Full Title: **CROSS-COUNTRY DETERMINANTS OF WEAK-FORM STOCK MARKET EFFICIENCY: A PRELIMINARY EXPLORATORY STUDY**

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Abstract: The present paper extends the short-horizon return predictability literature to explore the potential determinants of weak-form market efficiency in a sample of 50 countries over the period 1995-2005. Using the proposed rolling bicorrelation test statistic, we are able to compare the extent of weak-form market efficiency for all our sampled stock markets, and identify those country-level variables that account for the cross-country differences in the degree of efficiency. The univariate regression results indicate that the stock market is more efficient in countries that: (1) liberalize their stock market and capital account; (2) exhibit higher degree of institutional collectivism; (3) achieve better governance outcomes; (4) short selling is both allowed and commonly practiced; (5) possess higher number of security analysts; and (6) have higher real per capita GDP, higher degree of trade openness, and lower level of inflation. In the multivariate settings, we found that cross-country differences in market efficiency can be explained by quality of institutions, capital account liberalization, investor protection and macroeconomic environment.

JEL Classifications: G14; G15; C49.

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1. Introduction

The term 'market efficiency', first coined by Roberts (1967), later formalized and operationalized in the seminal review of Fama (1970), is generally referred to as the informational efficiency of capital markets. Specifically, the efficient markets hypothesis (EMH) defines a market as efficient when security prices fully reflect all available information. In his first review paper, Fama (1970) also outlined the classic taxonomy of information sets available to market participants and further classified the EMH into weak form, semi-strong form and strong form. It was argued that such classification permits researchers to pinpoint the level of information at which the hypothesis breaks down. The present paper, however, focuses only on the weak-form version, which asserts that stock prices fully reflect all information contained in past market prices and data. It is worth highlighting that in the voluminous literature of weak-form EMH, the unpredictability of stock returns on the basis of past price changes is the most commonly tested criterion of the hypothesis.[1]

According to Malkiel (2003, 2004, 2005), an advocate of the EMH over the last 30 years, the notion of efficiency is associated with the view that stock prices would move unpredictably. The logic behind the random walk idea is that if the flow of information is unimpeded and information is immediately reflected in stock prices, tomorrow's price changes will reflect only tomorrow's news and will be independent of price changes today. But true news is by definition unpredictable, thus resulting price changes must be unpredictable and random. Using the lack of return predictability as a measure of market efficiency, though not perfect, has an advantage of avoiding the joint hypothesis problem

[1] Instead, the more stringent condition of market efficiency that rules out the economic significance of the observed predictability has received relatively less attention, and this has always been used by proponents of EMH to downplay any serious challenge posed by those reported time-series patterns of stock market predictability (see Malkiel, 2003, 2004, 2005).

since it obviates the need to specify a benchmark equilibrium asset pricing model generating normal stock returns. The above notion has led to an explosion of research with detailed case studies on the weak-form efficiency of stock markets around the world (for a survey, see references cited in Lim and Brooks, 2006). Some of these papers further assessed, using sub-periods analysis, the impact of their postulated factors on market efficiency, such as the liberalization of financial market, changes in regulatory framework, the shift to electronic trading system, the implementation of price limits system and the occurrence of financial crisis (see references cited in Lim *et al*., 2007b).

The mainstream methodologies employed to test for the predictability of short-horizon stock returns are the serial correlation tests, runs test, variance ratio tests, unit root tests and spectral analysis. In this huge literature, the presence of linear serial dependence is taken not only as evidence against the unpredictable criterion of weak-form EMH, but also contradicts the implicit assumption that prices adjust without delay to the random arrival of new information. Despite its phenomenal growth, there are at least four shortcomings associated with these short-horizon return predictability literature or commonly known as the conventional efficiency studies. First, the definition of market efficiency is the absence of linear serial correlations, since these autocorrelation-based tests are designed to uncover only linear relationship between the returns and their past values. However, the lack of linear predictability does not necessarily imply efficiency as returns series can be linearly uncorrelated and at the same time nonlinearly dependent. A misleading conclusion could be reached when the underlying series have zero autocorrelation yet possess predictable nonlinearities in the mean, such as those generated by bilinear and nonlinear moving average processes. In recent decades, the advancement of computer power and statistical analysis have provided new statistical tools that are capable of uncovering any hidden nonlinear structures in white noise time

series data, and overwhelming evidence in support of nonlinearity has since been documented across international stock markets (see references cited in Lim *et al*., 2006b).[2] It is worth noting that the existence of nonlinear serial dependence not only implies the potential of predictability, but also reflects slower incorporation of past returns information into current market prices (for detailed discussions, see Lim *et al*., 2006b). On the other hand, the evidence of significant autocorrelation coefficients should be interpreted with caution given the possibility of spurious autocorrelations induced by thin trading and the imposition of price limits by stock exchanges (see Lo and MacKinlay, 1990; Lee and Chung, 1996). As argued by Hong and Lee (2005), since one can never be sure on the degree of significant autocorrelations that could be attributed to these trading frictions, an alternative approach would be to remove all linear serial correlations from the data and determine whether stock returns still contain predictable nonlinearities.

Second, conventional efficiency studies commonly assume a fixed level of market efficiency throughout the entire estimation period, as if it is a static characteristic that remains unchanged over different stages of market development. Conceptually, it is not unreasonable to expect market efficiency to evolve over time due to some underlying factors, such as institutional, regulatory and technological changes. Theoretically, the Adaptive Markets Hypothesis proposed by Lo (2004, 2005) postulated that market efficiency is not an all-or-none condition but is a characteristic that varies continuously over time and across markets, which is likely the result of institutional changes in the stock markets as well as the entry and exit of various market participants. On the other

[2] Based on the classification of Campbell *et al*. (1997), the conventional efficiency studies are testing the least restrictive version of the random walk hypothesis (Random Walk 3 with white noise property), but critics argued that tests for weak-form EMH should consider the Random Walk 1 that requires independent and identically distributed price changes (or pure white noise process), due to the possible existence of nonlinear dependence in financial data.

hand, statistical findings of inefficiency in the full sample could have masked those periods when market is indeed efficient and vice versa.[3] Motivated by the above concern, a different strand of literature has emerged that proposed new approaches for tracking the changing degree of efficiency over time in emerging stock markets (see references cited in Lim and Brooks, 2006; Lim *et al*., 2006a). Specifically, relying on the notion of Fama (1970) that market efficiency implies a lack of the return predictability, these studies examined the presence of serial dependence using autocorrelation coefficient (short-term linear dependence), Hurst exponent (long-term linear dependence) or bicorrelation statistic (short-term nonlinear dependence) in a time-varying or rolling sample framework. The possibility of evolving market efficiency is not limited to emerging markets, as evidence has been reported by a number of recent studies using data from the US stock market (see, for example, Gu and Finnerty, 2002; Lo, 2004, 2005; Anatolyev and Gerko, 2005; Chordia *et al*., 2005).

Third, the empirical implementation of the statistical tests focuses on testing the all-or-nothing notion of absolute market efficiency, handing down the verdict of whether a market is or is not weak-form efficient for the sample period under study. The problem with this research design is that it limits the ability of researchers to ascertain whether there has been any improvement in market efficiency over time or to conduct a quantitative comparison of the efficiency level among stock markets. In this regard, Campbell *et al*. (1997) argued that the notion of relative efficiency is of more consequence than the all-or-nothing view taken by most of the conventional efficiency studies. However, comparative analysis envisaged by Campbell *et al*. (1997) has only

[3] This possibility was highlighted by Self and Mathur (2006: 3154) who wrote: "*The true underlying market structure of asset prices is still unknown. However, we do know that, for a period of time, it behaves according to the classical definition of an efficient market; then, for a period, it behaves in such a way that researchers are able to systematically find anomalies to the behavior expected of an efficient market*".

been given serious attention in recent years (see Lim and Brooks, 2006 and references cited therein). In the emerging literature on evolving market efficiency discussed earlier, the time-varying or rolling window approach permits researchers to identify when and how often market inefficiency occurs, and hence a meaningful comparative analysis can further be conducted within the framework. For instance, Cajueiro and Tabak (2004) were able to rank their selected stock markets using the medians of those computed rolling Hurst exponents, while Lim and Brooks (2006) advocated using the percentage/proportion of time windows that the market deviates from random walk as a measure of relative market efficiency.

Last but not least, in the weak-form efficiency literature, there has been an increasing interest on the possible factors that might lead a market being efficient/ inefficient, which would provide useful input for the establishment of an efficiently functioning stock market (see references cited in Lim *et al*., 2007b). It is worth noting that in all these earlier empirical studies, the efficiency tests are conducted on sub-periods of pre- and post-changes. Given that the research design focuses on whether the random walk hypothesis can be rejected in those pre-determined sub-samples, it is not surprising to learn that most studies were not able to discern the effect of their postulated factors on market efficiency, in particular when the conventional statistical tests employed either reject or could not reject the null hypothesis in both sub-periods. In this regard, if the research framework departs from the traditional focus of absolute market efficiency and instead employs the concept of relative efficiency, then one is able to further explore the factors that are responsible for the time-series or cross-country variations in the level of weak-form market efficiency. However, only a handful of studies have adopted this approach to simultaneously measure and explain the extent of market efficiency (see Appiah-Kusi and Menyah, 2003; Griffin *et al*., 2007; Lagoarde-Segot and Lucey, 2007;

Lim *et al*., 2007a). Even so, these four studies either considered only a limited set of determinants or didn't justify the choice of each variable.

Since little is known about the factors that promote an efficient market, the present paper further extends the short-horizon return predictability literature to explore the potential determinants of weak-form market efficiency in a sample of 50 countries over the period 1995-2005. Taking into account the shortcomings of conventional efficiency tests, we instead employ the rolling bicorrelation test statistic for measuring the extent of weak-form efficiency in each individual market. Specifically, the bicorrelation test of Hinich (1996) is designed to detect nonlinear dependencies in a white noise series, while the rolling sample approach serves not only to capture the evolving dynamics of nonlinear predictability but also provides a useful framework to assess the relative efficiency of our sampled stock markets. After documenting the cross-country differences in the degree of market efficiency, we then explore the potential determinants beyond the widely used developed/emerging market classification.[4] The selected variables can be classified into six major groups: (1) financial liberalization; (2) culture; (3) quality of institutions; (4) stock market regulations; (5) stock market characteristics; (6) the general macro environment.

The plan of this paper is as follows. Section 2 reviews the limited number of empirical studies that simultaneously measured and explained the variations in the level of market efficiency across countries. Section 3 and Section 4 then explain the two major components of this paper, i.e. the measure of relative market efficiency and its potential

[4] Developed stock markets are widely expected to exhibit higher degree of efficiency than those emerging ones. The justification is that the detailed inspection by traders in those highly liquid markets should ensure any forms of serial dependency structures are quickly arbitraged away. However, Griffin *et al.* (2007) found that many emerging markets are just as efficient, and in some aspects more efficient, than some developed markets, at least in terms of incorporating public information into prices.

cross-country determinants, respectively. Empirical analyses and the subsequent discussions of results are contained in Section 5, while concluding remarks are given at the end of the paper.

2. A Review of Related Literature

This section provides a brief review of those earlier studies that explored cross-country determinants of weak-form market efficiency. Lagoarde-Segot and Lucey (2007) investigated the informational efficiency in relation to its theoretical underpinnings in a set of seven emerging Middle-Eastern North African (MENA) stock markets. The authors aggregated the results of their variance ratio tests and technical trade analyses into a single efficiency index, which enabled them to rank the efficiency level of their sampled MENA stock markets. Lagoarde-Segot and Lucey (2007) then analyzed the impact on the efficiency index exerted by market development (market capitalization, number of firms, value traded and turnover ratio), corporate governance (information disclosure, management liability and shareholder protection) and the overall degree of institutional and economic liberalization (rule of law, government intervention, external financial liberalization and the degree of economic freedom). The results from their multinomial ordered logistic regression showed that the extent of weak-form market efficiency in the MENA stock markets is primarily explained by differences in stock market development and corporate governance, while variables linked to the overall economic liberalization process do not seem to have explanatory power.

Griffin *et al*. (2007) is by far the most comprehensive study, in terms of country coverage, variables included, methodologies employed and analyses conducted. Specifically, these authors utilized standard tests of weak and semi-strong form efficiency to compare the degree of informational efficiency in 56 stock markets around

the world, comprising 33 emerging and 23 developed markets. In the context of weak-form efficiency, Griffin *et al*. (2007) employed the variance ratio test at both the individual stock and portfolio levels to measure how quickly past information is reflected in current stock price. Specifically, the absolute deviation of variance ratio from one is used as a quantitative indicator for gauging the relative efficiency across countries. This framework permits the authors to further conduct cross-sectional analyses in order to gain a deeper understanding of the relationship between weak-form market efficiency and a host of cross-country variables related to regulatory, economic/financial development, information environment, trading costs, volatility, correlation with world returns, and firm/industry concentration. The results from their variance ratio test suggested that, at daily and weekly frequencies, individual stock and size-ranked portfolio returns in emerging markets are at least as efficient as those in developed markets, indicating that emerging markets do a comparably good job at incorporating public information into prices. Turning to the multiple regression results, autocorrelations for individual stocks tend to be higher in markets with stronger insider trading laws, less analyst coverage, and lower volatility. At the portfolio level, higher level of autocorrelations is positively related to the ability to sell short, lower dispersion in analysts' forecasts, and lower market volatility. However, the explanatory power of the above variables is quite low. Similar results are also reported using the other three efficiency estimators (i.e. the delay measure, post-earnings drift and the average market model *R*-square), and hence led Griffin *et al*. (2007) to conclude that there is no evidence that better country-level legal, regulatory, and governance characteristics are positively related to higher levels of market efficiency.

On the other hand, the absence of nonlinear return predictability is used by Appiah-Kusi and Menyah (2003) and Lim *et al*. (2007a) for testing the weak-form efficiency of their selected markets. Appiah-Kusi and Menyah (2003) modelled weekly index returns adjusted for thin trading as a nonlinear autoregressive process with conditional heteroscedasticity to investigate the efficiency of eleven African stock markets. In their nonlinear model, the degree of market efficiency is captured by the magnitude of the estimated coefficients of the weak-form efficiency parameter in the mean equation. This coefficient is found to be significantly different from zero in the markets of Botswana, Ghana, Ivory Coast, Nigeria, South Africa, and Swaziland, indicating that their prices do not adjust rapidly to the arrival of new information, and hence future prices could be predicted from lagged prices. Further Spearman rank correlation analysis revealed that the cross-country differences in the magnitude of the efficiency parameter for these six African markets are not likely to be associated with trading volume, number of listed companies, market capitalization, transfer taxes, or trading commissions.

Lim *et al*. (2007a) re-examined the weak-form efficiency of ten Asian emerging stock markets. By dividing the full sample into equal-length non-overlapped moving time windows, the authors then computed the bicorrelation test statistic for detecting nonlinear predictability in each window. This framework not only allows the authors to uncover the episodic nature of the underlying nonlinear serial dependencies, but also provides a useful approach to assess the relative efficiency of their sampled Asian stock markets by comparing the total number of windows that exhibit nonlinear dependence in each market. Subsequently, Lim *et al*. (2007a) explored, using the Spearman rank correlation analysis, a number of possible factors that might account for the cross-country differences in the level of market inefficiency, i.e. the degree of stock market development, stock market liquidity and various legal indicators. The results revealed

that the reported cross-country variations can be explained by market size and trading activity, but not market liquidity and the legal environment of the country.

Despite the small number of empirical studies that explored the cross-country determinants of weak-form market efficiency as evidenced in the above review, it is worth highlighting that the stock price synchronicity measure proposed by Morck *et al.* (2000), in particular their average market model *R*-square statistic, has inspired an extensive cross-country studies on stock market efficiency. Given that the value of *R*-square lies between zero and one, it is possible not only to rank the sample countries where higher *R*-square indicates greater stock price synchronicity, but also to further explore the potential determinants that are responsible for those reported cross-country differences (for country-level *R*-square around the world, see Jin and Myers, 2006). Morck *et al*. (2000) argued that their synchronicity measure is inversely related to the amount of firm-specific information impounded into individual stock prices, with more firm-specific information being associated with a lower market model *R*-square. Subsequent studies by Durnev *et al*. (2003, 2004) provided evidence supporting the above information-based interpretation. More importantly, these two studies established the empirical link between stock price synchronicity and stock price informativeness, hence providing the basis for using market model *R*-square to measure the degree of informational efficiency in stock prices. Specifically, Durnev *et al*. (2003, 2004) found that lower *R*-square reflects the rapid incorporation of firm-specific information into stock prices, and hence indicates a more informationally efficient stock price.

The market model *R*-square has been used in cross-country setting to assess the impact on market efficiency brought about by securities laws (Daouk *et al*., 2006), short selling restrictions (Daouk *et al*., 2006; Bris *et al*., 2007) and insider trading laws (Beny, 2005,

2007; Daouk *et al*., 2006; Fernandes and Ferreira, 2007). However, it is difficult to relate the above measure to traditional Fama's (1970) taxonomy of efficiency. The closest category would be the semi-strong form as the information being considered is wider than patterns in past prices. On the other hand, some recent studies have challenged the robustness of market model *R*-square as an inverse measure of informational efficiency. For instance, using data from six stock markets and conducting extensive analyses, Ashbaugh-Skaife *et al*. (2006) did not find evidence supporting the notion that the synchronicity measure reflects the amount of firm-specific information impounded in stock price, hence questioning the validity of the information-based interpretation of *R*-square measure in international markets. Instead, their findings in general revealed that higher *R*-square values are associated with more informative prices in Germany and the U.S., and no statistically significant association between the two measures in Australia, France, Japan and the U.K. Kelly (2007) also found evidence against the widely held belief that a low market model *R*-square corresponds to higher stock price informativeness. Specifically, their results showed that lower *R*-square values are associated with greater impediments to informed trade, such as higher information costs, greater trading costs and lower liquidity.

3. Measuring the Degree of Weak-form Market Efficiency

Given that the present paper relies on the notion of Fama (1970) that weak-form market efficiency implies the unpredictability of stock returns on the basis of past price changes, only historical stock price data is required to measure the degree of efficiency across our sampled countries. For this purpose, we collect indices at daily frequency for 23 developed and 27 emerging stock markets from Morgan Stanley Capital International (MSCI), and these indices are denominated in U.S. dollar so as to give us the perspective

of an international investor. In order to allow for direct comparison, we use a common sample period for all markets, commencing from 1 January 1995 and ending in 31 December 2005. The choice of the starting date is dictated by data availability, since daily indices for Czech Republic, Egypt, Hungary, Morocco and Russia are only available from 31 December 1994. All the indices are first transformed into a series of continuously compounded percentage returns by taking 100 times the log price relatives, i.e. $r_t = 100 \cdot \ln\left(p_t / p_{t-1}\right)$, where p_t is the closing price of the index on day t, and p_{t-1} the price on the previous trading day. The above sample period of 11 years yields a total of 2870 daily returns series for each market.

Some basic information regarding the data is given here. First, the classification of 'developed' and 'emerging' by MSCI is determined by the income level of the country as defined by World Bank, and the existence of investment restrictions such as currency repatriation restrictions, capital controls and foreign share ownership limitations. Second, these country indices are end-of-period value-weighted indices of a large sample of companies in each country. Briefly, to construct an MSCI Country Index, every listed security in the market is identified. Securities are free float adjusted, classified in accordance with the Global Industry Classification Standard, and screened by size and liquidity. MSCI then constructs its indices by targeting for index inclusion 85% of the free float adjusted market capitalization in each industry group, within each country. By targeting 85% of each industry group, the MSCI Country Index captures 85% of the total country market capitalization while it accurately reflects the economic diversity of the market. These indices are computed consistently across markets, thereby allowing for a direct comparison across countries.

Due to the shortcomings of conventional efficiency tests as discussed in Section 1, we instead employ the rolling bicorrelation test statistic for measuring and comparing the degree of weak-form efficiency in each of the 50 sampled markets (for empirical applications, see Lim and Brooks, 2006; Lim, 2007; Lim *et al*., 2007b). The bicorrelation test of Hinich (1996) is a third-order extension of the standard correlation test for white noise, and is designed to test for the existence of non-zero third-order sample correlation coefficient or known as bicorrelation coefficient, which is effectively a correlation between the current return and previous autocorrelation coefficients. The rolling sample approach, on the other hand, serves not only to capture the evolving dynamics of nonlinear predictability but also provides a useful framework to assess the relative efficiency of our sampled stock markets. Specifically, the degree of country-level weak-form market efficiency is measured in terms of the proportion of time windows that those selected markets exhibit nonlinear departure from random walk over the sample period 1995-2005, where lower value indicates greater degree of market efficiency.

This section provides a brief description of the bicorrelation test statistic (henceforth denoted as the H statistic). The full theoretical derivation and some Monte Carlo evidence on the small sample properties of the test statistic are given in Hinich (1996) and Hinich and Patterson (1995, 2005). Let the sequence $\{y(t)\}$ denote the observed sampled data process, where the time unit, t, is an integer. The data in each time window is standardized to have a sample mean of zero and a sample variance of one by subtracting the sample mean of the window and dividing by its standard deviation in each case.

Define $Z(t)$ as the standardized observations that can be written as:

$$Z(t) = \frac{y(t) - m_y}{s_y} \tag{1}$$

for each $t = 1, 2, ...n$ where m_y and s_y are the sample mean and sample standard deviation of the window.

The null hypothesis for each time window is that the transformed data $\{Z(t)\}$ are realizations of a stationary pure white noise process. Under the null hypothesis, the bicorrelation coefficients $C_{ZZZ}(r,s) = E[Z(t)Z(t+r)Z(t+s)]$ are all equal to zero for all r, s except when $r = s = 0$. The alternative hypothesis is that the process in the window has some non-zero bicorrelations in the set $0 < r < s < L$, where L is the number of lags. In other words, if there exists nonlinear dependence in the data generating process, then $C_{ZZZ}(r,s) \neq 0$ for at least one pair of r and s value.

The H statistic and its corresponding distribution are:

$$H = \sum_{s=2}^{L} \sum_{r=1}^{s-1} G^2(r,s) \sim \chi^2_{L(L-1)/2} \tag{2}$$

where $G(r,s) = (n-s)^{\frac{1}{2}} C_{ZZZ}(r,s)$ and the (r,s) sample bicorrelation coefficient is:

$$C_{ZZZ}(r,s) = (n-s)^{-1} \sum_{t=1}^{n-s} Z(t)Z(t+r)Z(t+s) \quad \text{for } 0 \leq r \leq s \tag{3}$$

Given that the rejection of the null of pure white noise can be due to non-zero correlations (linear dependence) or non-zero bicorrelations (nonlinear dependence), data pre-whitening is necessary prior to the application of the bicorrelation test in order to

remove all linear serial correlations from the data, so that any remaining serial dependence must be due to a nonlinear data generating mechanism. The linear filtering procedure also serves to address the concern of spurious autocorrelations induced by trading frictions (see Hong and Lee, 2005). In this study, the autocorrelation structure in each window is filtered out by an autoregressive AR(p) fit. It is worth highlighting that the AR fitting is employed purely as a prewhitening operation, and not to obtain a model of best fit. The portmanteau bicorrelation test is then applied to the residuals of the fitted model of each window, in order to determine whether stock returns still contain predictable nonlinearities.

The number of lags L is specified as $L = n^b$ with $0 < b < 0.5$, where b is a parameter under the choice of the user. All lags up to and including L are used to compute the bicorrelations in each window. Based on the results of Monte Carlo simulations, Hinich and Patterson (1995, 2005) recommended the use of $b = 0.4$ which is a good compromise between (1) using the asymptotic result as a valid approximation for the sampling properties of H statistic for moderate sample sizes, and (2) having enough sample bicorrelations in the statistic to have reasonable power against non-independent variates.

Another element that must be decided upon is the choice of the window length. In the present context, the larger the window length, the larger the number of lags and hence the greater the power of the test, but this would average the test statistics across all the data and preclude the detection of episodic transient nonlinear dependence within the sample. Based on the Monte Carlo evidence provided by Hinich (1996) and Hinich and Patterson (1995, 2005) on the small sample properties of the bicorrelation test, most of the empirical applications have used window length of less than 50 observations (see

references cited in Lim *et al*., 2006a, b). However, such a small sample size might compromise the power of the test. Motivated by this concern, we then compute the time-dependent H statistic in a rolling window of 200 observations.[5] This choice is based on the Monte Carlo simulations conducted by Patterson and Ashley (2000) who examined the sizes and powers of six popular nonlinearity tests, which includes the bicorrelation test (see also Ashley and Patterson, 2006). Following these authors, resampling with replacement that satisfies the null hypothesis is used to determine a threshold level for the *p*-value of the H statistic. It is worth noting that the computed H statistic at each rolling time window reflects the changing nonlinear behaviour of the returns generating process due to the arrival of new information, and hence captures the evolving dynamics of market efficiency over time.[6] Since the evidence of evolving market efficiency implies that stock markets are not efficient all the time, and thus a meaningful comparative analysis can further be conducted within this rolling sample framework by comparing the proportion of time windows that those selected markets deviate from random walk. In other words, the degree of country-level weak-form market efficiency is measured in terms of the proportion of significant H windows over the sample period 1995-2005, where lower value indicates greater degree of market efficiency.

[5] In the rolling sample approach, the H statistic is computed for the first window of a specified length, and then the sample is rolled one point forward eliminating the first observation and including the next one for re-estimation of the H statistic. This process continues until the last observation is used. In other words, the start date and end date successively increase by one observation. For instance, in a fixed-length rolling window of 200 observations, the first window starts from day 1 and ends on day 200, the second window comprises observations running from day 2 through day 201, and so on. The last window is built with the last 200 observations.

[6] The possibility that the temporal dependence relationships in the market are constantly changing was acknowledged by Nawrocki (1996) and Lim *et al*. (2006b). Specifically, to study the day-to-day changes in time series dependence, Nawrocki (1996) computed the cross-sectional autocorrelation coefficient, while Lim *et al*. (2006b) employed intra-day data so as to provide sufficient number of observations for the estimation of their respective test statistics in each day.

The H statistic for each time window is computed using the T23 program coded in FORTRAN.[7] The program transforms the H statistic obtained from Equation (2) into a percentile (i.e. one minus the *p*-value) using the cumulative distribution function of the test statistic under the null hypothesis. It is this percentile that is reported as the H statistic for each window, but the *p*-value is used to summarize the results of the test statistic. Specifically, if the *p*-value of the H statistic in a time window is deemed small by the analyst, then the null hypothesis of pure white noise can be rejected. In this case, the significant H statistic indicates the presence of nonlinear serial dependence and hence market inefficiency for that particular window. In the present study, the threshold level (or cut-off point) for the *p*-value of the H statistic is set at 5%. As noted earlier, resampling with replacement is used to determine the threshold level that has a test size to be 5%. Specifically, a window is defined as significant when the *p*-value of the H statistic is less than or equal to the bootstrapped threshold drawn from 1000 replications that corresponds to the earlier specified nominal threshold level of 5%.

4. Potential Cross-Country Determinants of Weak-Form Market Efficiency

The present section discusses the variables selected for explaining the cross-country differences in the degree of weak-form market efficiency. In the absence of a theoretical model that offers a clear explanation of these determinants, the choice of our explanatory variables is determined by the availability of data and empirical results documented in extant literature. It is worth highlighting that most of the earlier studies tend to focus on the impact of one selected factor on market efficiency, and we discuss these papers when describing in detail each selected variable. Hence, we pull together these scattered studies into a unified framework. The possible determinants of stock market efficiency

[7] This program written by Melvin J. Hinich can be downloaded from http://www.gov.utexas.edu/hinich/.

covered in our empirical analysis can be classified into six major groups: (1) financial liberalization; (2) culture; (3) quality of institutions; (4) stock market regulations; (5) stock market characteristics; (6) the general macro environment.

4.1 Financial Liberalization

In the wake of the movement towards stock market liberalization around the world, some researchers explored the issue of whether allowing foreign investors the right to transact in domestic securities has caused stock markets to become more efficient, by examining the degree of efficiency before and after the date of liberalization. Groenewold and Ariff (1998) noted that an improvement in market efficiency is an important aim of such policy initiative. While there is no formal theoretical work studying the effect of financial liberalization on stock market efficiency, most of the empirical studies were carried out under the rubric of the EMH. Specifically, it was hypothesized that as stock markets are liberalized and made more open to the public (both domestic and international investors), prices should reflect the increased availability of information and hence become more efficiently priced. On the other hand, Jain-Chandra (2002) argued that foreign participation should result in improved liquidity, which will most likely be accompanied by an increase in the amount of research done on individual stocks and market-wide conditions in those liberalizing markets. Furthermore, foreign investors will typically require transparency and stricter disclosure rules and these in turn improve the quality of information reaching the market and hence should lead to increased informational efficiency.[8]

[8] Bae *et al.* (2006a) conducted a comprehensive investigation on the changes in the information environment that result from increased openness to foreign investors in 25 emerging stock markets. One of their hypotheses is that the number of analysts following local firms increases when a market becomes more open to foreign portfolio investment. This will in turn encourages these local firms to produce more disclosures and adhere more strongly to international norms of corporate governance. Their results showed that stock market liberalization indeed alters the local environment for disclosure, information production,

However, the empirical evidence on this subject matter is rather inconclusive. Kim and Singal (2000a, b) and Füss (2005) found that, in general, there is an improvement in market efficiency following the opening of stock markets in emerging economies. Using a panel dataset of sixteen countries, Jain-Chandra (2002) confirmed based on the findings of pooled ordinary least square and panel estimation that stock market liberalization renders emerging stock markets less predictable. The statistical results in Basu *et al*. (2000) weakly supported the hypothesis that financial liberalization has made emerging markets more efficient. In contrast, Groenewold and Ariff (1998), Kawakatsu and Morey (1999a, b) and Laopodis (2003, 2004) reported that their sampled markets are weak-form efficient even before the actual market opening dates. On the other hand, Maghyereh and Omet (2002) concluded that market liberalization has no discernible effect on the degree of efficiency, as the Amman Stock Exchange remains inefficient after the market opening. It is worth highlighting that all the aforementioned studies used the market opening dates documented in the literature as the breakpoint, treating financial liberalization as one-time event constituting an instantaneous and complete removal of barriers on foreign investment.[9] However, most countries liberalized their stock markets by lifting individual restrictions gradually over time and it could took several years before a market is completely open to foreign investors.[10] Moreover, the liberalization dates provided by Bekaert and Harvey (2000), Henry (2000) and Kim and

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and the analysis and use of information, and draws foreign resources, effort, and skill into the capital market.

[9] There are at least three other similarities among this group of studies. First, the efficiency of stock market was examined using statistical tests that focus on linear predictability of returns series, with variance ratio test being the popular tool. Second, with the exception of the cross-country study by Jain-Chandra (2002), most analyses divided the sample periods into pre- and post-liberalization and then observed the changes in efficiency test results for each individual market under study. Third, the focus of financial reform was on stock market liberalization.

[10] For example, Henry (2006) noted that South Korea began allowing foreigners very limited access to its stock market through closed-end country funds as early as 1982. However, the country only started lifting its statutory ceiling on foreign investment in 1992. For more details, consult the chronology of important financial, economic and political events for 55 emerging stock markets presented in Bekaert and Harvey (2005).

Singal (2000a) do differ for certain countries since these authors employed somewhat different criteria.

In order to capture the extent and evolution of stock market liberalization over time, we utilize the cross-country measure proposed by Edison and Warnock (2003) which is constructed using the Global index (IFCG) and Investable index (IFCI) computed by Standard and Poor's/International Finance Corporation (S&P/IFC). The IFCG is designed to represent the overall market portfolio for each country, whereas the IFCI represents a portion of stocks in the Global index that are available to foreign investors. The ratio of the market capitalizations of a country's IFCI and IFCG indices provides a quantitative measure of the availability of the country's equities to foreigners. The value for this measure on the intensity of liberalization for country i at time t, IOL_{it}, can vary from zero to one, with zero indicating that the market is completely closed to foreign investors, and a value of one representing a completely open market with no foreign restrictions. Given that we do not have access to Standard and Poor's Emerging Markets Database, the annual version of IOL_{it} over the sample period 1995-2005 is constructed using the information drawn from Emerging Stock Markets Factbook (1995-2002) and Global Stock Markets Factbook (2003-2005). Unfortunately, data on market capitalizations for IFCG and IFCI indices are not provided in these hardcopy sources. We then explore an alternative method by calculating the ratio of the number of firms in both indices for each country, and the resulting value carries similar interpretation as those based on market capitalization (see Bekaert *et al*., 2005). In fact, Bekaert *et al*. (2005) noted that this method could be less noisy given the high volatility of emerging

market stock returns.[11] In our cross-sectional analysis, data are averaged over 1995-2005 so that there is one observation per country.

The IOL_{it} of Edison and Warnock (2003) is a *de jure* measure of liberalization, which is associated with the lifting of legal restrictions on the flow of capital into the stock market (see Bekaert *et al*., 2006). However, as noted by Prasad *et al*. (2003) and Kose *et al*. (2006), many countries have capital controls that are quite strict on paper but ineffective in their actual enforcement, so their *de facto* level of integration as measured by stocks of foreign assets and liabilities is quite high. In contrast, many other countries are quite open to global capital markets on a *de jure* basis, but in practice capital flows are minimal. Hence, these authors argued that the distinction between *de jure* and *de facto* financial openness is crucial, and for many applications the *de facto* measure is more suitable. To address the above concern, we supplement the analysis by using a *de facto* indicator that is based on actual capital flows. The data is from Lane and Milesi-Ferretti (2007), which is an extension of their earlier popular *External Wealth of Nations* database (Lane and Milesi-Ferretti, 2001) by employing an extensively revised methodology and draws upon a richer range of data sources. Specifically, this

[11] For countries that were not included in the IFCI index for the whole sample period of 1995-2005, our treatments are as follows: (i) Since developed markets in our sample were not included in the IFCI index, we assume that both the IFCG and IFCI indices are identical and hence the values of IOL_{it} for these countries are one throughout the entire sample period (see Ahearne *et al*., 2004; Bekaert *et al*., 2005, 2006, 2007b). This is because pervasive restrictions on investment by non-resident investors do not generally exist in stock markets classified as 'developed' by Standard and Poor's; (ii) Among this group of developed markets, Portugal was removed from IFCG and IFCI indices on 31/3/1999, while Greece graduated from S&P Emerging Market index series in May 2001. Standard & Poor's transitioned these two markets to "developed market" status (see Standard & Poor's, 2006). Hence, the IOL_{it} measures for Portugal and Greece only took the value of one after their respective dates of graduation; (iii) In November 2001, five of our sampled emerging markets (Colombia, Jordan, Pakistan, Sri Lanka, Venezuela) were removed from the IFCI index due to their small size or illiquidity, which made them not investable or too expensive to hold in a truly investable benchmark (see Standard & Poor's, 2006). Hence, for years 2001 to 2005, their respective IOL_{it} measures took the value of zero; (iv) Israel and three other emerging markets (Egypt, Morocco and Russia) were only included in the IFCI index in December 1996 and February 1997, respectively (see Standard & Poor's, 2006). Their IOL_{it} measures took the value of zero before the date of inclusion since they do not have an investable index for those earlier years.

comprehensive and up-to-date *External Wealth of Nations Mark II (EWN II)* dataset contains information on the composition of international investment positions for 145 countries covering the period 1970-2004, though not every country has data for every year. Since the objective is to provide an alternative measure of stock market liberalization, we use an equity-based measure of openness (see Lane and Milesi-Ferretti, 2003, 2007), which is defined as $GEQGDP_{i,t} = \left(PEQA_{it} + FDIA_{it} + PEQL_{it} + FDIL_{it} \right) / GDP_{it}$, where $PEQA(L)$ and $FDIA(L)$ are the gross stocks of portfolio equity and foreign direct investment assets (liabilities), and GDP denotes gross domestic product.[12] The time series averages over the period 1995-2004 for each country are used in the cross-country regressions.

Apart from the above two measures that focus narrowly on the degree of openness of stock market, we follow Bekaert et *al*. (2005, 2006, 2007b) to further consider the broader concept of capital account liberalization. Unlike stock market openings, there is more than a dozen of capital control measures proposed in the literature, mainly based on the details given by the International Monetary Fund (IMF)'s Annual Report on Exchange Arrangements and Exchange Restrictions (for a survey, see Edison *et al*., 2004: Table 1; Miniane, 2004: Table 1). Some recently published indicators that allow for comparison on the magnitudes of foreign restrictions across countries and over time include Edwards (2005), Mody and Murshid (2005), Chinn and Ito (2006) and Lane and Milesi-Ferretti (2007). Given that there is no single index that is able to capture the complexity of real-world capital controls, in particular the problems of aggregation and

[12] Portfolio equity holdings measure ownership of shares of companies and mutual funds that are below the ten percent threshold. The foreign direct investment category includes controlling stakes in acquired foreign firms, in addition to greenfield investments. The International Monetary Fund (IMF) classifies an investment as direct if a foreign investor holds at least ten percent of a local firm's equity while the remaining equity purchases are classified under portfolio equity investment. The data on international equity integration, available for all sampled countries over the period 1995-2004, were downloaded from Philip Lane's web site at http://www.tcd.ie/iiis/pages/people/plane.php on 30 April 2007.

enforceability (for discussions, see Miniane, 2004; Chinn and Ito, 2006), our choice of broad indicators of capital account liberalization is hence determined by data accessibility and country/year coverage. Though the measure of the intensity of capital account openness constructed by Quinn (1997) is the most widely used in the empirical literature, the data are available only from 1950 to 1989 for 21 Organization for Economic Cooperation and Development (OECD) countries, and the coverage for 43 non-OECD countries is limited to certain years: 1958, 1973, 1982, and 1988. Even in the updated version by Quinn (2003) and Quinn and Toyoda (2006) that expanded the coverage to 94 countries, the index is constructed only up to year 1999.

Guided by the above selection criteria, we employ two publicly available indicators of capital account liberalization. The first one is a *de jure* measure developed by Chinn and Ito (2006). This index of $KAOPEN_{it}$ is the first principle component of the binary variables pertaining to cross-border financial transactions based upon the IMF's categorical enumeration reported in Annual Report on Exchange Arrangements and Exchange Restrictions, which includes an indicator variable for the existence of multiple exchange rates; restrictions on current account; capital account transactions; and a variable indicating the requirement of the surrender of export proceeds (for details, see Chinn and Ito, 2006). The index takes on higher values the more open the country is to cross-border capital transactions. One of the merits of the $KAOPEN_{it}$ index is that it measures the intensity of capital controls, insofar as the intensity is correlated with the existence of other restrictions on international transactions.[13] Another advantage is its wide coverage of 181 countries over a long time period from 1970 to 2005, though not

[13] Chinn and Ito (2006) noted that the correlation between the Quinn (1997) index and $KAOPEN_{it}$ is found to be 83.9%, suggesting that the latter is proxying the intensity of capital controls.

every country has data for every year.[14] In order to avoid the complexity of interpreting the estimated coefficients, the index of $KAOPEN_{it}$ is adjusted such that their values range between zero and some positive figure (see Ito, 2006; Chinn and Ito, 2007). For our *de facto* openness measure, the analysis draws upon the *External Wealth of Nations Mark II (EWN II)* dataset provided by Lane and Milesi-Ferretti (2007). Specifically, the second broad indicator of capital account openness is defined as $IFIGDP_{i,t} = \left(FA_{it} + FL_{it}\right)/GDP_{it}$, where $FA\left(FL\right)$ refers to the gross stocks of foreign assets (liabilities), and GDP denotes gross domestic product (see Lane and Milesi-Ferretti, 2003, 2007).[15] This measure, in particular the scaling by GDP, is strongly advocated by Kose *et al*. (2006) given that the annual gross capital flows tend to be quite volatile and are prone to measurement error. Our cross-sectional analysis uses data averaged over 1995-2005 and 1995-2004 for the two variables $KAOPEN_i$ and $IFIGDP_i$, respectively.

4.2 Culture

The next empirical question that arises is whether culture is an important cross-country determinant for market efficiency. The consideration of cultural variable as a potential candidate is motivated by the growing attention given by economic and finance researchers in cross-country studies (see, for example, de Jong and Semenov, 2002; Stulz and Williamson, 2003; Garretsen *et al*., 2004; Chui *et al*., 2005; Licht *et al*., 2005; de Jong *et al*., 2006). In this emerging literature, Chui *et al*. (2005) is the only study we are

[14] The data for 49 of our sampled countries (except Taiwan) over the period 1995-2005 were downloaded from Hiro Ito's web site at http://web.pdx.edu/~ito/ on 30 April 2007. We thank Hiro Ito for responding to our enquiries related to his dataset.

[15] The components for gross stocks of foreign assets and liabilities are portfolio equity investment, foreign direct investment, external debt, financial derivatives and total reserves minus gold (see Kose *et al*., 2006: Table 1; Lane and Milesi-Ferretti, 2007). The data on international financial integration, available for all sampled countries over the period 1995-2004, were downloaded from Philip Lane's web site at http://www.tcd.ie/iiis/pages/people/plane.php on 30 April 2007.

aware that addressed the association between market efficiency and cultural variables, though inefficiency is measured in terms of momentum profits. Specifically, these authors explored how cross-country differences in individualism influence investors' trading behavior, and in turn, the profitability of momentum trading strategies. They found a strong cross-country relationship between individualism and momentum, which is consistent with the idea that investors in different cultures interpret information in different ways and are subjected to different biases. Their finding continues to hold, after controlling for other country-level variables that are likely to proxy for the informational efficiency of capital markets, such as the legal protection of investors and the quality of accounting standards.

Given that the objective of this paper is not to theorize about culture, we follow Chui *et al*. (2005) to focus on one specific cultural dimension, i.e. the degree of individualism across countries.[16] Chui *et al*. (2005) argued that people in individualistic cultures tend to think positively about themselves and focus on their own abilities, and hence they are likely to be more overconfident and more prone to self-attribution bias than people in collectivistic cultures. These behavioral biases, according to extant behavioral finance models, could cause investors to underreact or overreact to new information. The present paper argues that the above investors' reactions could be related to the formation of nonlinear dependency structures in the underlying stock returns series. Our conjecture is based on the work of Antoniou *et al*. (1997) who noted that nonlinearity may be explained in terms of nonlinear feedback mechanisms in price movements. For instance, when stock price deviates from its fundamental value, then market forces will drive the

[16] According to Hofstede (2001), individualism pertains to societies in which the ties between individuals are loose: everyone is expected to look after him/herself and his/her immediate family. Collectivism, on the other hand, pertains to societies in which people from birth onwards are integrated into strong, cohesive in-groups, often extended families which continue protecting them in exchange for unquestioning loyalty.

price back to its equilibrium level, but the correction will not always be proportional to the original deviation. This nonlinear correction could arise in cases where the markets overreact to bad news and underreact to good news. In fact, Antoniou *et al*. (1997) argued that given the complexities in stock markets with diverse set of participants, it would be a miracle if these complexities always averaged out to give an aggregate linear feedback. This discussion hence suggests that it is worthwhile to explore empirically the possible link between culture (individualism) and weak-form market efficiency (nonlinear structures).

Following Chui *et al*. (2005), we employ two different set of indices to measure the degree of individualism across countries. The first one is the index of individualism constructed by Hofstede (2001), which we denoted as $INDV\_GH_i$. Briefly, Hofstede's database consists of paper-and-pencil survey results collected within the local subsidiaries of International Business Machines (IBM) Corporation covering questions on work-related values. The survey was conducted between 1967 and 1973, producing a total of more than 116,000 questionnaires from 72 countries in 20 languages. Later on, additional data were collected from other populations, unrelated to IBM but matched across countries. From the initial results, and later additions, Hofstede developed a model that identifies four primary dimensions to assist in differentiating national cultures, i.e. power distance index, individualism, masculinity and uncertainty avoidance index. Every country included in the survey was given a score on each of the dimensions, which is an interval scale with a minimum value of zero, but no fixed maximum though the majority of observations for all dimensions do not exceed a value of 100. The summary of index

scores for 66 countries was given by Hofstede (2001: 500-502, Appendix 5).[17] Even though the survey was conducted about 40 years ago, the updates and extensions in Hofstede (2001) have re-affirmed earlier conclusions, and the author argued that the country scores on his cultural indices are quite persistent over time (see also Merritt, 2000; Garretsen *et al*., 2004).

An alternative index of individualism is provided by the Global Leadership and Organizational Behavior Effectiveness (GLOBE) Research Project (for details, see House *et al*., 2002, 2004).[18] Briefly, the idea of a global research program concerned with leadership and organization practices was conceived by Robert J. House in 1991, but the project formally began in October 1993 after receiving funding. In the period 1994-1997, about 170 country co-investigators based in 62 of the world's cultures collected data from 17,370 middle managers from 951 organizations in the industries of food processing, financial services and telecommunication services. GLOBE examined national cultures in terms of 9 dimensions: performance orientation, future orientation, assertiveness, power distance, humane orientation, institutional collectivism, in-group collectivism, uncertainty avoidance and gender egalitarianism. For each dimension, the questionnaire distinguished cultural practices ('as is') and cultural values ('should be'), hence producing 18 culture scores for each of the 62 societies surveyed. Among these dimensions, the institutional collectivism is intended to reflect the same constructs as Hofstede's individualism, hence can be regarded as an updated index for the Hofstede's individualism index. The GLOBE's institutional collectivism index, however, reflects the degree of collectivism in each country where higher scores indicate greater

[17] The index scores on individualism, available for 47 of our sampled countries except Egypt, Jordan and Sri Lanka, were downloaded from Geert Hofstede's web site at http://www.geert-hofstede.com/ on 30 April 2007.

[18] Both Hofstede's and GLOBE's country-level cultural indicators have their own merits and shortcomings (for recent debates, see Earley, 2006; Hofstede, 2006; Javidan *et al*., 2006; Smith, 2006). Nevertheless, these two datasets are the most widely employed by researchers in social sciences.

collectivism. To be consistent with Hofstede's individualism index, we follow Chui *et al*. (2005) and define our second individualism index, $INDV\_GLOBE_i$, to be equal to the GLOBE's institutional collectivism index multiplied by -1. Hence, higher values of $INDV\_GLOBE_i$ indicate greater degree of individualism.[19]

4.3 Quality of Institutions

In a survey of existing quantitative governance indicators, Arndt and Oman (2006) highlighted that the past 15 years have seen an explosion of interest in the quality of governance in the developing world, notably among international investors, national and multilateral providers of official development assistance, development analysts and academics. One of the four contributing factors identified by these authors is the spectacular growth of international portfolio investment in developing and emerging economies, especially by major pension funds and other large institutional investors. In the academic literature, there is now growing evidence that the quality of institutions matters for investment decisions. For instance, Gelos and Wei (2005) found clear evidence that government transparency has distinct positive effect on investment flows from international funds into a particular country. Specifically, foreign institutional investors prefer to hold more assets in more transparent markets. Hooper and Kim (2007) examined the impact recipient country opacity has upon three types of international capital flows, i.e. net foreign direct investments, net portfolio investments and net international bank lending. Their results showed that the overall opacity index is negatively associated with all three types of capital flows, though there are

[19] The GLOBE's societal institutional collectivism practices scores, corrected for response bias, were extracted from House *et al*. (2004: 742-744, Table B.2). The data are available for 42 of our sampled countries, except Belgium, Chile, Czech Republic, Jordan, Norway, Pakistan, Peru and Sri Lanka. For Germany, we take the average score of Germany (West) and Germany (East), South Africa is the average score of white and black samples, while the French-speaking sample is taken into account to arrive at the average score for Switzerland.

counterintuitive results using disaggregated opacity sub-indices (corruption, legal, economic, accounting, and regulation). Jin and Meyers (2006) showed, theoretically, that the market-model *R*-square is related to the degree of opaqueness. Specifically, their theory predicts that, other things equal, *R*-square should be higher in countries where firms are more opaque to outside investors. Using stock returns from 40 stock markets from 1990 to 2001, the authors found strong positive relationship between country-average *R*-square and several measures of opaqueness. Using the popular information-based interpretation, this higher *R*-square in more opaque countries would suggest that transparency promotes rapid incorporation of firm-specific information into stock prices, and hence leads to a more informationally efficient stock price.

It is worth noting that the above three studies utilized, among others, the PricewaterhouseCoopers (PwC) Opacity Index (for details, see Lipsey, 2001).[20] However, among the literally hundreds of existing indicators,[21] Arndt and Oman (2006) acknowledged that the most comprehensive publicly available set of governance indicators is the Worldwide Governance Indicators (WGI) produced by the team at World Bank Institute. These indicators are also the most widely quoted and widely used governance indicator in the media, academia and among international organizations, and hence are selected to assess empirically the impact of institutional quality on stock market efficiency. The 2006 version of the WGI dataset, as documented in Kaufmann *et al*. (2006),[22] measures six dimensions of governance quality, covering 213 countries and

[20] Another commonly used indicator of institutional quality in cross-country studies is the commercial dataset of political risk rating provided by International Country Risk Guide of the PRS group (some recent users include Bekaert *et al*., 2005, 2006, 2007b; Lesmond, 2005; Chinn and Ito, 2006, 2007; Eleswarapu and Venkataraman, 2006; Ito, 2006; Bris *et al*., 2007; Fernandes and Ferreira, 2007).

[21] The World Bank provides an inventory of those available governance datasets and instruments, in order to facilitate the user's access to a broad spectrum of such data, and to let user decides which one is the most relevant. The URL is: http://www.worldbank.org/wbi/governance/govdatasets. The total number of user-accessible sets of governance indicators in the inventory exceeds 160 as of 30 April 2007.

[22] Most of our subsequent discussions on the WGI dataset borrow from this particular reference.

territories for 1996, 1998, 2000, and annually for 2002-2005. The indicators are based on several hundred individual variables measuring perceptions of governance, drawn from 31 separate data sources constructed by 25 different organizations.[23] The World Bank team assigned these individual measures of governance to categories capturing key dimensions of governance, and used an unobserved components model to construct six aggregate governance indicators: (1) voice and accountability (VA_{it}); (2) political stability and absence of violence (PV_{it}); (3) government effectiveness (GE_{it}); (4) regulatory quality (RQ_{it}); (5) rule of law (RL_{it}); (6) control of corruption (CC_{it}). The six composite governance indicators are measured in units ranging from about -2.5 to 2.5, with higher values corresponding to better governance outcomes. Though there are a number of academic studies that combine several or all of the six aggregate indicators into a single "governance" indicator, Arndt and Oman (2006: 44-46) strongly criticized such an approach and noted that Kaufmann and his co-authors never did so in their empirical analyses.

Despite the criticisms by Arndt and Oman (2006) and some other researchers (see also Kaufmann *et al*., 2007 for replies), the Worldwide Governance Indicators project should be lauded for their transparency and accessibility. First, the producers for the first time published in the 2006 version of the dataset, the individual indicators of governance from all but three of the 31 separate data sources that form their six aggregate indicators. Besides promoting greater transparency in their methodology, the availability of these

[23] The International Country Risk Guide of the PRS group is one of the contributors to the WGI dataset (see Kaufmann *et al*., 2006: Appendix, 74-75). Specifically, these authors used 10 components from the political risk rating, which report subjective assessments of the factors influencing the business environment in a particular country. The PricewaterhouseCoopers (PwC) Opacity Index, on the other hand, is among the few data sources that has been dropped in the 2006 version, on the basis that the index has either been discontinued, or has not been updated or do not appear likely to be updated in the future on a regular basis.

measures on sub-dimensions of governance also helps data users and policy-makers to identify specific governance challenges in individual countries. Second, Kaufmann *et al*. (2006) are among the few producers of governance indicators who recognized and explicitly acknowledged the imprecision associated with measuring governance across countries. Specifically, these authors complemented their estimates of governance for each country with estimates of margins of error, and encouraged users to exercise caution when making comparisons across countries and over time. However, they noted that these margins of error have declined over time with the addition of new data sources to their aggregate indicators, and are substantially smaller than for any of the individual data sources. Third, the worldwide aggregate governance indicators, together with the underlying indicators from all but three of the sources, are available electronically at www.worldbank.org/wbi/governance/. This site also features a number of Web-based interactive data tools that allow users to compare the six dimensions of governance within a country over time or compare each dimension of governance across several countries. The data for all of our 50 sampled countries were downloaded from the WGI's web site on 30 April 2007. Our cross-sectional analysis uses data averaged over the period 1996-2005 for each country.

4.4 Stock Market Regulations

In the weak-form EMH literature, only a few studies have actually examined the impact of regulation on stock market efficiency. For instance, Antoniou *et al*. (1997) argued that it is necessary to examine efficiency at different stages of development to reflect changes in market regulations. Using daily data on the Istanbul Stock Exchange (ISE) Composite Index, the authors investigated efficiency on a yearly basis for the period from 1988 to 1993. Their results showed that changes in the regulatory structure from late 1989 have led the ISE to become efficient since the year 1991. Hence, these authors concluded that

an efficient market is brought about by providing a regulatory framework that encourages participation in the market, removes institutional restrictions on trading, and ensures investors have access to high quality and reliable information. Groenewold *et al*. (2003, 2004) postulated that changes in the regulations governing the direct involvement of banks in the stock market would have significant effects on market efficiency given the fact that Chinese banks traditionally played a dominant role in their country's financial system. To address this question empirically, the authors examined market efficiency over three different sub-periods in which banks were subjected to different regulations. The statistical results supported their conjecture, in particular, market efficiency suffers when banks were excluded from the stock market during the sub-period of 1/7/1996-31/12/1999, but there is improvement in efficiency when banks were readmitted during 1/1/2000-29/3/2001.

One possible reason for this lack of empirical studies is the difficulty in quantifying laws and regulations of a country for econometric analysis. The pioneering work by La Porta *et al*. (1998) represents a major breakthrough that provides researchers the data for assessing the impact of cross-country differences in regulatory framework, and the phenomenon growth of the law and finance literature can be partly attributed to their path-breaking study.[24] With the wide acceptance of numerical comparative laws in the field of finance and economics, it then provides a strong basis for us to examine the effect of regulations on stock market efficiency. The present section provides a brief

[24] The legal institutions in general, and investor protection in particular, have been shown to affect, among others, the development of financial markets, corporate financial policies, firms' equity valuations, ownership concentration, availability and cost of external finance, investors' portfolio holdings, quality of accounting information, stock price informativeness, distributional characteristics of stock returns, and economic growth (for selected survey, see La Porta *et al*., 2000; Beck and Levine, 2005). While Siems (2005a, b) have been highly critical of the use of numbers in comparative law, the author noted that its potential to open new vistas of research in the area of comparative law should not be shunned. In fact, Lele and Siems (2007) recently proposed a new shareholder protection index, with the objective that their index will constitute a basis for future econometric study.

discussion on the four legal variables selected in our exploratory study, i.e. the protection of outside investors, general securities laws, insider trading laws and short selling restrictions. If the chosen legal indicators are found to be significant determinants of market efficiency, this would imply that the securities commission[25] should improve the legal infrastructure of a country, in particular the level of protection afforded to minority shareholders and the enforcement of securities laws.

4.4.1 Investor protection

In cross-country empirical studies, the anti-director rights index is the most popular indicator for measuring how strong a country's legal system protects outside investors against expropriation by the insiders, referring to both managers and controlling shareholders.[26] This shareholder rights index was first introduced by La Porta *et al.* (1998) for 49 countries, and updated by Pagano and Volpin (2005) to the entire interval between 1993 and 2002 for all countries except Jordan and Sri Lanka. Pistor *et al.* (2000) later constructed the same index for 24 transition countries, followed by Allen *et al.* (2005) for China. With an emphasis on consistent coding, i.e. categorizing all countries according to the same criteria, Spamann (2006) re-coded the anti-director rights index from La Porta *et al.* (1998) with the help of local lawyers, for all countries except Indonesia, Sri Lanka and Zimbabwe. The main finding from his re-coding exercise

[25] Information on stock market regulators in most countries can be obtained from the web site of International Organization of Securities Commissions (IOSCO) at http://www.iosco.org/.

[26] Another common proxy for investor protection in comparative studies is the classification of legal systems based on their origins (see for example, Beny, 2005, 2007; Bushman *et al.*, 2005; Francis and Wang, 2006; Leuz *et al.*, 2006; Kusnadi and Wei, 2007). This choice is based on the findings of La Porta *et al.* (1998) for 49 countries that legal origin is an important determinant of shareholders' rights. Specifically, La Porta *et al.* (1998) found that countries with English common-law origin (French civil law origin) provide the strongest (weakest) legal protection of investors, while German- and Scandinavian-civil law countries fell somewhere between the English and French systems. In a subsequent extension, Djankov *et al.* (2007) classified 129 countries into English, French, German, Scandinavian and Socialist legal origins. However, Siems (2007) criticized this legal origin approach given that the categorization of legal families is to a large extent arbitrary. On the other hand, using the re-coded anti-director rights index, Spamann (2006) found that there is no significant difference for the degree of investor protection between common and civil-law countries.

showed that the original index was systematically incorrectly measured and contained various coding errors. Djankov *et al*. (2006) accepted the criticisms by a number of scholars including Spamann (2006) against their original shareholder rights index, in particular for its *ad hoc* collection of variables, for mistakes in its coding, and for conceptual ambiguity in the definitions of some of its components. In response, they presented a revised index of anti-director rights for 72 countries based on laws and regulations applicable to publicly-traded firms in May 2003. It is worth noting that Spamann (2006) has also re-corded the revised index by Djankov *et al*. (2006), and reported that the impact of re-coding is weaker but still strong even with the revisions. Though Spamann (2006) made available his properly re-corded anti director rights index, he cautioned that the index might not be a valid measure of legal shareholder protection, and suggested that effort would be better spent on more theory-guided variables such as the anti-self dealing index of Djankov *et al*. (2006), or the securities law indices from La Porta *et al*. (2006).

Guided by the above developments, we select the anti-self-dealing index presented by Djankov *et al*. (2006) as our proxy of investor protection $\left(INV\_PRO_i\right)$.[27] With the help of attorneys from Lex Mundi law firms, this index was calculated for 72 countries based on legal rules prevailing in May 2003, and addressed the protection of minority shareholders against self-dealing transactions benefiting controlling shareholders. Specifically, these authors started with a fixed self-dealing transaction and then measured

[27] The anti-self-dealing index for all of our 50 sampled countries was downloaded from Andrei Shleifer's web site at http://www.economics.harvard.edu/faculty/shleifer/data.html on 15 June 2007. An alternative shareholder protection index that allows comparison across countries and over time has been constructed by Lele and Siems (2007) using a "leximetric" approach. However, the annual data covering the period 1970-2005 are available only for France, Germany, India, United Kingdom and United States at the time of writing. Nevertheless, the authors stated that this is the first of a series of papers that they intend to produce as part of the project on "Law, Finance and Development" at the Centre for Business Research, University of Cambridge, UK.

the hurdles that the controlling shareholder must jump in order to get away with this transaction. The higher the hurdles, the higher the anti-self-dealing index is, and hence stronger protection afforded to minority shareholders. As such, it is better grounded in theory than the index of anti-director rights. In fact, Djankov *et al*. (2006) argued that the anti-self-dealing index is preferred to the anti-director rights index in cross-country empirical work, given that self-dealing is the central problem of corporate governance in most countries, and hence the law's effectiveness in regulating this problem is the fundamental element of shareholder protection.

4.4.2 Securities laws

In a recent paper, Daouk *et al*. (2006) developed a composite capital market governance index that captures three dimensions of securities laws: the degree of earnings opacity, the enforcement of insider laws, and the effect of removing short selling restrictions. The authors then examined the effects of these exchange-based regulations and their enforcement on a wide range of market performance measures in a broad cross-section of 33 countries. Their results, among others, showed that an improvement in the composite index increases market pricing efficiency, which is measured in terms of stock price synchronicity and IPO underpricing. Detailed analyses indicated that the pricing efficiency results are driven primarily by the insider trading and short selling variables, with earnings opacity playing a lesser role. In this study, we first investigate the effect of general securities regulations on the predictability of stock returns, before considering individually the impact of specific laws governing insider trading and short selling.[28]

[28] We do not include earnings opacity for two reasons. First, Bhattacharya *et al*. (2003: 642) defined earnings opacity of a country as the extent to which the distribution of reported accounting earnings of firms in that country fails to provide information about the distribution of the true, but unobservable, economic earnings of firms in that country. The authors used measures that are intended to capture three attributes of earnings numbers that could lead to earnings opacity: earnings aggressiveness, loss avoidance and earnings smoothing. In this context, it is difficult to provide specific policy prescriptions to stock

Instead of using the composite index constructed by Daouk *et al*. (2006), we utilize the database assembled by La Porta *et al*. (2006) on rules and regulations governing the issuance of new equity to the public in 49 countries as of December 2000. We follow Hail and Leuz (2006) to construct a proxy that captures the overall effectiveness of a country's securities regulations (see also Leuz *et al*., 2006). This composite index $\left(SEC\_LAWS_i\right)$ is computed as the arithmetic mean of three indices: (1) the disclosure requirements index, capturing the extent to which there is required disclosure of information for firms issuing securities through a prospectus including information on the compensation of executives, shareholder ownership structure, inside ownership, irregular contracts, and related-party transactions; (2) the liability standard index, measuring the procedural difficulties for investors to recover damages from issuers of securities, company directors, distributors and accountants, in a civil liability case for losses due to misleading statements in the prospectus; and (3) the public enforcement index, capturing the characteristics of the supervisor/regulator of the securities markets, and its powers in terms of rule-making, conducting investigation, imposing non-criminal and criminal sanctions for violations of securities laws. The score for the composite index ranges from zero to one, with higher values indicating stricter securities regulations. It is worth highlighting that the factor analysis conducted by Hail and Leuz (2006) supported the aggregation of these three indices.[29]

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market regulators. Second, the cross-country data of earnings opacity from Bhattacharya *et al*. (2003) and Daouk *et al*. (2006) are available only for 34 and 33 of our sampled countries, respectively.

[29] The data, available for 44 of our sampled countries except China, Czech Republic, Hungary, Morocco, Poland and Russia, were downloaded from Andrei Shleifer's web site at http://www.andrei-shleifer.com/data.html on 30 April 2007.

4.4.3 Insider trading laws

The question of whether insider trading enhances or reduces stock market efficiency is an unresolved theoretical debate in the law, economics and finance literature (for detailed discussions, see Beny, 2007 and references cited therein). Empirically, the evidence from cross-country studies in general favors the regulation of insider trading (see Beny, 2005, 2007; Daouk *et al*., 2006; Fernandes and Ferreira, 2007). It is worth highlighting that all the aforementioned papers utilized the market model *R*-square statistic as a measure of market efficiency, while the voluminous return predictability literature has largely ignored this issue.[30] In empirical studies, the commonly used insider trading data can be categorized into three types: (1) the perception-based index of insider trading extracted from World Competitiveness Yearbook (see Shen and Chih, 2005; Bae *et al*., 2006b) or Global Competitiveness Report (see Du and Wei, 2004; Fernandes and Ferreira, 2007), in which respondents were asked to rate the prevalence of insider trading in their respective domestic stock markets; (2) an index constructed by Beny (2005, 2007) for measuring the stringency of insider trading laws in 33 countries as of the mid-1990s (for users other than the developer, see Bris, 2005; Durnev and Nain, 2007); (3) the comprehensive survey conducted by Bhattacharya and Daouk (2002) on the existence of an insider trading law and the year of first prosecution under the law (if any) in 103 countries with stock markets at the end of 1998, which is by far the most popular dataset utilized by researchers, in particular the enforcement date (some recent users include De Fond *et al*., 2007; Durnev and Nain, 2007; Fernandes and Ferreira, 2007; Griffin *et al*., 2007; Li, 2007).

[30] The only exception that we are aware of is the work by Griffin *et al*. (2007), in which the variance ratio test was employed as one of their four measures of market efficiency. Their multiple regressions results showed that autocorrelations for individual stocks tend to be higher in markets with stronger insider trading laws, suggesting that the prohibition of insider trading has negative effect on market efficiency.

The final type of data is our preferred choice for two reasons besides its wide acceptance. Firstly, given that our objective is to examine the effect of regulation on market efficiency, the perception-based index of insider trading is deemed inappropriate since it surveys the prevalence of insider trading in a particular stock market and hence is not related to the regulation of such activity. Secondly, Bhattacharya and Daouk (2002) showed that it is the enforcement rather than the mere existence of insider trading laws that reduces the cost of capital. In a subsequent paper, Bhattacharya and Daouk (2005) argued, both theoretically and empirically, that sometimes no security law may be better than a good security law that is not enforced. Using the insider trading law as a case study, the authors found that the cost of capital actually rises when a country introduces an insider trading law but does not enforce it. On that basis, we rule out the index on the stringency of insider trading regulation by Beny (2005, 2007) as it measures laws on the books and not the enforcement of laws. Moreover, the data is only available for 32 of our sampled countries. This then leaves us with the dataset assembled by Bhattacharya and Daouk (2002), though not perfect, is sufficient for us to assess the effect of insider trading laws on stock market efficiency.[31] To be precise, we construct a dummy variable, $INSIDER_i$, that takes the value of one in country where the first legal prosecution for insider trading has been recorded by the end of 1999, zero otherwise.

4.4.4 Short sales restrictions

In a survey involving stock exchange regulators with regards to their perceived need for short sales regulation, Bris *et al.* (2004: 326) noted that regulators were largely concerned with market efficiency and the probability of market crashes. Hence, the

[31] It would be ideal if international data on the incidence and intensity of insider trading enforcement are available. However, Bhattacharya and Daouk (2002) noted that such data is extremely difficult to get from the countries' regulators. In fact, they only managed to obtain historical data on all prosecutions for three countries. Another limitation is that the insider trading enforcement date ended in 1999. For our sample, there are fifteen countries that have no legal prosecution by the end of 1999. As noted by De Fond *et al.* (2007), it is possible that some countries might enforce insider trading laws after 1999.

present inquiry on the efficacy of short sales restrictions would be of interest to regulatory agencies. Earlier cross-country studies by Daouk *et al*. (2006) and Bris *et al*. (2007) found that stock markets are more efficient when short sales are allowed.[32] However, using return predictability as the measurement of market efficiency, the findings in Griffin *et al*. (2007) favored the imposition of short selling restrictions. Specifically, their multiple regression results yielded a positive coefficient on the short sales dummy variable, indicating that a higher level of autocorrelations in portfolio returns is positively related to the ability to sell short. This result implies that the relaxation of short sales constraints adversely affect market efficiency.

In the present empirical analysis, we utilize two existing datasets on market-wide short selling restrictions: (1) based on the survey of exchange officials, Charoenrook and Daouk (2005) assembled a comprehensive dataset on the legality and feasibility of short selling and put option trading for 111 countries (including all of our sampled countries) up to December 2002. The reason for including the existence of equity put options in their questionnaire is because it offers an alternative method to implement a short position. On the other, the authors argued that the feasibility of short selling and put option trading should have a stronger influence on capital markets than simple legality.[33] Hence, to capture the effect of short selling regulation on market efficiency, we follow Charoenrook and Daouk (2005) to construct a binary variable that reflects the ability of investors to take short positions. This variable, denoted as $SSALE\_CD_i$, equals one if either short selling or put options trading is feasible in a given country by the end of

[32] In Daouk *et al*. (2006), market efficiency is measured in terms of stock price synchronicity and IPO underpricing. In addition to the popular market model *R*-square statistic, Bris *et al*. (2007) also employed the cross-autocorrelation of Hou and Moskowitz (2005).

[33] Charoenrook and Daouk (2005) noted that many countries do not have rules prohibiting short selling, but it cannot take place because there are no enabling institutional facilities. Conversely, some countries (like Singapore) officially ban short selling, yet it routinely took place via offshore markets.

2002, zero otherwise; (2) Bris *et al*. (2004, 2007) compiled information on the legality and practice of short selling for 49 countries over the period 1990 to 2001, with investment banks, market regulators, industry publications and market participants their primary sources. The data are available for 46 of our sampled countries except Egypt, Morocco, Russia and Sri Lanka. We follow Bris *et al*. (2007) to construct a short sales dummy variable, $SSALE\_BGZ_i$, that takes the value of one when short selling is both allowed and commonly practiced in a given country by the end of 2001, zero otherwise (see also Bae *et al*., 2006b; Griffin *et al*., 2007). Bris *et al*. (2007) noted that there is clearly a difference between what the law allows and what the common practice is. For instance, Argentina, Brazil, Chile, Finland, Hungary, Israel, New Zealand, the Philippines, Poland, Spain, Taiwan, and Turkey are countries in which short selling is allowed but rarely practiced.

4.5 Stock Market Characteristics

In general, it is common for researchers to relate their findings of efficiency/inefficiency to the underlying stock market characteristics, in particular the developed/emerging market classification. The conventional wisdom is that emerging stock market prices were bound to show significant divergence from random walk as these markets are characterized by low liquidity, thin trading and less well informed investors. Hence, it is logical to expect emerging markets to be less efficient than their developed counterparts that have high levels of liquidity, sophisticated investors and few institutional impediments. For instance, Matteo *et al*. (2003, 2005) noted that the long term predictability detected by Hurst exponent is associated with financial market development. Their empirical analysis revealed that there is a tendency for mature developed markets to have values of generalized Hurst exponent smaller than 0.5,

whereas less developed markets show a tendency to have values greater than 0.5. However, the explanation using a dichotomous variable based on market status is not informative, as it masks the diversity among stock markets in terms of market development, liquidity/transaction costs, trading systems and the number of security analysts, which are important characteristics of stock markets that could affect the level of market efficiency. This section justifies each of these independent variables selected for our cross-sectional analysis.

4.5.1 Stock market development

To address the question of whether the development of stock market in terms of market size and liquidity has rendered the underlying returns series to behave more like a random walk, we follow Demirgüç-Kunt and Levine (1996) and Levine and Zervos (1998) to construct a composite index of stock market development, denoted as SMD_i.[34]

It is worth highlighting that a number of studies in the weak-form efficiency literature have explored whether their findings can be explained by the level of stock market development. For instance, Appiah-Kusi and Menyah (2003) found that the nonlinear predictability detected in their sample of African stock markets is not related to the total number of listed companies, total market capitalization and turnover ratio. Lim *et al.* (2007a), in contrast, reported significant rank correlation coefficients for market capitalization/GDP and total value traded/GDP, indicating that the existence of nonlinear dependence in their sampled Asian emerging stock markets is associated with market size and trading activity. The latter finding is consistent with Lagoarde-Segot and Lucey

[34] Demirgüç-Kunt and Levine (1996) noted that stock market development is a complex and multifaceted concept, and no single measure will capture all aspects of stock market development. The use of a composite index that averages the information contained in the individual indicators serves to produce an assessment of the overall level of stock market development, and hence is helpful for cross-country comparative studies. For instance, using their aggregate index, the authors found that from 1986 to 1993 the most developed stock markets in the world are in Japan, U.S. and U.K., while the most underdeveloped markets are in Colombia, Venezuela, Nigeria and Zimbabwe.

(2007) for seven emerging MENA stock markets. Specifically, the ordered logit analysis revealed that the informational efficiency in their sampled markets can be explained by differences in market capitalization, total numbers of listed firms, value traded and turnover ratio.

Our conglomerate index averages the means-removed values of three popular stock market development indicators in the finance and growth literature (for a recent survey, see Levine, 2005): (1) market capitalization ratio, measuring the size of the stock market relative to that of the economy, is equal to the value of listed domestic shares on domestic stock exchanges divided by GDP; (2) total value traded ratio, capturing trading activity relative to the size of the economy, is equal to the value of the trades of domestic shares on domestic exchanges divided by GDP; (3) turnover ratio, quantifying the level of trading relative to the size of the stock market, is equal to the value of the trades of domestic shares on domestic exchanges divided by the value of listed domestic shares. Specifically, the construction of this index follows a two-step procedure. First, for each country i, we compute the means-removed value as $X_i^m = \left(X_i - \bar{X}\right) \Big/ \left|\bar{X}\right|$, where X_i (representing market capitalization ratio, total value traded ratio or turnover ratio) equals the ratio for country i averaged over 1995-2005, and $\bar{X}$ is the average value of that particular variable across all countries. Second, we construct the composite index $\left(SMD_i\right)$ by taking a simple average of these transformed values of market capitalization ratio, total value traded ratio, and turnover ratio. The data for the above three individual indicators are obtained from the World Bank's Financial Development and Structure database compiled by Beck *et al*. (2000), and updated until 2005 by the authors.[35]

[35] The data, available for all of our sampled countries over the period 1995-2005, were downloaded from World Bank Finance and Private Sector Research Datasets at http://go.worldbank.org/X23UD9QUX0 on 30 April 2007.

4.5.2 Stock market liquidity

It is commonly hypothesized that short-horizon return predictability from past information should be quickly arbitraged away when the stock market is liquid. Using a panel dataset of sixteen countries, Jain-Chandra (2002) first examined the impact of stock market liberalization on liquidity, and further ascertained the empirical link between liquidity (proxied by turnover ratio, value traded and volume traded) and stock market efficiency (measured in terms of the absolute deviation of variance ratio from one). The author found strong evidence that liquidity increases in the post liberalization era, and this increased liquidity contributes to enhanced efficiency while liberalization has a separate impact on market efficiency. In another related paper, Griffin *et al*. (2007) argued that impediments to trade are likely to impact the incorporation of information in security prices. For instance, bid-ask spreads, trading commissions, and lack of liquidity undermine the ability of arbitrageurs to exploit deviations from efficient pricing. Given that intraday transaction cost measures are not available for a broad number of countries, the authors then derived two different estimates of transactions costs from daily data using the approaches proposed by Hasbrouck (2006) and Lesmond *et al*. (1999) respectively. Overall, the Lesmond *et al*. (1999) trading cost estimates indicate that daily frictions are larger in emerging markets, whereas with the Hasbrouck (2006) estimates, the differences are quite small. If one expects higher transactions costs to be associated with less information efficiency, then the above findings suggest relatively greater information efficiency in developed markets. However, Griffin *et al*. (2007) found that, despite higher transactions costs, emerging markets are at least as efficient as developed markets and often more so. Their subsequent cross-sectional analyses confirm the lack of association between both transactions cost measures and the four efficiency estimators.

To explore the potential role of market liquidity, we need to first decide on the choice of proxy for this variable. In this regard, it is widely acknowledged that stock market liquidity is notoriously difficult to measure and hence it is unsurprising to learn that many proxies have been proposed in the literature. This also includes two of our three stock market development components, in particular the turnover ratio which is one of the popular indicators in the growth and finance literature. However, these trade-based measures do not directly quantify trading costs facing investors or the price impact of transactions. A finer approach would be to use realized transaction cost data directly such as the bid-ask spreads,[36] but such data is difficult to obtain for emerging markets and over long periods of time.[37] Due to this constraint, we use a simple proxy for liquidity that obtains estimates of transaction costs based on the incidence of zero returns and requires only the time series of daily stock returns, which Bekaert *et al*. (2007a) justified as an attractive empirical alternative for cross-country studies involving emerging markets (for other users, see Levine and Schmukler, 2006; Bris *et al*., 2007). Specifically, the market liquidity for a given country $\left(LIQUID_i\right)$ is computed as the number of days when our MSCI country index has a zero return, divided by the total number of days with available return data over our sample period 1995-2005. This approach was originally proposed by Lesmond *et al*. (1999) and further analyzed by Lesmond (2005). These authors argued that if the value of an information signal is insufficient to outweigh associated transaction costs, market participants will elect not to trade, resulting in an observed zero return. Hence, the proportion of zero returns is

[36] This is evidenced by the fact that the bid-ask spread information was often used as the benchmark for judging the efficacy of those liquidity proxies included in the horseraces (see, for example, Lesmond *et al*., 1999; Lesmond, 2005; Goyenko *et al*., 2006; Hasbrouck, 2006).

[37] A number of studies provided country-specific estimates of equity trading costs, using the actual institutional trades compiled by financial consulting firms such as Elkins/McSherry and Plexus Group (Domowitz *et al*., 2001; Chiyachantana *et al*., 2004), or actual bid-ask quotes (Jain, 2003; Eleswarapu and Venkataraman, 2006). However, these data cover either a relatively short period of time or limited number of countries, and hence cannot be used directly for our cross-country regressions.

associated with transaction costs, in which a security with high transaction costs will have less frequent price movements and more zero returns than a security with low transaction costs.

4.5.3 Trading systems

One major reform that has been undertaken by stock exchanges around the world in recent decades is the replacement of physical trading floors by computerized trading systems. For instance, Jain (2005) assembled the announcement and actual introduction dates of electronic trading by the leading stock exchange of 120 countries, and reported a strong trend towards full automation of trading. Specifically, his survey found that the leading exchange in 101 of the 120 sample countries have introduced fully automated and transparent electronic trading systems within the last 25 years. Freund and Pagano (2000) noted that it is difficult to discern theoretically the effect of automation on the level of informational efficiency, and hence the issue is very much an empirical one. Given the significance of such inquiry to policymakers, a number of studies have examined its impact on the weak-form efficiency of the underlying stock market, using autocorrelation-based test (Naidu and Rozeff, 1994; Maghyereh, 2005) and rescaled range analysis (Freund *et al*., 1997; Freund and Pagano, 2000). Except for the positive results documented in Naidu and Rozeff (1994) for the Singapore Stock Exchange, the other three studies found that the shift to electronic trading systems does not appear to have a material effect on the degree of market efficiency. This section extends the above single-country sub-periods studies to a broader multi-country regression setting, exploiting the cross-sectional variations in the introduction dates of electronic trading. Based on the information provided by Jain (2005), the stock exchanges in our sampled countries have all replaced their physical trading floors with computerized trading systems, with the latest been Ireland, Jordan and the United States in year 2000. Given

this unique situation, we then construct a dummy variable, TD_SYS_i, that measures the fraction of time during our sample period 1995-2005 in which a country has automated its trading system.

4.5.4 Number of security analysts

It is generally hypothesized that the presence of security analysts, who provide firm-specific earnings forecasts, improves the quality and quantity of information available to market participants, and hence should lead to a more efficient stock market. However, empirical evidence drawn from cross-country studies for this conjecture is not conclusive. Using the *R*-squared statistic as a measure of stock return synchronicity, Chan and Hameed (2006) examined its relationship with the level of analyst activity in 25 emerging markets. The authors found that greater analyst coverage increases stock price synchronicity, which would imply a negative impact on market efficiency. In contrast, the variance ratio test results in Griffin *et al*. (2007) report a positive association between market efficiency and analyst forecasting activities. Specifically, the autocorrelations for individual stocks tend to be higher in markets with less analyst coverage. In empirical studies, Thomson I/B/E/S (Institutional Broker Estimate System) database is the common source of data on analyst activity and their earning forecasts for a large number of companies around the world. Unfortunately, we do not have access to the above database. As an alternative, we use the country-level measure of analyst coverage provided by Fernandes and Ferreira (2007), which is the logarithm of one plus the median number of analysts across firms in each country-year. Specifically, data for the variable $ANALYSTS_i$ were extracted from Fernandes and Ferreira (2007: Table 1) that reported the time series average of analyst coverage over the period 1980-2003. It

covers 42 of our sampled countries, except China, Czech Republic, Egypt, Hungary, Jordan, Morocco, Poland and Russia.

4.6 Macroeconomic Environment

Though there is no study that examines the direct impact of macro factors on stock market efficiency, we include a set of commonly used variables to control for the general macroeconomic environment:

(i) Real Per Capita GDP (GDP_i): The natural logarithm of real per capita gross domestic product is used to measure the level of economic development. The data were collected from World Development Indicators for all countries except Taiwan from 1995 through 2005. The cross-sectional analysis uses the time series averages for each country over this period.

(ii) Trade Openness (TD_OPEN_i): This is measured as the sum of exports and imports of goods and services as a share of GDP. The data, averaged over the period 1995-2005, were collected from World Development Indicators for all countries except Taiwan.

(iii) Inflation Rate (INF_i): The inflation rate is measured by the annual growth rate of the GDP implicit deflator. The data were collected from World Development Indicators for all countries except Taiwan from 1995 through 2005. The time series averages over this period for each country are used in the cross-country regressions.

5. Empirical Analyses and Discussions

The first stage of our analysis involves comparing the relative efficiency of the 50 sampled stock markets. We then present the descriptive statistics for all our explanatory

variables and their correlations. Univariate and multivariate regression analyses are subsequently conducted to determine how well the selected variables explain the cross-country differences in the degree of weak-form market efficiency.

5.1 Cross-Country Variations in the Degree of Weak-form Market Efficiency

As stated earlier, our objective of using the rolling sample approach is to capture the evolving dynamics of the underlying nonlinear predictable patterns over time, and these results are best be communicated through graphical depiction. Figure 1 plots, for the purpose of illustration, the *p*-values of the H statistics in each rolling time window for two selected indices, one for a developed market (United States), and one for an emerging stock market (South Korea). The vertical axis shows the *p*-values, while the horizontal axis is labelled with the dates of the time windows. The bootstrapped threshold level is plotted as a horizontal dotted line parallel to the X-axis. Graphically, a time window is significant if the *p*-value lies below or on the threshold line, implying the potential of nonlinear predictability during that particular time window. Indeed, the visual inspection confirms our conjecture that the detected nonlinear predictability follows an evolutionary time path, suggesting that market efficiency is not an all-or-none condition but is a characteristic that varies continuously over time. This applies to both groups of emerging and developed stock markets.

<<Insert Figure 1 about here>>

Given that the evidence of evolving market efficiency implies stock markets are not efficient all the time, a meaningful comparative analysis can further be conducted within our rolling sample framework by comparing the total time periods each market attains efficiency over 1995-2005. In other words, the relative weak-form efficiency of each

market is assessed using the proportion of rolling time windows that the underlying MSCI returns series exhibit significant nonlinear dependence as detected by the H statistic. Specifically, we define a time window as significant when the *p*-value of the H statistic is less than or equal to the bootstrapped threshold level (or cut-off point) that corresponds to the nominal level of 5%. With a window length of 200 observations, the total number of rolling time windows is 2670 for each country. The results from the application of the rolling bicorrelation test on all the 50 MSCI country indices are summarized in Figure 2. This figure provides the proportion of significant rolling H windows across countries, with lower value indicates smaller number of windows that exhibits significant nonlinear predictability, and hence suggests higher level of weak-form market efficiency. Table 1 further reports the summary statistics for the proportion of significant rolling H windows across the entire sample, as well as the sub-groups of emerging and developed markets. The results as a whole indicate that the degree of weak-form market efficiency varies widely across countries, from a minimum of 0.1745 in Thailand to a maximum of 0.6255 in Sri Lanka. On average, the proportion of significant rolling H windows in developed markets is 8.65% lower than emerging markets, conforming to the general expectations that developed markets are more efficient than emerging ones. The subsequent *t*-test of the equality of means between these two groups confirms that the differences are statistically significant at the 1% level.

<<Insert Figure 2 about here>>

<<Insert Table 1 about here>>

On a country-by-country basis, however, some emerging markets are found to be more efficient than the developed ones. In fact, sorting the results from the lowest proportion of significant rolling H windows to the highest, four emerging markets occupy the top five in the chart, with Hong Kong the only representative from developed countries. Specifically, Thailand (0.1745) is the most efficient market, followed by Jordan (0.1775), Hong Kong (0.1835), South Korea (0.2412) and Malaysia (0.2584). Somewhat surprising, the largest stock market in the world, United States, is ranked 31st, as 41.35% of the total rolling time windows exhibit strong evidence of nonlinear serial dependence. These results, while puzzling, are in general consistent with those reported by Griffin *et al*. (2007), in particular the inferences derived from their efficiency proxies that measure the speed of public information incorporation, i.e. the delay measure and variance ratio test. In terms of the latter, the authors found that emerging markets exhibit similar or less autocorrelations in individual stock and size-ranked portfolio returns, suggesting that these markets are not under or overreacting to news contained in past returns any more than developed markets do. Furthermore, Griffin *et al*. (2007) reported that the largest stock markets like the U.K., Canada, and the U.S. tend to exhibit absolute variance ratios of individual stocks that are slightly larger than other developed markets. On the other hand, the variance ratios computed from equally-weighted portfolio returns revealed that the markets in the U.S. and U.K exhibit the highest positive serial autocorrelation, which is similar to those generated by Bulgaria and Cyprus. To explain why some emerging markets are quite efficient in information incorporation, Griffin *et al*. (2007) argued that it could be due to less information is generated in these markets or that information collection is more costly, so that in an absolute sense their market prices reflect less information. However, with respect to the potentially limited information available, they perform at least as well as those developed markets. Given that the existence of both

linear and nonlinear dependence reflects a slower adjustment of prices to information, the above justification applies equally to our findings. The present results also provide further support to the conjecture of Griffin *et al*. (2007) that the emerging/developed classification might not be a relevant criterion for discerning cross-country differences in efficiency.

5.2 The Explanatory Variables: Descriptive Statistics and Correlations

Table 2 provides the descriptive statistics for all the explanatory variables employed in the analysis. Detailed variable definitions along with their respective sources are given in the appendix. Some notable observations are highlighted here. In terms of stock market liberalization, the mean and median measures indicate that on average our sampled markets are quite open to foreign investors on a *de jure* basis (IOL_i), but in practice capital flows are minimal ($GEQGDP_i$). The distinction between *de jure* and *de facto* openness is also evident in the broader measures of capital account liberalization. In terms of stock market regulations, 70% of our sampled markets have recorded their first legal prosecution for insider trading at least once by the end of 1999. The two competing measures of short sales restrictions provide a rather contrasting assessment. Using the dataset assembled by Charoenrook and Daouk (2005), short selling or put options is feasible in 78% of our sampled markets by the end of 2002 (see $SSALE\_CD_i$). However, using the information provided by Bris *et al*. (2004, 2007), short selling is both allowed and commonly practiced in only 48% of our sampled countries by the end of 2001 (see $SSALE\_BGZ_i$).

Table 3 reports the correlations among the explanatory variables in our sample. For the first group of financial liberalization, all the four competing proxies are significantly correlated. Similarly, the $SSALE\_CD_i$ and $SSALE\_BGZ_i$ also exhibit strong and

significant correlation. The only exception occurs in the case of individualism, where the index constructed by Hofstede (2001) is negatively correlated (though insignificant) with those provided by the Global Leadership and Organizational Behavior Effectiveness (GLOBE) Research Project, despite the fact that both measures are intended to reflect the degree of individualism across countries. In the case of institutional quality, though Arndt and Oman (2006: 44-46) strongly criticized earlier studies that combine several or all of the six aggregate indicators into a single "governance" indicator, the results in Table 3 indicate that these six variables are significantly correlated with each other and hence should not be included in the same regression simultaneously. On the other hand, it is worth highlighting that some of the explanatory variables also exhibit strong correlations, making it difficult to disentangle the effect of individual variable on the level of weak-form market efficiency.

<<Insert Table 2 about here>>

<<Insert Table 3 about here>>

5.3 Univariate Regression Results

Table 4 reports the univariate ordinary least square regressions of our country-level weak-form market efficiency on the explanatory variables. The coefficients, *p*-values (computed based on White heteroskedasticity-consistent standard errors), and adjusted *R*-squares are reported for 24 one-variable regressions. These simple regressions are not hampered by the problem of multicollinearity, and they serve to capture association between variables. Overall, our efficiency measure has significant association with most of the country specific variables, except those related to stock market regulations and

stock market characteristics. The results indicate that the stock market is more efficient in countries that: (1) liberalize their stock market and capital account; (2) exhibit higher degree of institutional collectivism; (3) achieve better governance outcomes; (4) short selling is both allowed and commonly practiced; (5) possess higher number of security analysts; and (6) have higher real per capita GDP, higher degree of trade openness, and lower level of inflation. In terms of explanatory power, $KAOPEN_i$, a *de jure* measure on the intensity of capital account liberalization constructed by Chinn and Ito (2006), is the most important variable.

<<Insert Table 4 about here>>

5.4 Multivariate Regression Results

Given the significance and explanatory power for several of the one-variable regressions, a multiple regression analysis is needed to disentangle the individual effect of each cross-sectional variable.[38] However, our ability to draw sharp conclusions is hampered by the high correlations among a number of the explanatory variables as reported in Table 3. In the absence of a theoretical model, we adopt stepwise multiple linear regression analysis in this exploratory phase of research, which adds and removes variables based on mathematical criteria (significance level is set at 5%). In forming model specifications, the four proxies of financial liberalization (IOL_i, $GEQGDP_i$, $KAOPEN_i$, $IFIGDP_i$) are not included in the same regression simultaneously. This also applies to the competing measures of culture ($INDV\_GH_i$, $INDV\_GLOBE_i$), quality of institutions (VA_i, PV_i, GE_i, RQ_i, RL_i, CC_i) and short sales restrictions ($SSALE\_CD_i$, $SSALE\_BGZ_i$). The above groupings yield 96 model specifications. To conserve space, the results are summarized

[38] For this purpose, Griffin *et al*. (2007) employed the specific to general strategy, i.e. including a variable in the multivariate analysis only when it is significant for a given one-variable regression.

as follows: (1) For models that have regulatory quality (RQ_i) as the explanatory variables, the results show that all variables are excluded except RQ_i, with the expected negative coefficient (-0.078) and *p*-value of 0.002; (2) Only rule of law (RL_i) is significant in all regressions that include this variable; (3) When $KAOPEN_i$ is chosen to enter the regressions, only two variables are significant, i.e. $KAOPEN_i$ and INV_PRO_i, with coefficients of -0.039 and -0.151, respectively. However, this excludes those regressions with RQ_i, or RL_i; (4) Only government effectiveness (GE_i) is significant in all regressions that include this variable, except when $KAOPEN_i$ enters simultaneously as a proxy for financial liberalization; (5) When PV_i is chosen to enter the regressions, only two variables are significant, i.e. PV_i and INV_PRO_i, with coefficients of -0.054 and -0.141, respectively. However, this doe not applies to those regressions that have $KAOPEN_i$ as the independent variable; (6) When voice and accountability (VA_i) or control of corruption (CC_i) is chosen, the significant variables depend on the proxy used for individualism. Specifically, if $INDV\_GH_i$, enters the regression, GDP_i and INV_PRO_i, are significant. Instead, when $INDV\_GLOBE_i$ is selected as the proxy, only INF_i is significant.

The present findings are more promising than the multivariate regression results reported by Griffin *et al*. (2007), who employed four different measures (i.e. delay, variance ratios, post-earnings drift, and average market model *R*-squared) to assess how quickly information is incorporated into prices and hence capture different aspects of market efficiency. Their regression results reveal that a host of cross-sectional variables like security laws, investor protection, and information proxies are largely unrelated to cross-country differences in market efficiency measures. Even if any significant association is found, it typically indicates larger inefficiencies in more mature markets. The authors

noted that it is tempting to attribute their results to noisy efficiency proxies. However, the relation runs opposite to predictions for several regulatory and development measures and is remarkably consistent across all of the efficiency estimators.

6. Conclusions

The present paper extends the short-horizon return predictability literature to explore the potential determinants of weak-form market efficiency in a sample of 50 countries over the period 1995-2005. Using the proposed rolling bicorrelation test statistic, we are able to compare the extent of weak-form market efficiency for all our sampled stock markets, and identify those country-level variables that account for the cross-country differences in the degree of efficiency. The univariate regression results indicate that the stock market is more efficient in countries that: (1) liberalize their stock market and capital account; (2) exhibit higher degree of institutional collectivism; (3) achieve better governance outcomes; (4) short selling is both allowed and commonly practiced; (5) possess higher number of security analysts; and (6) have higher real per capita GDP, higher degree of trade openness, and lower level of inflation. In the multivariate settings, we found that cross-country differences in market efficiency can be explained by quality of institutions (regulatory quality, rule of law, government effectiveness, political stability and absence of violence), capital account liberalization ($KAOPEN_i$), investor protection, and macroeconomic environment (real per capita GDP, inflation). Although the results are suggestive, it is important to stress that they are tentative. In future work, we plan to exploit both the cross-sectional and time-series variation of the data. One advantage of the above-mentioned panel data analysis over the present cross-sectional approach is that the former controls for biases due to unobserved country-specific effects. Moreover, the promising results from our preliminary exploratory study give us

confidence that this is a potentially fruitful line of inquiry, besides the significance of the study. Specifically, an understanding of the determinants of market efficiency is likely to have important implications for the optimal design of markets, trading protocols, and regulatory policy.

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Table 1
Summary Statistics for the Proportions of Significant Rolling *H* Windows

	No. of Observations	Mean	Median	Standard Deviation	Maximum	Minimum
All markets	50	0.3964	0.3719	0.1171	0.6255	0.1745
Developed markets	23	0.3497	0.3375	0.0662	0.4888	0.1835
Emerging markets	27	0.4362	0.4809	0.1362	0.6255	0.1745
			Test of Equality of Means			
Developed vs. emerging markets						
t-statistic			2.7746			
(*p*-value)			(0.0079)			

Table 2
Descriptive Statistics for the Explanatory Variables

	No. of Observations	Mean	Median	Standard Deviation	Maximum	Minimum
IOL_i	50	0.7890	0.9327	0.2803	1.0000	0.0820
$GEQGDP_i$	50	0.9017	0.4951	1.0657	4.9881	0.1004
$KAOPEN_i$	49	3.0037	3.3682	1.4021	4.3695	0.6019
$IFIGDP_i$	50	2.4995	1.5404	2.5727	12.0796	0.4507
$INDV\_GH_i$	47	48.8936	48.0000	24.7976	91.0000	12.0000
$INDV\_GLOBE_i$	42	-4.3076	-4.3050	0.4356	-3.4100	-5.2600
VA_i	50	0.5678	0.8384	0.8387	1.5377	-1.5427
PV_i	50	0.2143	0.4694	0.9050	1.4772	-1.8681
GE_i	50	0.9046	0.8447	0.9329	2.3232	-0.9147
RQ_i	50	0.7659	0.9048	0.7188	1.8544	-0.6799
RL_i	50	0.7555	0.7567	0.9658	2.0697	-1.0059
CC_i	50	0.8021	0.6579	1.0936	2.4671	-0.9428
INV_PRO_i	50	0.4930	0.4450	0.2438	1.0000	0.0900
SEC_LAWS_i	44	0.5446	0.5028	0.1801	0.9667	0.1756
$INSIDER_i$	50	0.7000	1.0000	0.4629	1.0000	0.0000
$SSALE\_CD_i$	50	0.7800	1.0000	0.4185	1.0000	0.0000
$SSALE\_BGZ_i$	46	0.4783	0.0000	0.5050	1.0000	0.0000
SMD_i	50	0.0000	-0.1780	0.7535	2.2449	-0.9061
$LIQUID_i$	50	0.0256	0.0101	0.0403	0.2321	0.0049
TD_SYS_i	50	0.9200	1.0000	0.1370	1.0000	0.5000
$ANALYSTS_i$	42	1.6840	1.6700	0.3659	2.5220	0.9350
GDP_i	49	9.4065	9.6894	0.8332	10.4284	7.5452
TD_OPEN_i	49	82.6444	62.8096	68.1705	404.7815	20.5769
INF_i	49	6.9340	3.5792	10.1393	51.3105	-1.1890

Note: The Appendix describes all the explanatory variables listed above along with their respective data sources.

Table 3
Correlations for the Explanatory Variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)	IOL_i	1.000											
(2)	$GEQGDP_i$	0.439**	1.000										
(3)	$KAOPEN_i$	0.495**	0.493**	1.000									
(4)	$IFIGDP_i$	0.397**	0.972**	0.510**	1.000								
(5)	$INDV\_GH_i$	0.563**	0.230	0.515**	0.214	1.000							
(6)	$INDV\_GLOBE_i$	-0.182	-0.190	-0.121	-0.122	-0.132	1.000						
(7)	VA_i	0.784**	0.324*	0.622**	0.305*	0.762**	-0.144	1.000					
(8)	PV_i	0.716**	0.530**	0.680**	0.492**	0.570**	-0.299	0.777**	1.000				
(9)	GE_i	0.769**	0.600**	0.713**	0.554**	0.649**	-0.349*	0.810**	0.873**	1.000			
(10)	RQ_i	0.749**	0.611**	0.729**	0.571**	0.585**	-0.236	0.817**	0.856**	0.953**	1.000		
(11)	RL_i	0.729**	0.560**	0.726**	0.527**	0.670**	-0.349*	0.817**	0.884**	0.977**	0.939**	1.000	
(12)	CC_i	0.728**	0.589**	0.733**	0.540**	0.668**	-0.361*	0.810**	0.860**	0.980**	0.948**	0.981**	1.000
(13)	INV_PRO_i	0.258	0.376**	-0.013	0.334*	-0.011	-0.280	-0.025	0.098	0.282*	0.261	0.230	0.245
(14)	SEC_LAWS_i	0.127	0.241	0.018	0.160	0.074	-0.188	-0.006	0.030	0.182	0.181	0.124	0.126
(15)	$INSIDER_i$	0.474**	0.156	0.270	0.101	0.259	0.036	0.425**	0.319*	0.392**	0.413**	0.392**	0.348*
(16)	$SSALE\_CD_i$	0.805**	0.292*	0.277	0.271	0.367*	0.028	0.611**	0.523**	0.522**	0.515**	0.494**	0.455**
(17)	$SSALE\_BGZ_i$	0.485**	0.379**	0.541**	0.398**	0.560**	-0.093	0.560**	0.523**	0.533**	0.513**	0.553**	0.522**
(18)	SMD_i	0.445**	0.496**	0.263	0.433**	0.104	-0.185	0.251	0.386**	0.498**	0.436**	0.452**	0.423**
(19)	$LIQUID_i$	-0.627**	-0.227	-0.092	-0.186	-0.492**	0.027	-0.478**	-0.339*	-0.367**	-0.393**	-0.298*	-0.337*
(20)	TD_SYS_i	0.313*	-0.081	-0.066	-0.152	-0.336*	-0.072	0.035	0.066	0.033	-0.011	-0.021	0.020
(21)	$ANALYSTS_i$	0.421**	0.359*	0.439**	0.344*	0.286	0.094	0.241	0.393*	0.387*	0.406**	0.326*	0.355*
(22)	GDP_i	0.829**	0.528**	0.725**	0.504**	0.671**	-0.195	0.854**	0.826**	0.892**	0.882**	0.868**	0.872**
(23)	TD_OPEN_i	0.160	0.684**	0.241	0.653**	-0.130	-0.134	-0.032	0.301*	0.327*	0.379**	0.288*	0.286*
(24)	INF_i	-0.271	-0.317*	-0.457**	-0.293*	-0.317*	0.214	-0.418**	-0.529**	-0.571**	-0.538**	-0.576**	-0.540**

Notes: Detailed variable definitions and data sources are given in the appendix. The asterisks * and ** denote correlation coefficient is significant at the 5% and 1% levels, respectively (two tailed test).

Table 3 (Continued)

		(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
(1)	IOL_i												
(2)	$GEQGDP_i$												
(3)	$KAOPEN_i$												
(4)	$IFIGDP_i$												
(5)	$INDV\_GH_i$												
(6)	$INDV\_GLOBE_i$												
(7)	VA_i												
(8)	PV_i												
(9)	GE_i												
(10)	RQ_i												
(11)	RL_i												
(12)	CC_i												
(13)	INV_PRO_i	1.000											
(14)	SEC_LAWS_i	0.576**	1.000										
(15)	$INSIDER_i$	0.111	0.282	1.000									
(16)	$SSALE\_CD_i$	0.133	0.121	0.601**	1.000								
(17)	$SSALE\_BGZ_i$	0.051	-0.018	0.073	0.439**	1.000							
(18)	SMD_i	0.299*	0.449**	0.376**	0.363**	0.170	1.000						
(19)	$LIQUID_i$	-0.276	-0.115	-0.335*	-0.520**	-0.318*	-0.119	1.000					
(20)	TD_SYS_i	0.052	-0.066	0.257	0.185	-0.118	0.050	-0.443**	1.000				
(21)	$ANALYSTS_i$	-0.011	0.179	0.155	0.268	0.260	0.219	-0.346*	0.153	1.000			
(22)	GDP_i	0.142	0.033	0.414**	0.636**	0.620**	0.426**	-0.473**	0.049	0.349*	1.000		
(23)	TD_OPEN_i	0.400**	0.342*	0.127	0.166	0.043	0.296*	-0.039	-0.046	0.330*	0.220	1.000	
(24)	INF_i	-0.252	-0.236	-0.200	-0.090	-0.358*	-0.301*	0.040	0.107	-0.283	-0.399**	-0.210	1.000

Notes: Detailed variable definitions and data sources are given in the appendix. The asterisks * and ** denote correlation coefficient is significant at the 5% and 1% levels, respectively (two tailed test).

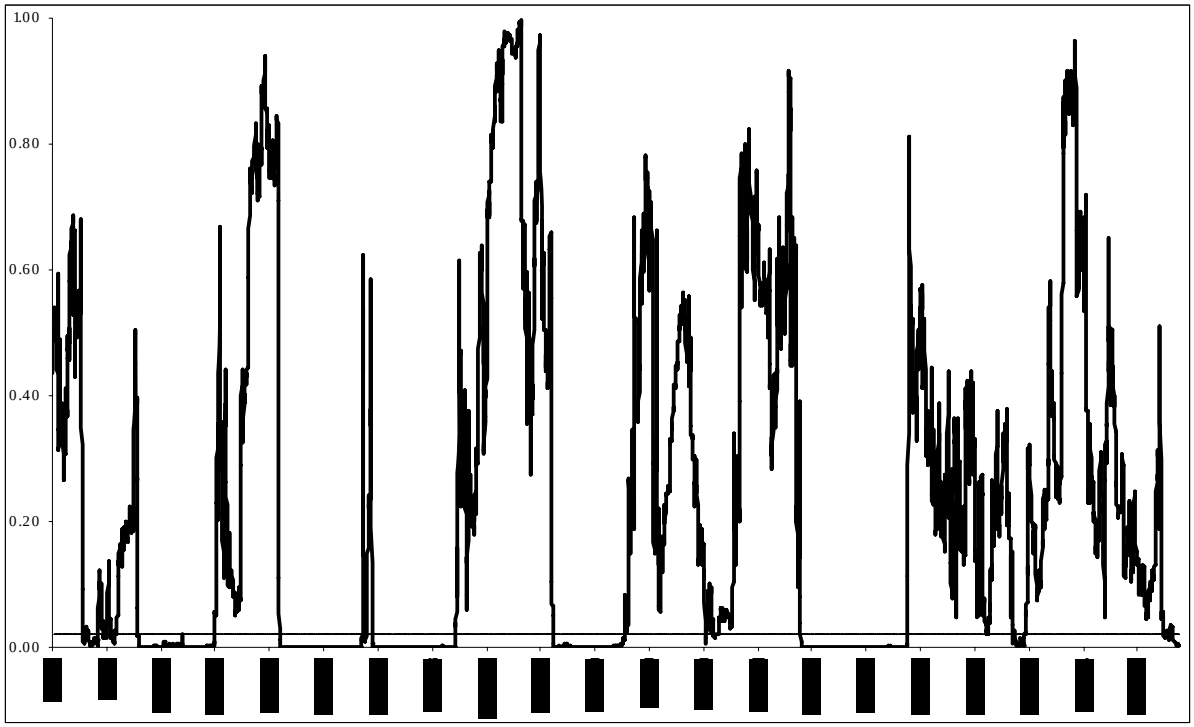
Table 4: Univariate Regression Results

	Coefficient	*p*-value	Adjusted *R*-square	Remark
IOL_i	-0.1284	0.0984	0.0757	All the four measures of financial liberalization have negative and significant coefficients, indicating that the stock market is more efficient in countries that liberalize their stock market and capital account.
$GEQGDP_i$	-0.0353	0.0025	0.0844	
$KAOPEN_i$	-0.0426	0.0002	0.2429	
$IFIGDP_i$	-0.0156	0.0010	0.0997	
$INDV\_GH_i$	-0.0010	0.0942	0.0332	Both measures of individualism have contrasting signs, which is expected given that they are negatively correlated. However, $INDV\_GLOBE_i$ has the expected positive sign, as individualistic cultures tend to give rise to behavioral biases, and hence higher proportion of significant *H* windows.
$INDV\_GLOBE_i$	0.0668	0.0385	0.0470	
VA_i	-0.0369	0.0567	0.0503	All the six measures of institutional quality are negatively related to our measure of weak-form market efficiency, indicating that countries with good governance have more efficient stock market.
PV_i	-0.0591	0.0004	0.1924	
GE_i	-0.0570	0.0003	0.1895	
RQ_i	-0.0725	0.0008	0.1816	
RL_i	-0.0594	0.0000	0.2238	
CC_i	-0.0465	0.0007	0.1718	
INV_PRO_i	-0.0957	0.1518	0.0197	All the stock market regulation proxies have negative coefficients, indicating that stock market is more efficient when stronger protection is afforded to minority shareholders, stricter securities regulations are in place, insider trading law is enforced, and no short sales restriction is imposed. However, all variables are insignificant except $SSALE\_BGZ_i$.
SEC_LAWS_i	-0.1204	0.1484	0.0115	
$INSIDER_i$	-0.0316	0.4130	-0.0049	
$SSALE\_CD_i$	-0.0418	0.3590	0.0019	
$SSALE\_BGZ_i$	-0.0581	0.0723	0.0488	
SMD_i	-0.0368	0.1308	0.0364	In terms of stock market characteristics, only $ANALYSTS_i$ is significant at the 10% level, suggesting that higher number of security analysts is associated with higher level of stock market efficiency.
$LIQUID_i$	-0.2895	0.5593	-0.0107	
TD_SYS_i	0.0853	0.4859	-0.0107	
$ANALYSTS_i$	-0.0787	0.0934	0.0408	
GDP_i	-0.0541	0.0089	0.1293	All the macro variables are significant with expected signs. Specifically, the stock market is more efficient in countries with higher real per capita GDP, higher degree of trade openness, and lower level of inflation.
TD_OPEN_i	-0.0006	0.0616	0.0969	
INF_i	0.0051	0.0018	0.1765	

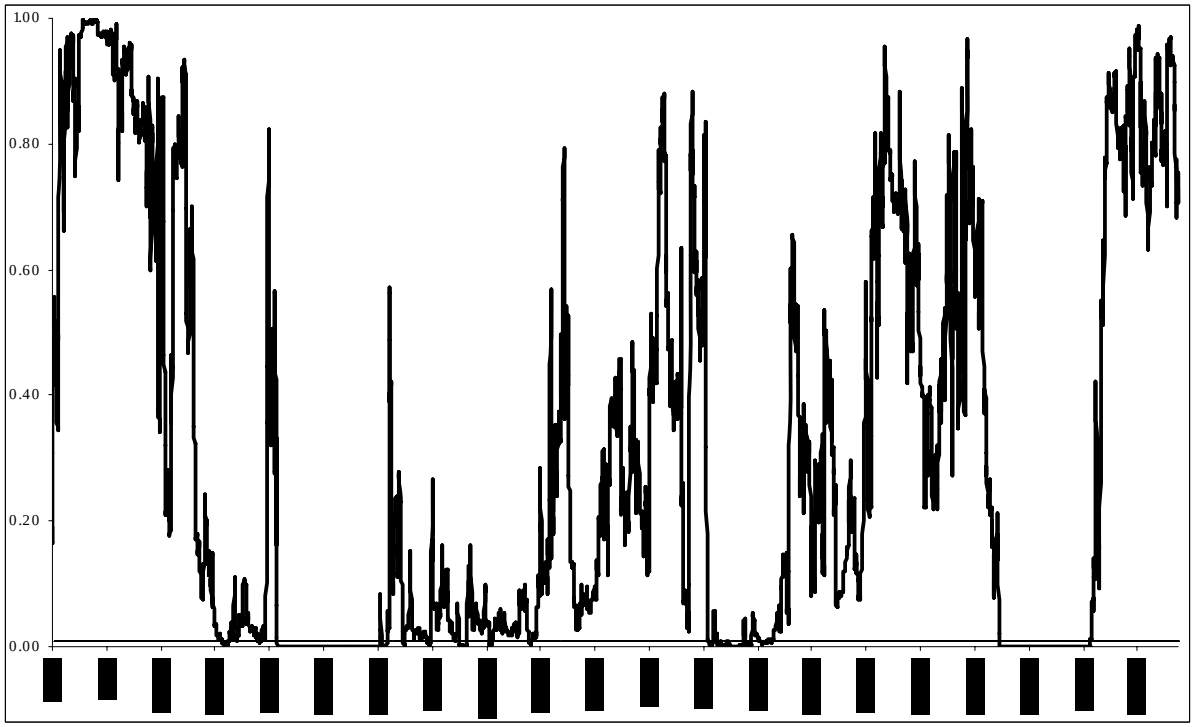
Note: The Appendix describes all the explanatory variables listed above along with their respective data sources.

Figure 1
Time Series Plots for *p*-values of the *H* Statistics for Selected Markets

USA



South Korea



Notes: The vertical axis shows the *p*-values of the *H* statistics, while the horizontal axis is labelled with the dates of the time window. The horizontal dotted line denotes the bootstrapped threshold level (or cut-off point) for the *p*-value, and a time window is defined as significant when the *p*-value lies below or on the threshold line.

Figure 2
Proportions of Significant Rolling *H* Windows across Countries

Notes: The degree of weak-form market efficiency for each country is measured in terms of the proportion of rolling time windows that the MSCI returns series exhibit significant nonlinear dependence as detected by the *H* statistic over the sample period 1995-2005, where lower value indicates greater degree of market efficiency. With a window length of 200 observations, the total number of rolling time windows for each market is 2670.

Appendix: Summary Descriptions of Variables

Variable	Description
	Dependent Variable
$WFME_i$	The degree of weak-form market efficiency for country i is measured in terms of the proportion of rolling time windows that the MSCI returns series exhibit significant nonlinear dependence as detected by the H statistic, with lower value indicates greater degree of market efficiency. We define a window as significant when the *p*-value of the H statistic is less than or equal to the threshold level (or cut-off point) of 5%.
	Financial Liberalization
IOL_i	A *de jure* measure on the intensity of stock market liberalization, using the Global index (IFCG) and Investable index (IFCI) computed by Standard and Poor's/International Finance Corporation (S&P/IFC). However, due to data limitation, we explore an alternative method by calculating the ratio of the number of firms in IFCI and IFCG for each country. The value ranges from zero to one, with zero indicating that the market is completely closed to foreign investors, and a value of one representing a completely open market with no foreign restrictions. The required data for all countries were collected from Emerging Stock Markets Factbook (1995-2002) and Global Stock Markets Factbook (2003-2005). Our cross-sectional analysis uses data averaged over 1995-2005, so that there is one observation per country.
$GEQGDP_i$	A *de facto* indicator on the intensity of stock market liberalization based on actual capital flows. This equity-based measure of openness is defined as: $GEQGDP_{i,t} = \left(PEQA_{it} + FDIA_{it} + PEQL_{it} + FDIL_{it} \right) / GDP_{it}$, where $PEQA(L)$ and $FDIA(L)$ are the gross stocks of portfolio equity and foreign direct investment assets (liabilities), and GDP denotes gross domestic product. The data for all countries over the period 1995-2004 were downloaded from Philip Lane's web site at http://www.tcd.ie/iiis/pages/people/plane.php on 30 April 2007. The time series averages over the period 1995-2004 for each country are used in the cross-country regressions.
$KAOPEN_i$	A *de jure* measure on the intensity of capital account liberalization constructed by Chinn and Ito (2006). This index takes on higher values the more open the country is to cross-border capital transactions. In order to avoid the complexity of interpreting the estimated coefficients, the index is adjusted such that their values range between zero and some positive figure. The data for 49 sampled countries (except Taiwan) over the period 1995-2005 were downloaded from Hiro Ito's web site at http://web.pdx.edu/~ito/ on 30 April 2007. In our cross-country regressions, all data are averaged over 1995-2005.

Appendix (Continued)

Variable	Description
$IFIGDP_i$	A *de facto* indicator on the intensity of capital account liberalization based on actual capital flows. This measure is defined as $IFIGDP_{i,t} = (FA_{it} + FL_{it}) / GDP_{it}$, where $FA(FL)$ refers to the gross stocks of foreign assets (liabilities), and GDP denotes gross domestic product. The data for all sampled countries over the period 1995-2004 were downloaded from Philip Lane's web site at http://www.tcd.ie/iiis/pages/people/plane.php on 30 April 2007. Our cross-sectional analysis uses data averaged over 1995-2004.
	Culture
$INDV\_GH_i$	The index of individualism constructed by Hofstede (2001), based on a survey conducted between 1967 and 1973. Every country included in the survey was given a score on the cultural dimension of individualism, which is an interval scale with a minimum value of zero, but no fixed maximum though the majority of observations for all dimensions do not exceed a value of 100. The higher the country score, the greater the degree of individualism. The data are available for 47 of our sampled countries except Egypt, Jordan and Sri Lanka, and can be extracted from Hofstede (2001: 500-502, Appendix 5), but we downloaded from Geert Hofstede's web site at http://www.geert-hofstede.com/ on 30 April 2007.
$INDV\_GLOBE_i$	The index of individualism constructed from the societal institutional collectivism practices scores provided by Global Leadership and Organizational Behavior Effectiveness (GLOBE) Research Project. In its original form, the GLOBE's institutional collectivism index reflects the degree of collectivism in each country where higher scores indicate greater collectivism. To be consistent with Hofstede's individualism index, we define $INDV\_GLOBE_i$ to be equal to the GLOBE's institutional collectivism index multiplied by -1, so that higher values indicate greater degree of individualism. The data, available for 42 of our sampled countries (except Belgium, Chile, Czech Republic, Jordan, Norway, Pakistan, Peru and Sri Lanka), were extracted from House *et al*. (2004: 742-744, Table B.2).
	Quality of Institutions
	We select the 2006 Worldwide Governance Indicators (WGI) assembled by Kaufmann *et al*. (2006). This dataset measures six dimensions of governance quality, covering all of our sampled countries for 1996, 1998, 2000, and annually for 2002-2005. The six composite governance indicators are measured in units ranging from about -2.5 to 2.5, with higher values corresponding to better governance outcomes. All the data were downloaded from the WGI's web site at www.worldbank.org/wbi/governance/ on 30 April 2007. Our cross-sectional analysis uses data averaged over the period 1996-2005 for each country.

Appendix (Continued)

Variable	Description
VA_i	Voice and accountability measures the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and free media.
PV_i	Political stability and absence of violence indicates perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including political violence and terrorism.
GE_i	Government effectiveness measures the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
RQ_i	Regulatory quality is the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
RL_i	Rule of law measures the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence.
CC_i	Control of corruption measures the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.
	Stock Market Regulations
INV_PRO_i	Our proxy for investor protection is the anti-self-dealing index presented by Djankov *et al*. (2006). This index is based on legal rules prevailing in May 2003, and measures the hurdles that controlling shareholders must jump in order to get away with self-dealing transaction. The higher the hurdles, the higher the anti-self-dealing index is, and hence stronger protection afforded to minority shareholders. The data for all our sampled countries were downloaded from Andrei Shleifer's web site at http://www.economics.harvard.edu/faculty/shleifer/data.html on 15 June 2007.
SEC_LAWS_i	To capture the overall effectiveness of a country's securities regulations, we construct a composite index which is the arithmetic mean of three indices assembled by La Porta *et al*. (2006): (1) the disclosure requirements index; (2) the liability standard index; and (3) the public enforcement index. The score for the composite index ranges from zero to one, with higher value indicates stricter securities regulations. The data for 44 of our sampled countries (except China, Czech Republic, Hungary, Morocco, Poland and Russia) were downloaded from Andrei Shleifer's web site at http://www.andrei-shleifer.com/data.html on 30 April 2007.

Appendix (Continued)

Variable	Description
$INSIDER_i$	This is a dummy variable that takes the value of one in country where the first legal prosecution for insider trading has been recorded by the end of 1999, zero otherwise. The data, available for all countries, were extracted from the comprehensive survey conducted by Bhattacharya and Daouk (2002) on the existence of an insider trading law and the year of first prosecution under the law (if any) in 103 countries.
$SSALE\_CD_i$	This variable equals one if either short selling or put options trading is feasible in a given country by the end of 2002, zero otherwise. The information was extracted from the dataset assembled by Charoenrook and Daouk (2005) on the legality and feasibility of short selling and put option trading for 111 countries, including our 50 sampled markets.
$SSALE\_BGZ_i$	This dummy variable takes the value of one when short selling is both allowed and commonly practiced in a given country by the end of 2001, zero otherwise. The variable was constructed based on Bris *et al*. (2004, 2007) who compiled information on the legality and practice of short selling for 49 countries over the period 1990 to 2001. The data are available for 46 of our sampled countries except Egypt, Morocco, Russia and Sri Lanka.
	Stock Market Characteristics
SMD_i	This composite index of stock market development is constructed by averaging the means-removed values of market capitalization ratio, total value traded ratio, and turnover ratio. The means-removed value for each variable is computed as $X_i^m = \left(X_i - \bar{X}\right)/\left\|\bar{X}\right\|$, where X_i equals the ratio for country i averaged over 1995-2005, and $\bar{X}$ is the average value of that particular variable across all countries. The data, available for all of our sampled countries over the period 1995-2005, were downloaded from World Bank Finance and Private Sector Research Datasets at http://go.worldbank.org/X23UD9QUX0 on 30 April 2007.
$LIQUID_i$	The stock market liquidity for a given country is computed as the number of days when our MSCI country index has a zero return, divided by the total number of days with available return data over our sample period 1995-2005.
TD_SYS_i	This dummy variable measures the fraction of time during the period 1995-2005 an electronic system is in place. The information on the introduction dates of electronic trading is taken Jain (2005).
$ANALYSTS_i$	The country-level measure of analyst coverage is the logarithm of one plus the median number of analysts across firms in each country-year. The data, available for 42 of our sampled countries (except China, Czech Republic, Egypt, Hungary, Jordan, Morocco, Poland and Russia), were extracted from Fernandes and Ferreira (2007: Table 1) that reported the time series average of analyst coverage over the period 1980-2003.

Appendix (Continued)

Variable	Description
	Macroeconomic Environment
GDP_i	The natural logarithm of real per capita gross domestic product is used to measure the level of economic development. The data were collected from World Development Indicators for all countries except Taiwan from 1995 through 2005. The cross-sectional analysis uses the time series averages for each country over this period.
TD_OPEN_i	Trade openness is measured as the sum of exports and imports of goods and services as a share of GDP. The data, averaged over the period 1995-2005, were collected from World Development Indicators for all countries except Taiwan.
INF_i	The inflation rate is measured by the annual growth rate of the GDP implicit deflator. The data were collected from World Development Indicators for all countries except Taiwan from 1995 through 2005. The time series averages over this period for each country are used in the cross-country regressions.