected for both excess price returns and total returns. These events are the renewal of the Iran-Libya Act, the September 11 attacks on World Trade Center, the start of the war in Afghanistan, and the liberalization of foreign exchange rates. Except for renewal of the Iran-Libya Act, all other events induce negative cumulative abnormal returns. For two events, the start of the Iraq war and inauguration of the new chairman of the Tehran Stock Exchange, we observe rejection of the null of no abnormal returns for one of the series studied, but not the other. In case of the Iraq war, we reject the null hypothesis of no abnormal returns for excess returns of the price index, but fail to do so for excess returns of the total return index. In the case of the TSE's chairman ouster, we have the reverse case, we reject the null hypothesis for excess returns of the total return index, but not for the price index.

For the remaining two cases, scientific sanctions by the U.S. Department of the Treasury and election of president Ahmadinejad in 2005, we fail to reject the null hypothesis of no

[15]Gambling is considered a sin in Islam. Many investors interpreted these opinions as hostility towards the stock market on the part of the new administration.

See www.bbc.co.uk/persian/business/story/2007/06/070611ka-letter.shtml and www.bbc.co.uk/persian/business/story/2006/06/060615mfkaletter.shtml.

abnormal returns in excess returns computed from both price and total return indices. While the former case does not seem particularly surprising, the latter certainly is. Mr. Ahmadinejad was considered a long-shot candidate, and his victory came as a surprise. It seems that either markets did not view his platform as a threat, or already discounted such a threat. Our current analysis does not allow us to disentangle these two assertions.

8 Conclusions

We conduct a study to better understand the basic efficiency, returns, and volatility properties of the Tehran Stock Exchange returns. We find supporting evidence in favor of international CAPM efficiency at the monthly frequency. This characteristic is lost once we increase the sampling frequency to daily. Empirically, we could not improve the performance of the ICAPM model through inclusion of factors such as exchange rates and oil price fluctuations or international macroeconomic factors, such as increased risk of an economic downturn reflected in term spreads. Our findings corroborate those of Foster and Kharazi (2008), and point to an interesting aspect of TSE. That is, our study shows that a market dominated by naive traders can still be efficient, in a classical textbook sense. The TSE is an efficient market, even in the presence of insider trading, collusion, price fixing, and considerable informational asymmetry.[16] Another issue that we did not formally address in this study is the reaction to new information in the Tehran stock exchange. Based on the work by Hong and Stein (1996), several empirical studies have investigated the possibility of delayed reactions to new information. Carrying out a similar exercise for TSE returns may provide a potential solution to the observed anomaly of CAPM-efficient monthly excess returns, but inefficiency at the daily frequency.

The issue of suitable measures of the risk-return trade-off, or volatility spillover in TSE excess returns, remains an open question. We study the risk-return trade-off in TSE returns by using GARCH-in-Mean models. These results are, at best, mixed. In the light of recent developments in modeling downside volatility and the shape of the risk-return relationship, our findings are not surprising and indicate scope for further research. TSE excess returns data seem to support mild international integration of this market. Our empirical findings here both corroborate ICAPM results and are also in line with the literature on the pricing of risk in the MENA region.

Our event study shows that non-market events, such as sanctions, terrorism, war, or drastic

[16] Daragahi (2004) provides an overview from a practitioner's point of view.

changes in economic policy or leadership have significant impacts on returns in the Tehran stock exchange. By construction, our sample does not include data for the Great Recession period or the recent bull market in the Tehran stock exchange in the spring and summer of 2010. We study these new developments as data become available.

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Table 1: **Descriptive Statistics of the Data**

	DJW	EM	TEPIX	TEDPIX	Industrial
Mean	21.49	9.60	2.70	17.75	1.88
Std. Dev.	20.23	24.49	53.51	55.80	53.50
Skewness	0.66	-1.44	-8.18	-7.28	-7.97
Kurtosis	2.57	4.80	79.34	68.41	76.80

This table reports summary statistics of excess returns. Calculation of the returns is based on subtracting the daily 3-month U.S. Treasury Bill rate from the log difference of each market index return. Mean excess returns and standard deviations are reported as annualized percentages. Excess kurtosis values are reported. The sample period spans March 30, 1998 to April 25, 2006.

Table 2: **Estimated Parameters of Static International CAPM**

		Monthly		Daily
Index	Parameter	DJW	EM	DJW
TEPIX	α	-0.635 (1.490)	0.010 (1.407)	0.008 (0.078)
	β	0.381* (0.128)	-0.093 (0.064)	0.086 (0.097)
TEDPIX	α	0.694 (1.553)	1.268 (1.502)	0.072 (0.081)
	β	0.338† (0.146)	-0.127 (0.084)	0.078 (0.098)
Industrial	α	-0.684 (1.463)	-0.081 (1.437)	0.005 (0.078)
	β	0.368* (0.138)	-0.091 (0.065)	0.080 (0.097)

Newey-West HAC consistent standard errors appear in parentheses. *, ‡, and † denote rejection of the null hypothesis that the parameter equals zero at the 1%, 5%, and 10% significance levels, respectively. The estimated parameters were obtained by applying OLS to $r_t = \alpha + \beta r_t^W + \varepsilon_t$, and ε_t^i is assumed to be a white noise innovation process.

Table 3: **Estimated Parameters of Constant Parameter Intertemporal CAPM (GARCH-in-Mean)**

Index	Panel A: GARCH-M							
Monthly	μ	λ	ω	α	β		AIC	SBC
TEPIX	$-0.056*$ $(6.47E-5)$	$2.30E-5$ (0.015)	$236.233*$ (12.592)	$3.15E-12$ $(4.52E-10)$	$4.56E-23$ $(2.27E-15)$		927.534	935.662
TEDPIX	$1.200*$ $(4.78E-5)$	$2.50E-5$ (0.012)	$256.700*$ $(1.87E-4)$	$4.53E-23$ $(6.13E-16)$	$8.74E-5$ (0.048)		938.831	949.669
Industrial	$-0.127*$ $(6.16E-5)$	$-8.11E-6$ (0.015)	$236.158*$ (12.185)	$6.43E-16$ $(3.06E-12)$	$5.89E-23$ $(1.39E-15)$		927.495	935.623
Daily								
TEPIX	-0.003 (0.003)	0.001 (0.039)	$11.518*$ $(5.33E-4)$	$-5.60E-23$ $(6.59E-15)$	$1.45E-8$ (0.006)		10671.952	10694.393
TEDPIX	$0.046*$ (0.002)	0.002 (0.021)	$12.300*$ $(2.89E-4)$	$2.96E-23$ $(4.04E-13)$	$1.47E-4$ (0.003)		10804.215	10826.656
Industrial	-0.007† (0.003)	0.001 (0.039)	$11.498*$ (0.070)	$4.57E-23$ $(1.09E-7)$	$2.37E-23$ $(3.36E-16)$		10666.390	10683.221
	Panel B: EGARCH-M							
Monthly	μ	λ	ω	α	β	θ		
TEPIX	$7.401*$ (0.100)	-0.034 (0.211)	$6.223*$ (0.213)	$-0.814*$ (0.100)	$-0.234*$ (0.081)	$0.240*$ (0.090)	913.560	929.817
TEDPIX	$3.356*$ (0.474)	$-3.00E-4$ $(3.18E-4)$	$3.168*$ (0.727)	$1.650*$ (0.196)	0.324‡ (0.173)	$-0.688*$ (0.064)	814.979	831.236
Industrial	$7.401*$ (0.142)	-0.036 (0.226)	$6.439*$ (0.144)	$-0.733*$ (0.098)	-0.266‡ (0.141)	0.250‡ (0.143)	914.200	930.457
Daily								
TEPIX	$0.032*$ $(1.46E-4)$	$6.18E-6$ $(6.08E-6)$	$1.435*$ (0.003)	$3.367*$ (0.007)	$0.565*$ (0.002)	$0.741*$ (0.008)	5204.440	5238.102
TEDPIX	$0.203*$ $(8.14E-6)$	0.010 (0.052)	$0.391*$ (0.113)	$-0.340*$ (0.113)	$0.746*$ (0.111)	0.133 (0.114)	10600.407	10634.070
Industrial	$-0.205*$ $(4.58E-6)$	$-5.88E-7*$ $(8.40E-8)$	$0.072*$ $(2.05E-4)$	$1.722*$ $(3.59E-5)$	$-0.038*$ $(1.02E-4)$	$1.023*$ $(2.00E-5)$	6248.003	6281.665

This table presents maximum likelihood estimation results for TSE returns. Standard errors appear in parentheses. *, †, and ‡ denote rejection of the null hypothesis that the parameter equals zero at the 1%, 5%, and 10% significance levels, respectively. In each case, the conditional mean equation is given by $r_t = \mu + \lambda h_{t-1} + \epsilon_t$, where r_t is the excess returns, h_t is the conditional variance of the market excess returns, and $\epsilon_t \sim N(0, 1)$. Volatility dynamics follow Bollerslev (1986) for GARCH-M, and Nelson (1991) for EGARCH-M.

Table 4: **Estimated Parameters for Markov Switching CAPM**

	TEPIX	TEDPIX
Sample Statistics for $\hat{\phi}$		
Mean	0.4987	0.4988
Median	0.4999	0.4999
Standard Deviation	0.0080	0.0153
Transition Probabilities		
$\hat{p}_{11}$	0.7743* (0.0416)	0.9515* (0.0064)
$\hat{p}_{22}$	0.9287* (0.0112)	0.5109* (0.0495)
Risk Premia		
$\hat{\lambda}^W$	2.629 (2.291)	4.172* (1.520)
$\hat{\lambda}$	3.941† (1.494)	1.213 (1.333)

This table presents parameters from maximum likelihood estimation of $r_t = \phi_{t-1}\lambda^W Cov_{t-1}[r_t^W, r_t] + (1 - \phi_{t-1})\lambda Var_{t-1}[r_t] + \varepsilon_t$. In this equation, r_t^W and r_t represent world market excess returns and TSE excess returns, respectively. We use two measures for TSE returns, TEPIX and TEDPIX, which represent the price index returns and total returns, respectively. Similarly, we use TEPIX excess returns in conjunction with DJW price index returns, and TEDPIX excess returns in conjunction with DJW total returns. λ^W and λ are risk premia associated with the world market and the domestic market respectively. $\phi_t = Prob(S_t = 1|\mathcal{F}_{t-1})$, $p_{11} = Prob(S_t = 1|S_{t-1} = 1)$, and $p_{22} = Prob(S_t = 2|S_{t-1} = 2)$. Standard errors appear in parentheses. *, †, and ‡ represent statistical significance at 1, 5, and 10% levels, respectively.

Table 5: **Important Events**

Event	Date
Iran-Lybia Act Renewal	08/05/2001
Terrorists attack WTC.	09/11/2001
Coalition operations begin in Afghanistan.	10/07/2001
Foreign exchnage rate liberalized.	03/18/2002
Operation “Iraqi Freedom” starts.	03/20/2003
Sanctions on scientific exchange with Iran	02/09/2004
Ahmadinejad elected as president.	06/17/2005
New chairperson of TSE appointed.	11/21/2005

Table 6: **Event Study Results**

Event	Var	CAR_{τ_2,τ_1}	$\sigma^2_{CAR_{\tau 2,\tau 1}}$	η
Iran-Lybia Act Renewal	TEPIX	4.9294	0.3908	7.8849 *
	TEDPIX	5.0956	0.0025	101.9145 *
September 11, 2001	TEPIX	-12.9537	0.0195	-92.6476 *
	TEDPIX	-11.0130	1.9650	-7.8563 *
War in Afghanistan	TEPIX	-10.1920	2.2494	-6.7956 *
	TEDPIX	-9.6102	5.5539	-4.0779 *
FX Liberalization	TEPIX	-144.8900	4.0269	-72.2028 *
	TEDPIX	-150.6642	193.5044	-10.8309 *
Iraq War	TEPIX	83.8431	745.0466	3.0717 *
	TEDPIX	76.8544	3088.3024	1.3830
Scientific sanctions	TEPIX	-4.7349	3907.1977	-0.0757
	TEDPIX	-12.6044	3295.7460	-0.2196
2005 Presidential Election	TEPIX	-6.3646	21.9034	-1.3599
	TEDPIX	-9.6184	53.5824	-1.3140
New chairperson for	TEPIX	-0.8727	2.3692	-0.5670
TSE	TEDPIX	4.9957	2.0437	3.4945 *

This table contains the estimation results for event studies conducted on TSE returns. The methodology follows MacKinlay (1997). Two models are studied here. In the first model, excess returns of TSE price index are studied and in the second model, excess returns of TSE total returns index are examined. CAR_{τ_2,τ_1} denotes the cumulative sum of abnormal returns between the beginning and the end of the event window, a total of sixty observations. $\sigma^2_{CAR_{\tau 2,\tau 1}}$ denotes the variance of the abnormal returns in the event window. The test statistic $\eta = CAR_{\tau_2,\tau_1}/\sigma_{CAR_{\tau 2,\tau 1}}$, has a standard normal distribution under the null hypothesis of no abnormal returns. *, †, ‡ represent the two-sided rejection of the null hypothesis of no abnormal returns at 1, 5, and 10% confidence levels, respectively.