Does financial market liberalization increase the degree of market efficiency? The case of the Athens stock exchange

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A B S T R A C T

In this paper we assess if the financial market liberalization introduced in the beginning of the 1990s in Greece has changed the degree of market development (efficiency) by studying time-varying global Hurst exponents. Our results suggest that changes in financial market liberalization have important positive implications on the degree of development of stock markets. These results have important policy implications for the development of stock markets around the world.

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1. Introduction

The past two decades have witnessed an extensive research effort in understanding the impacts of financial market liberalization on the development of financial markets. In the early 1980s and 1990s many emerging markets underwent a set of reform measures to enhance and deepen their financial markets.

Recent research has suggested the following benefits from stock market liberalization: 1. It may reduce the country's cost of equity capital by allowing for risk sharing between domestic and foreign agents (Henry, 2000a); 2. capital account liberalization may have a positive impact on investment.1

Thereafter, an important topic in the financial research agenda has been to understand the impact of financial market liberalization on the cost of equity, volatility and asset returns, and on investment. Bekärt and Harvey (2000) argue that uncovering these relationships may help on efforts to incorporate emerging markets into global asset allocation models.

An important research question is how financial liberalization induces the development of domestic capital markets. The Greek stock market presents an interesting opportunity for such tests, since this market has been liberalized in the end of the 1980s and beginning of the 1990s.

The main contributions of this paper are threefold. First place we employ a recently introduced methodology (Barabási & Vicsek, 1991; Di Matteo, Aste, & Dacorogna, 2005) to test for structural changes in the degree of market development. Secondly, we innovate in using a “rolling sample” approach, instead of analyzing different periods. Therefore, we do not have to use a “liberalization date,” which is always subject to criticism.2 Finally, we relate structural changes in the degree of equity market development to equity market liberalization and find a positive association between these variables. Our main findings suggest that equity market liberalization plays an important role in enhancing equity market development, which induces decreases in the cost of capital and increases in the productivity of capital and better capital allocation.

The paper is organized as follows: section 2 provides a brief literature review. Section 3 describes the methodology associated with testing for time-varying long-range dependence. Section 4 describes the data.

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1 Henry (2000b) presents evidence that the mean growth rate of private investment in the 3 years following stock market liberalizations exceeds the sample mean by 22 percentage points.

2 Such liberalization dates are static and in general it may take a long time to full liberalization to take place. Therefore, evaluating dynamics statistics may prove fruitful as the assessed impacts are not dependent on the a priori chosen liberalization date.

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Section 5 presents the results of applying the methodology. Finally, section 6 offers a brief conclusion.

2. Brief literature review

Financial market liberalization have been pervasive amongst many countries in the past two decades. Specifically, liberalization of equity markets have important implications on growth and investment and the effects of equity market liberalization have been the subject of extensive research in recent years.

Liberalization is understood as a decision to allow foreigners to purchase shares in a country’s stock market and repatriate their gains. Assessing the impact of liberalization is important as it leads to important changes in both the financial sector and the real economy. Therefore, in the relevant literature on this issue presented below, precise dating of the financial liberalization, is of crucial importance in testing for its effects.

Kim and Singal (2000) study the impact of market opening in emerging markets and find that the benefits are likely to outweigh the perceived risks associated with foreign portfolio flows. Stock
markets seem to be less auto-correlated subsequent to market openings, rendering markets more efficient. This increase in efficiency is followed by better allocation of capital and an increase in the productivity of capital. More recently, Garas and Argyrakis (2007) using daily closing prices from the Athens stock exchange for the 1987–2004 period, find that correlations between stocks during a crisis period become stronger implying lower efficiency.

Henry (2000a,b) analyzes the effects of stock market liberalization on emerging market equity prices and presents evidence that liberalization reduces the cost of capital, allowing for risk sharing between domestic and foreign agents. Other studies using panel data from developing countries find evidence that financial liberalization is associated with higher capital allocative efficiency as investment funds are going to firms with a higher marginal return to capital as in Galindo, Schiantarelli, and Weiss (2007) and reduced variation in expected marginal returns as in Abiad, Oomes, and Ueda (2008) respectively.

Iwata and Wu (forthcoming) finds that financial liberalization increases international risk sharing resulting in reduced equity premium and cost of capital. Furthermore, Bekaert, Harvey, and Lundblad (2001) study the impact of financial liberalization on economic development and suggest that the former is associated with significant increases in real economic growth. Klein and Olivei (2008) use a cross-section of both developed and developing countries finding a significant effect of open capital accounts to financial depth and economic growth. Yang and Yi (2008) applying tests of super-exogeneity to annual Korean data find that financial development control causes economic growth and the opposite is not true. Several studies though find little to no effect of liberalization to growth.

Grilli and Milesi-Ferretti (1995) and Kraay (1998) using lagged values of financial openness indicators as instruments and Edison et al. (2002) employing legal origin and distance from the equator as instruments, find little evidence of an effect of liberalization. Kim and Shamsuddin (2008) test for the martingale hypothesis in stock prices for a group of Asian markets and they find that pricing efficiency depends on market development as well as the regulatory framework conducive of transparent corporate governance. Nonetheless, Honig (2008) shows that one possible explanation for these results is reverse causation: low growth countries liberalize to spur growth thus leading to underestimation of the impact of capital account openness. Quinn and Toyoda (2008) use data for 94 nations and a period from 1954 to 2004 and find positive association of capital liberalization with growth in both developed and emerging markets.

Often, emerging markets have been subject to concerns regarding speculative capital flows, due to increased instability that may arise. Bekaert and Harvey (2000) argue that speculative activity may enhance the informational and allocational role of asset markets. Therefore, we would expect that after liberalization has taken place in financial markets, both the investor base and liquidity increase, thereby increasing foreign speculative activity. This foreign speculative activity may be important for emerging markets for a number of reasons. At first, since in most emerging markets liquidity is poor, foreign speculation may reduce the degree of market manipulation. Furthermore, if emerging markets increase their degree of integration with world markets, then it is likely that the cost of capital would be reduced. Therefore, with equity market liberalization and increased speculative activity one would expect emerging markets to become more efficient as prices would reflect information more accurately as the investor base increases.

A problem that arises in the previously mentioned studies is that they study the impact of financial liberalization evaluating changes in specific variables using liberalization dates. Bekaert, Harvey, and Lundblad (2003) argue that there is a considerable variation in liberalization initiatives, which suggests that evaluating the sequencing of liberalizations may be worthwhile. However, financial liberalization is complex and may take many years to mature. If liberalization takes many years to be completed then one has to take care with traditional tests that search for endogenous/exogenous (announcement dates, for example) thresholds that function as liberalization dates.
An interesting paper is that of Odabasi, Aksu, and Akgiray (2004), that have shown that the Turkish stock exchange has become more efficient over time using both parametric and non-parametric tests. Ciner and Karagozoglu (2008) studying the same exchange over the period 1998–2003, find that proxies used for informational asymmetry have explanatory power in terms of speculative trading. They argue that foreign traders may have an informational advantage due to better access to expertise and talent, and local market participants accentuate the impact of their trades improving market efficiency. Therefore, it is expected that with financial liberalization stock markets become more efficient.

In this paper we will search for breaks in market inefficiency using a long range dependence parameter, global Hurst exponents, that were introduced by Barabási and Vicsek (1991) and considered in Di Matteo et al. (2005) to measure the degree of market development. Here, we use the methodology developed by Cajueiro and Tabak (2004, 2005) to analyze if the degree of long-range dependence of a given financial market varies over time.

The financial literature has shown that the Greek stock market may have long range dependence. For example, Barkoulas, Baum, and Travlos (2000) find significant evidence of positive long-term persistence in the Greek stock market. The authors show that out-of-sample long memory forecasts significantly improve forecasting accuracy compared to random walk forecasts. Panas (2001) also finds evidence of long memory in the Athens stock exchange. Apergis and Eleptheriou (2001) study the period 1990–1999 and find persistence in volatility clustering which they interpret as evidence of inefficiency of the Athens stock exchange. Siourounis (2002) using similar period data finds time dependency not only to the second but to the first moment of Athens stock returns implying inefficiency. In contrast, Laopodis (2004) tests for changing degree of market efficiency in Greece due to financial liberalization. The author suggests that the country’s equity market was weak-form efficient long before these announcements were made. The author employs variance ratio statistics and tests for short-term autocorrelation in both local currency and dollar-equivalent returns, and did not find any changes in such statistics and could not reject the null hypothesis of a random walk, even before financial liberalization dates.

However, such studies fail in relating the measures of long range dependence to structural changes in this stock market. To the best of our knowledge no prior study has employed the long range dependence in this market as a measure of stock market efficiency due to financial liberalization.

### 3. The estimation of the long range dependence parameters

There are several methods that may be used to take into account the long range dependence phenomena.\(^3\) However, in spite of the existence of several methods, the task of calculating the Hurst

<p>| Table 1 |
| We present descriptive statistics for time-varying Hurst exponents |</p>
<table>
<thead>
<tr>
<th>q = 1</th>
<th>q = 2</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.55</td>
</tr>
<tr>
<td>Median</td>
<td>0.55</td>
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<tr>
<td>Maximum</td>
<td>0.62</td>
</tr>
<tr>
<td>Minimum</td>
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<tr>
<td>Standard Deviation</td>
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<tr>
<td>Skewness</td>
<td>0.34</td>
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<tr>
<td>Kurtosis</td>
<td>2.42</td>
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<tr>
<td>Jarque–Bera</td>
<td>127.10</td>
</tr>
<tr>
<td>Probability</td>
<td>0.00</td>
</tr>
</tbody>
</table>

The Jarque–Bera statistic tests the null of normal distribution.

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\(^3\) A survey of these methods may be found in Taqqu, Teverovsky, and Willinger (1995), Montanari, Taqqu, and Teverovsky (1999), and Willinger, Taqqu, and Teverovsky (1999).
exponent is not straightforward and the methods sometimes present incompatible estimations of the long range dependence parameter. In the econometric literature, most authors have employed parametric ARFIMA models (Sowell, 1992) to estimate the long memory parameter. The problem with this parametric specification is that it is highly dependent on the short run dynamics (ARMA component), which has to be specified in the model a priori. For these reasons another popular way of determining the long memory parameter is a semiparametric estimator (denoted GPH). The GPH due to Geweke and Porter-Hudak (1983) is robust to many forms of complicated short run dynamics as it is based on a frequency domain ordinary least squares regression ordinates in a shrinking band of frequencies around zero. However, its performance is very poor when compared to other estimators like the R/S due to Hurst (1951) (for details, see Weron, 2002) which is known that is seriously biased and highly influenced by outliers. Besides, the R/S modified statistic due to Lo (1991) presents a preference for the null hypothesis of absence of long range dependence (Willinger et al., 1999).

In this paper, we follow a different approach and employ the generalized exponent method introduced by Barabási and Vicsek (1991) and used recently by Di Matteo et al. (2005) to measure the degree of market development of several financial markets. According to Di Matteo et al. (2005), it combines sensitivity to any type of dependence in the data and simplicity. Moreover, since it does not deal with max and min functions, it is less sensitive to outliers than the popular R/S statistics.

Let $X(t)$ be the price of a stock on a time $t$. The generalized Hurst exponent is a generalization of the approach proposed by Hurst. Barabási and Vicsek (1991) suggest analyzing the $q$-order moments of the distribution of increments, which seems to be a good characterization of the statistical evolution of a stochastic variable $X(t)$,

$$K_q(\tau) = \frac{\langle |X(t + \tau) - X(t)|^q \rangle}{\langle |X(t)|^q \rangle},$$  \hspace{1cm} (1)

where the time-interval $\tau$ can vary. The generalized Hurst exponent can be defined from the scaling behavior of $K_q(\tau)$, which can be assumed to follow the relation

$$K_q(\tau) - \left( \frac{\tau}{\tau_0} \right)^{qH_q}.$$  \hspace{1cm} (2)

An important question is whether the degree of long memory varies over time. Cajueiro and Tabak (2004, 2005) have shown that this seems to be the case in both equity returns and volatility for emerging markets.

In order to assess whether Hurst exponents are time-varying we employ a "rolling sample" approach. In this analysis, the sample size was arbitrarily set at 1008 observations (a window size of 1008), with the oldest observation dropping off and a new observation being added as the sample selection moved forward in time. The choice of 1008 observations (approximately 4 years of data) was made due to comparability with previous studies that have focused on general indices and that it is a sufficiently long time series.

If global Hurst exponents are time-varying then the process is said to be multifractal. Multifractality has been studied by Sun, Chen, Yuan, and Wu (2001), Calvet and Fisher (2001), Fillol (2003), Xu and Cencay (2003) and Wei and Huang (2005).

If multifractality is present in stock returns then multifractal models such as the one presented in Calvet and Fisher (2001) may fit well the data and may be used for forecasting purposes. These models are competitors to traditional ARCH and GARCH models.

4. Data

This study uses daily closing prices for the general index of the Athens stock exchange (Fig. 1). The period under examination is from 01/02/1987 to 04/26/2005, for a total of 4563 observations. We

Fig. 5. Kernel density for time-varying Hurst exponents with $q = 1$.  

4 For $q = 2$, the $K_q(\tau)$ is proportional to the autocorrelation function $\rho(\tau) = \langle X(t + \tau)X(t) \rangle$.  

employ data provided by the Bloomberg database. The analysis is carried using dollar-equivalent returns (Fig. 2), due to interest from international investors in emerging markets stocks.

Bekaert and Harvey (2000) employ December 1987 as the liberalization date for Greece. The authors argue that in that particular year Europeans were allowed to participate in the equity market and to repatriate their capital gains and also that it coincides with a significant number of macroeconomic reforms (including privatization). However, although liberalization plans started in 1986, only by 1994 the removal of short-term capital restrictions were completely phased out.

The period under analysis is of major importance because it was associated with major changes in the financial market liberalization in Greece. Laopodis (2004) suggest that the deregulation of capital flows took place over the December 1992 to May 1994 period. Three events highlight this period: (1) the announcement in 12/21/1992 that Greece would abolish currency restrictions; (2) enactment of Greece legislation in 2/23/1993 adopting the European Union directive; (3) announcement by the government on 5/14/1994 that it would liberalize on 5/16/1994 all foreign currencies.

5. Empirical results

This section presents the Hurst exponent’s estimates for daily closing prices for the general index of the Athens stock exchange using the rolling sample approach. Figs. 3 and 4 present time-varying Hurst exponents for $q = 1$ and $q = 2$, respectively. The main characteristic of this time-series is that with financial liberalization Hurst exponents have a clear downward trend, and converge to 0.5 (random walk behavior) reducing substantially long-term predictability.

Laopodis (2004) tests for structural changes due to financial market liberalization using Chow and Wald statistics and fails to find any significant differences in equity returns. Furthermore, with the use of traditional variance ratio tests the evidence in his paper suggests that the Athens stock exchange was weak form efficient prior to the announcement dates that we use as thresholds to study the dynamics of the Greek stock market. The author does not test for gradual shifts and evaluating changes in market efficiency around these announcement dates.

Figs. 3 and 4 suggest that studying the impact of market liberalization using traditional event studies and structural breaks may be misleading, if the convergence towards market efficiency is slow or gradual as one would expect. As we can see, from these figures, there is a strong convergence in the beginning of the sample, towards a more mature and developed stock market.

Table 1 presents descriptive statistics for time-varying Hurst exponents (we have 3555 Hurst exponents). Hurst exponents fluctuate in a wide range, from 0.48 to 0.62 and from 0.45 to 0.59, for $q = 1$ and $q = 2$, respectively. Furthermore, from Jarque–Bera statistics we reject the null hypothesis of normality.6

A Kruskal–Wallis nonparametric test for equality of medians has a statistic equal to 604.10 and an associated $p$-value of 0.0000, which suggests that using both $q = 1$ and $q = 2$ may be worthwhile as these Hurst exponents may provide different information. However, the correlation between these Hurst exponents is approximately 90.5%.

Figs. 5 and 6 presents a nonparametric kernel density estimation for time-varying Hurst exponents (using $q = 1$ and $q = 2$). It is worth noting that the distribution of Hurst exponents is bimodal. Since most of the discrepancies are due to the major change that took place in the Greek financial market, global Hurst exponents are able to identify a structural break in the dynamics of this emerging stock market. Furthermore, there is a significant decrease in the degree of market inefficiency immediately after the liberalization period took place. The 2nd mode that is related to higher Hurst exponents is related to the period prior to financial market liberalization, while the first mode, with much lower Hurst exponents, is related to the period after market liberalization.

Previous research has documented that the Athens stock exchange was weak-form efficient even before market liberalization occurred and did not find any evidence of structural breaks in stock returns in

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6 We also test for normality using Cramer–von Mises and Anderson–Darling statistics, and qualitative results remain unchanged.
the period analyzed. Therefore, the possibility that our results are driven by short-term dependencies or structural breaks are ruled out.\footnote{See Laopodis (2004).}

Bayraktar, Horst, and Sircar (2004) have presented a model where an order flow with random, heavy-tailed, durations between trades leads to long-range dependence in returns. The authors present a model in which randomness and heavy tail of durations between trades (instructor inertia) generates long-range dependence in returns. Therefore, in small stock markets with many small inert investors that trade infrequently one would expect to find long-range dependence in stock returns. This model suggests that further analysis in the microstructure of stock markets is necessary to understand the driving forces of the dynamics of asset prices, and to assess structural breaks in the microstructure of financial markets.

The financial liberalization that was implemented in Greece has increased the shareholders base and many international and sophistication investors have entered the Greek stock market, which could be seen as an explanation for our empirical results. For example, Alexakis, Niarchos, Patra, and Poshakwale (2005) document that equity mutual funds have increased substantially their activity in the Greek stock market after financial liberalization. The authors suggest that inflows and outflows of cash in equity funds seem to cause higher and lower stock returns. These funds tend to invest massive amounts of money as they are institutional investors. Papapetrou (2006) using different methods to estimate the saving–investment relationship in Greece finds that the degree of correlation between the two weakens during financial liberalization periods, implying the increased significance of foreign funds in domestic investments. Therefore, in the light of Bayraktar et al. (2004) results the relative importance of small investors in the market may have been substantially reduced with financial liberalization due to the increase of institutional investors’ (and sophisticated) relative importance, which reduces the degree of long-range dependence.

The increase in internet activity may also imply more efficiency. Barber and Odean (2001, 2002) find that the web effect is large (trading frequency doubles after 18 months of access), and that investors trade more actively, more speculatively and less profitably than before. The internet effect coupled with market liberalization may explain why a delay may occur and suggests that traditional event studies methodology may not be able to capture these changes.

An interesting finding is that in the last part of the sample a reverse trend is noticed. In this last period of our sample, after November 1999, the Athens stock exchange experienced very significant losses when the general index dropped in 2 months more than 50% and over a period of two and a half years almost 80%. During this period the estimated time-varying Hurst exponent departs from convergence to market efficiency towards long memory and persistence. In this period the international stock market crisis led major international institutional investors to sell and flee the Athens stock exchange, a move that led according to the findings of Ciner and Karagozoglu (2008) to herding behavior by local market participants that perceive foreign investors as possessing asymmetric information. The reduced efficiency in this part of our sample is consistent with Garas and Argyrakis (2007), that find that correlations between stocks during a crisis period become stronger as all stocks move together with the market, thus implying lower efficiency. This suggests that other phenomena, such as reversals in portfolio capital flows, may impact the degree of market development, and that convergence may take some time to occur.

As discussed in the methodology section evidence of time-varying Hurst exponents suggests presence of multifractality. Very little is known regarding the origins of multifractality in asset returns. Our approach suggests that changes in the dynamics of asset prices may be reflecting structural changes in institutions, market microstructure such as trading frequency, among others. Therefore, we believe that, at least partially, the multifractality presented in the Greek stock market in this paper may be due to the financial liberalization process.

6. Conclusions

This paper presents empirical evidence of strong long-range dependence in the end of the 1980s and beginning of the 1990s for the Greek stock market, prior to financial market liberalization that occurred during that period. However, with the deepening of the liberalization process, generalized Hurst exponents converged to levels which characterize more efficient and developed markets (low evidence of predictability). Furthermore, time-varying Hurst exponents may be seen as evidence of multifractality. Our results suggest that Greek stock returns follow complex patterns and are of a multifractal nature.

The convergence of generalized Hurst exponents to random walk provide empirical evidence of the benefits of liberalizing the capital account and portfolio flows. Stock markets may evolve and converge to more mature markets, increasing their degree of efficiency. These effects may reduce the cost of capital for companies that are listed in such countries, providing a better environment for the economy. Furthermore, the reduction of financing costs can lead the economy to a virtuous circle.

Further research could focus on other countries and experiences in order to ascertain the impact of financial liberalization on the stock market.

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