©*The Pakistan Development Review*
55:2 (Summer 2016) pp. 79–93

A Raging Bull or a Long-term Speculative Bubble? The Puzzling Case of the Karachi Stock Exchange

EHSAN AHMED, J. BARKLEY ROSSER, JR., and JAMSHED Y. UPPAL

The objective of the study is to examine possible presence of nonlinear speculative bubbles in the Karachi Stock Exchange (KSE). Bubbles are argued to exist when there are substantial deviations of market value from the estimated fundamental values. We estimate a series of fundamental values from a four variable Vector Autoregression Model (VAR) using the main KSE100 index along with measures of world stock prices, the Pakistani exchange rate, and the Pakistani short-term interest rate. Residuals of this estimated fundamental time series are then tested for possible speculative deviations using a Hamilton regime switching test and a rescaled range Hurst coefficient test, with a further test for nonlinearity beyond the ARCH effects using the BDS statistic. For all of these, we reject the null hypotheses of the absence of speculative bubbles and nonlinearities beyond ARCH in these series. While these results suggest the possible presence of such bubbles, we note methodological limits on proving that due to the problem of mis-specified fundamentals. We further discuss some characteristics of the regulatory environment that may make it especially susceptible to such phenomena and may be considered by the policy-makers for the attenuation of speculative and manipulative behaviour.

Keywords: Bubble, Pakistan, Stock Market, Regime Switching, Rescaled Range Analysis, Nonlinearity

INTRODUCTION

Asset markets in emerging and frontier economies have exhibited high levels of variance with sharp increases followed by even sharper crashes. This has led to widespread discussion that these markets may be exhibiting speculative bubbles in which prices diverge from the fundamental values frequently [Ahmed, Rosser, and Uppal (2010, 2014)]. Among the markets that have been showing such behaviour very markedly has been the Karachi Stock Exchange. The main equity market of Pakistan apparently presents a case of either an ongoing long-term bubble or of recurring bubble. The unprecedented performance of the KSE over the over the 2001-2014 period in particular remains a puzzle to many observers in view of the relatively poor performance of the real sectors of the country's economy. Though alternative explanations, such as structural reforms, favourable tax and regulatory treatment, and technicalities of the stock index construction, have been offered, the existence of speculative bubble, and the possibilities of manipulative behaviour cannot be precluded. It is particularly imperative to examine the questions whether the stock market presents a case of a long-term or a recurring

Ehsan Ahmed <ahmedex@jmu.edu> and J. Barkley Rosser, Jr. <rosserjb@jmu.edu> affiliated with the James Madison University, Harrisonburg, Virginia, USA. Jamshed Y. Uppal <Uppal@cua.edu> affiliated with the Catholic University of America, Washington, DC, USA.

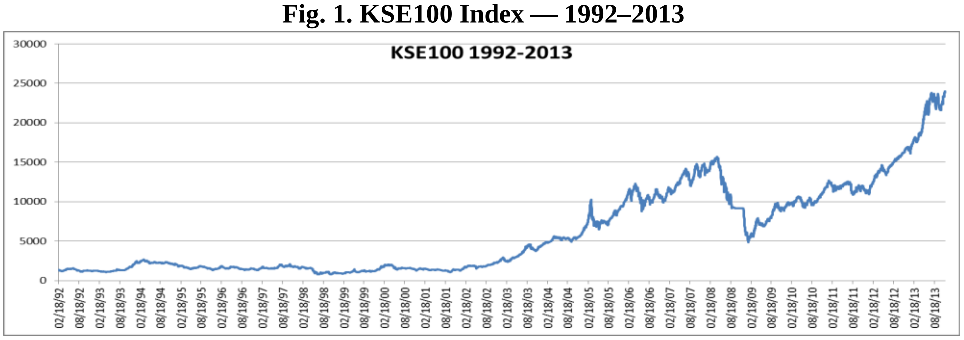
bubble for its implication both for the theory of speculative bubbles as well as for its policy implications. While such bubbles are regarded as destabilising and disruptive to the economy in many ways, these are especially detrimental to sustaining confidence in the fairness and efficiency of the financial markets and to the flow and allocation of real investment that is crucial to the development process.

In this paper we use well-developed methodologies to consider KSE's behaviour more rigorously. The next section describes the historical performance of the KSE indices, noting some popular explanations for its meteoric rise. This is followed by a section on the theory of speculative bubbles. The third section explains our methodology and data used in the study, which is followed by a section on the empirical results. The final section summarises our findings and presents the conclusions. In brief, we find that there is a strong evidence to suggest that this market has been exhibiting speculative bubbles characterised by substantial nonlinearities.

HISTORICAL PERFORMANCE OF THE KARACHI STOCK MARKET

The market's benchmark index, Karachi Stock Exchange 100 Index (KSE100) was launched in November 1991 with a base of 1,000 points.[1] By the beginning of 2001, it had move up to 1508 registering a steady but modest annualised growth rate of 4.5 percent (Refer to Figure 1). The market started to take off right after Pakistan became a major player in the war on terror following the 9-11 terrorist attacks in the US. The KSE100 index skyrocketed to 15,122 by the end of April in 2008, by ten folds, registering a record breaking growth of 31 percent per year. Meanwhile the markets around the world registered a nominal growth rate of only 0.47 percent in the Morgan Stanley Capital International (MSCI) World Index, and the emerging markets a growth of 17.4 percent in the MSCI Emerging Market Index); Figure 2 provides visual comparisons. However, tightening of the monetary policy by the State Bank of Pakistan and an unexpected increase in the interest rates in May 2008, combined with adverse political events and the onset of the Global Financial Crisis, ushered a period of crashing stock prices. By July the index had plunged by one-third of its peak value. In an effort to stabilise the financial markets the regulators set a floor for stock prices on August 28 effectively shutting down the market till December 15 when the floor on stock prices was removed and the trading resumed.

Fig. 1. KSE100 Index — 1992–2013



[1]KSE100 is a market capitalisation weighted index of 100 companies with the highest market capitalisation. However, the company with the highest market capitalisation from each sector is also included to make it more representative of the market.

Fig. 2. KSE Comparative Performance —Local Currency Denominated Indices

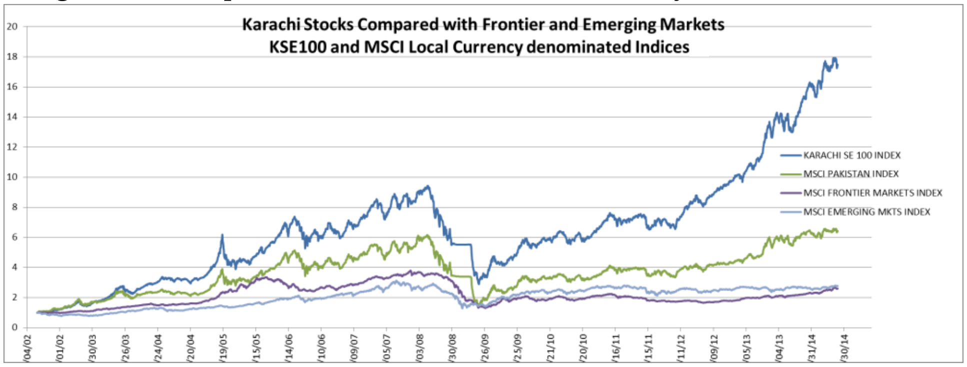


Table 1

Karachi Stock Exchange Summary Statistics

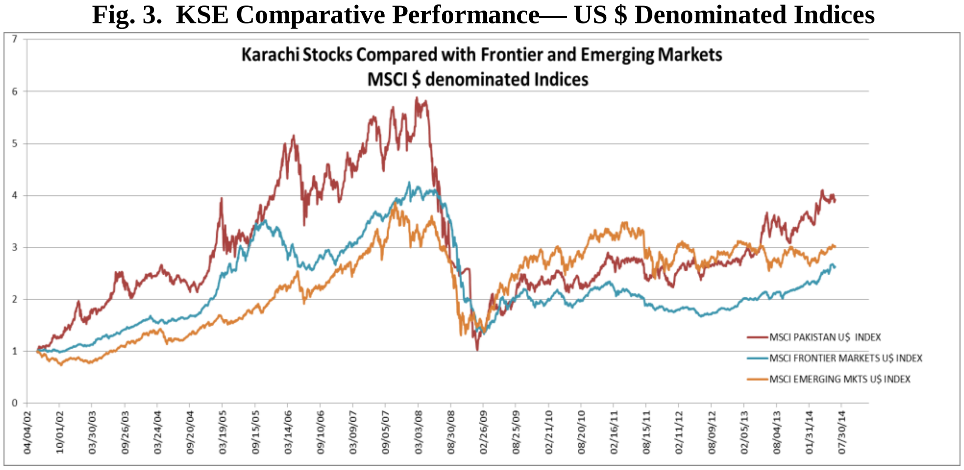
Year	1989	1993	1997	2001	2005	2009	2013
No. of Listed Companies	440	653	781	747	661	651	569
Market Capitalisation (mil. US $)	2,457	11,602	10,966	4,944	45,937	33,238	56,083
Market Capitalisation as Percentage of GDP	6.50%	23.90%	17.40%	6.90%	42.00%	19.80%	15.89%
Trading Value (mil. US $)	231	1,844	11,476	12,455	140,996	23,526	70,406
Turnover Ratio (%)	8.00%	18.70%	103.70%	226.80%	375.70%	82.94%	91.48%
P/E Ratio*	8	27.6	14.8	7.5	13.1	3.9	6.7
Price to Book Value*	1.3	4.2	2.3	0.9	3.5	1.2	2.6
Dividend Yield (%)*	8.30%	1.50%	3.20%	12.50%	2.50%	9.21%	8.87%
% Change in KSE100 Index (Over Previous Period)	–	680.50%	–19.00%	–27.40%	650.60%	–1.78%	169.11%

Right after the re-opening of the market it recovered quickly reaching new highs. The KSE100 index which had dropped to 5865 by the end of 2008 continued to rise at a rapid pace. By the end of September 2012 it registered new all-time highs surpassing the previous peak of 15,622. Since then its pace has accelerated and the index's most recent value stands as of 7/1/2014 at 29,702, thus it has increased at a 29 percent annualised rate since its bottom at the end of 2008. In comparison, the MSCI Index for Frontier Markets increased by an annualised rate of 8 percent over this period.

The unprecedented performance of the Karachi Stock Exchange over the last 14 years remains a puzzle to many observers. It is particularly so in view of the relatively poor performance of the real sectors of the country's economy. Over the period 2001-2013 period the economy grew at a rate below the rate experienced by peer countries, except for the years 2004 and 2005 (see Figure 4). The country has been beset by a host of political and economic issues which are a continuing drag on the economy. These include a deteriorated law and order situation, persistent incidence of terrorist attacks, unsettled political structures, and irresolute economic policies. The weakening economic condition is exacerbated by extraordinary energy shortages, which have inhibited much of the economic life. Being situated next to on-going ISAF[2] anti-insurgency operations in Afghanistan, the country is itself in virtual war conditions, besides facing internal insurgencies, as well as sectarian and ethnic conflicts. The sharp contrast between the performance of the real sector and the stock market is, therefore, prima facie evidence of a speculative market bubble. However, in this case, it seems that either the market has remained diverged from its fundamentals over a long period of time, or it keeps on spawning new speculative bubbles.

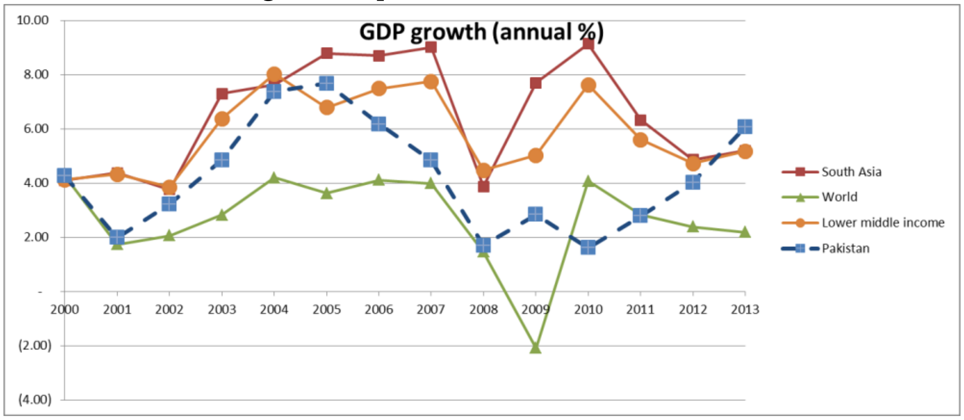
Observers of the KSE's extraordinary performance have advanced explanations based on both technical and fundamental factors. Some explain that the market performance in the recent years may be reflective of the country's potential buoyed by the country's strengthening of democratic institutions and financial markets, continued lending by international financial institutions, and general enthusiasm for "frontier markets" on the part of international investors [*The Economist* (2013)]. The market's continuing rise is also attributed to special tax and disclosure treatment afforded to it by the regulators, such as an amnesty scheme that allows investors to buy stocks with no questions asked about the source of funds, and lower or no tax on capital gains. Critics have pointed out that such provisions open wide possibilities for money laundering legally, and have been the major impetus for cash inflows into the stock market, especially considering rather lax enforcement on part of the market regulators [Houreld (2013)]. A number of analyses also point to the fact that the Price/Earning (P/E) ratios of the Pakistani companies do not seem to be excessive compared to P/E ratios for other emerging market companies. Besides, a high rate of inflation and a deteriorating currency value over the years contribute to the apparent rise in nominal value of the index which is denominated in the local currency. Figure 3 plots the dollar denominated Emerging Markets and Frontier Markets MSCI indices, and indeed in comparison, the KSE's does not appear to be excessively far off from the others, while still running higher.

Fig. 3. KSE Comparative Performance— US $ Denominated Indices



[2]ISAF—International Security Assistance Force.

Fig. 4. Comparative Growth Rates in GDP



Among the technical reasons possibly explaining this outcome, one focus has been the structure and methodology of the KSE100 Index. The index is constructed using the Market Capitalisation Method. Since the KSE capitalisation is concentrated in a handful of stocks, the Index is also dominated by a few stocks and sectors of economy and tends to reflect the performance of the companies with the highest capitalisation, inflating market performance as compared to the overall corporate sector and the economy [Iqbal (2008)]. The stock market lacks breadth as well as depth and liquidity; only 60 of its 569 listed companies trade regularly. The 10 largest stocks accounted for 74 percent of the total market capitalisation as of 9 July 2013. Trading of stocks is likewise highly concentrated. Free float is rather limited; an average of only 20 percent of the shares of the listed companies are available for trading, resulting in relatively low market liquidity. This feature coupled with a high turnover paints a picture of a highly speculative market. Thus, it is claimed that the KSE 100 Index does not represent the economy or the corporate sector. Therefore, other indices have been advocated as alternatives, such as the KSE-30, or the MSCI Pakistan Index. The former is based on only on the free-float of shares, rather than on the basis of paid-up capital and is adjusted for dividends and right shares (formally implemented from September 1, 2006 with base value of 10,000 points).The latter is designed to measure the performance of the large and mid-cap segments of the Pakistan market. With 12 constituents, the index covers approximately 85 percent of the Pakistan equity universe.

In this paper we document and analyse the behaviour of Pakistan's equity market for presence of speculative bubbles using established empirical methodologies. In order to address issues of inflation and foreign exchange, we construct a four-variable VAR model which includes in addition to the KSE100 index, foreign exchange rate against US dollar, and the interest rate series which would reflect the expected inflation.

THEORY OF SPECULATIVE BUBBLES

A speculative bubble involves an asset market dominated by agents purchasing an asset with the expectation that its price will rise in some near term future so that they can make a capital gain within a relatively near term period. This then leads the price to rise above the long run fundamental value, presumably based on the present value of a rationally expected future stream of net real returns properly discounted. While there is a long and classic literature arguing for the historical existence of such bubbles going back centuries [Kindleberger (2000)], theoretical literature faces certain complications. The first is that it is difficult to reconcile such agent behaviour with the assumption of rationality. Indeed, Tirole (1982) argued that bubbles will not happen in a world of infinitely lived, perfectly informed rational agents, operating in discrete time markets. Due to the idea that the bubble must end at some point and it will not be rational to be holding the asset in the period before it ends, an assumption of common knowledge feeds a backward induction argument to show that it is irrational to become involved in the bubble to begin with.

However, rational bubbles may be possible as some of these assumptions are relaxed. Thus, Tirole (1985) showed that allowing finitely lived agents in overlapping generations models can pass a stationary bubble on to later generations, with this argument having been made for the long run existence of a stable fiat money (whose fundamental value is zero). But stationary bubbles are not empirically observable as most tests for bubbles (such as those we use below) involve seeking to observe apparently rapid movements away from presumed fundamentals. Such bubbles can be rational even if they are expected to crash in finite time but inflate at an accelerating rate that provides a risk premium for rational agents [Blanchard and Watson (1982)]. Such bubbles have been studied by various observers [Elwood, Ahmed, and Rosser (1999); Sornette and Zhou (2005)].

The standard approach would be to identify a bubble by

$$b(t) = p(t) - f(t) + \varepsilon(t) > 0 \qquad \ldots \qquad (1)$$

where t is time period, b is bubble value, p is price, f is the fundamental value, and ε is an exogenous stochastic noise process, usually assumed to be i.i.d. or even Gaussian normal, even though many asset returns are known to exhibit higher moments than do Gaussian distributions, such as skewness and kurtosis ("fat tails"). This formulation leads us to the other major problem in the theory of bubbles, i.e., designing of a empirical tests for the presence of bubbles, namely how to tell what is the fundamental versus the bubble (or the stochastic noise process), with the price being the only item that is unequivocally identifiable. This has been labeled the misspecified fundamental problem by Flood and Garber (1980) who argue that it is impossible to econometrically identify for certain a fundamental, although Ahmed, *et al.* (1997) have argued that one can observe fundamentals in closed-end country funds in the form of net asset values, with premia above those clearly constituting bubbles. Any peculiar price movement that appears to deviate from a presumed fundamental may actually be a rationally expected fundamentals movement by agents, even if it proves *ex post* not to be justified. After all, rational expectations simply mean being right on average, not all the time; errors can be made. Beyond this argument there are some who argue that the concept of a fundamental is theoretically empty due to fundamental uncertainty [Davidson (2004)] or because high frequency price changes are all that matter [Bouchaud and Potters (2003)]. In any case, we must recognise for our study here that we are not fully able to overcome the misspecified fundamental critique, and therefore must garnish our conclusions with a strong caveat acknowledging that we are not definitely proving the existence of bubbles in the KSE market, even if the evidence is highly supportive.

Rejecting the idea of considering rational bubbles is the idea that they are inherently irrational, perhaps most eloquently expressed by the title of Robert Shiller's book *Irrational Exuberance* (2015). In this psychological view agents become overwhelmed by excitement over prospective short term gains and underestimate and misprice the risks that they are engaging in. Thus waves of optimism (or even "mania") alternate with pessimism (or "panic"), with Kindleberger supporting this view. The earlier work of Hyman Minsky (1972) is also in this line of argument, arguing that financing standards become relaxed during the boom phase of a speculative bubble helping to push it upwards.

In between the competing strands of the rational bubble literature is the view that there may be heterogeneous agents, some rational and some not. Earlier literature [Baumol (1957); Zeeman (1974)] recognised this and saw bubbles arising as the less rational trend chasers came to dominate an asset market, only to be chased out by the rational fundamentalists when the bubble would crash, and the balance going back and forth in any given market over time. This line of argument fell out of favour in the later 1970s and in the 1980s as the rational expectations revolution took hold, but with the apparent occurrences of bubbles and crashes in many markets, beginning with the US stock market crash of 1987, this belief weakened. The idea that some agents might not be rational was also argued by Black (1985), and DeLong, *et al.* (1991), who showed that the supposedly irrational "noise traders" might actually do better (or at least some of them) than the rational fundamentalists and thus survive, the argument that such traders would lose money and be driven out of the market long being used to dismiss their possible existence.

More recent theoretical study in which agents switch strategies over time is due to Föllmer, Horst, and Kirman (2005). Such an approach has also been studied using agent-based modeling of heterogeneous agents as has been done by Chiarella, *et al.* (2003), with Gallegati, Rosser, and Palestrini (2011) providing an example that can exhibit the phenomenon recognised by Minsky of a period of financial distress in a bubble, a period of gradually declining prices after a peak but prior to a full crash, which has been observed in many historical bubbles.

METHODOLOGY AND DATA

Following the initial approach of Canova and Ito (1991), we estimate our assumed fundamental value time series by estimating a Vector Autogressive (VAR) model using daily data for the KSE100 stock market index with daily data for world stock prices, the Pakistani foreign exchange rate, and the Pakistani middle 30-day Repo interest rate. It is from this VAR model (with 8 lags) that we then estimate residuals that we apply our various tests of possible bubbles and nonlinearity on.

The vector autoregression (VAR) is used to capture the linear interdependencies among multiple time series. A VAR model captures the evolution of a set of k endogenous variables over the sample period (t = 1, ..., T) as a linear function of only their past values. These variables are collected in a $k \times 1$ vector y_t, which has as the ith element, $y_{i,t}$, the observation at time "t" of the ith variable. A p-th order VAR, denoted VAR(p), is:

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \varepsilon_t \qquad \ldots \qquad \ldots \qquad \ldots \qquad (2)$$

where the l-periods back observation y_{t-l} is the l-th lag of y, c is a k×1 vector of constants, A_i is a time-invariant $k \times k$ matrix and ε_t is a k×1 vector of error terms; contemporaneous covariance matrix of error terms is Ω, and there is no across time or serial correlation in the individual error terms. In our model the four variables are as described above, KSE100 returns, short-term interest rates, the PKR/USD exchange rate and the MSCI World stock index. The lag-length of eight was found to be econometrically appropriate following usual criteria (*SIC*, *BIC*). Examination of the residuals (see Table 5) shows that the model residuals are well-behaved.

As noted above, this is subject to the difficult-to-avoid misspecified fundamental problem. We hope to capture expectations of discounted future streams of net returns for the stock market. Some of the variables we use clearly affect this, most obviously the interest rate one. We are constrained by the fact that more specific and frequent estimates of the market fundamentals are just not available. Using GDP itself is also not useful given that it does not remotely vary on a daily basis. We presume that the exchange rates, interest rates and the world market index would reflect expectations of the market regarding the economic and stock expected cash flows. The world stock market index provides some estimate of expectations about future global economic performance, which should influence future Pakistani economic performance. The Pakistani foreign exchange rate should provide some information regarding expectations of future Pakistani performance relative to global performance. The interest rate provides information regarding both expected future performance as well as the discount rate for future returns.

Before proceeding further we note that it might be worthwhile to test our method against other econometric ones derived from the set of theoretical models of bubbles listed above, as well as others not discussed. However, we note that there is a vast array of such methods and such a project would be a different paper rather than the one we are engaged in here examining the Karachi stock market in particular. As it is there have been some studies attempting to survey the wide variety of such techniques, including Gurkayanak (2008) and Homm and Breitung (2012). We take some comfort in the finding in this latter study that tests involving structural breaks have "the highest power," and our use of regime switching tests fits into this category.

EMPIRICAL TESTS FOR SPECULATIVE BUBBLES

This section describes the three empirical tests employed in the study. These are: (i) Regime Switching Test, (ii) Hurst Persistence Test, and (ii) Nonlinearity Test.

(i) Regime Switching Test

Hamilton (1989) introduced an approach to regime switching tests that can be used to test for trends in time series and switches in trends, as used in Engel and Hamilton (1990) and van Norden and Schaller (1993). We use this approach as our main test for the null of no bubbles on the residual series derived above which is given by

$$\in_t = n_t + z_t \qquad \text{… … … … … … …} \qquad (3)$$

where

$$n_t = \mu_1 + \mu_2 s_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

and

$$z_t - z_{t-1} = \phi(z_{t-1} - z_{t-2}) + \ldots + \phi(z_2 - z_1) + \varepsilon_1 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

with ϕ an autoregressive function.

with s = 1 being a positive trend, s = 0 being a negative trend, and $\mu_1 \neq 0$ indicating the possible existence of a trend element beyond the VAR process. Furthermore, let:

$$Prob\ [s_t = 1 \;\; s_{t\text{-}1} = 1] = p,\ Prob\ [s_t = 0 \;\; s_{t\text{-}1} = 1] = 1 - p \quad \ldots. \quad \ldots \quad (6)$$

$$Prob\ [s_t = 0 \;\; s_{t\text{-}1} = 0] = q,\ Prob\ [s_t = 1 \;\; s_{t\text{-}1} = 0] = 1 - q. \quad \ldots \quad \ldots \quad (7)$$

Following Engel and Hamilton (1990) a "no bubbles" test proposes a null hypothesis of no trends given by $p = 1 - q$. This is tested by with a Wald test statistic given by

$$[p - (1 - q)]/[\text{var}(p) + \text{var}(1 - q) + \text{covar}(p, 1 - q)]. \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

(ii) Hurst Persistence Tests

Hurst (1951) developed a test to study persistence of Nile River annual flows, which was first applied to economic data by Mandelbrot (1972). This technique is also known as *rescaled range analysis*. For a series x_t with n observations, mean of x^*m and a max and a min value, the range $R(n)$ is:

$$R(n) = [\max 1 \leq k \leq n \textstyle\sum_{j=1}^{k}\left(x_j - x^*\right) - \min 1 \leq k \leq n \sum_{j=1}^{k}\left(x_j - x^*\right)] \quad \ldots \quad (9)$$

The scale factor, $S(n, q)$ is the square root of a consistent estimator for spectral density at frequency zero, with $q < n$,

$$S(n,q)^2 = g_0 + 2\textstyle\sum_{j=1}^{q} w_j(q) g_j, w_j(q) = 1 - [\frac{j}{q-1}] \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

with g's autocovariances and w's weights based on the truncation parameter, q, which is a period of short-term dependence. Lo (1991) has criticised the used of the classical Hurst coefficient for studying long-term persistence due to this presence of short-term dependence in it, but this is not a problem for us. The classical Hurst case has q = 0, which reduces the scaling factor to a simple standard deviation.

Feller (1951) showed that if x_t is a Gaussian i.i.d. series then

$$R(n)/S(n) \propto n^H, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

with H = 1/2, which implies integer integro-differentiation and thus standard Brownian motion, the "random walk." H is the Hurst coefficient, which can vary from zero to one with a value of 1/2 implying no persistence in a process, a value significantly less than 1/2 implying "anti-persistence" and a value significantly greater than 1/2 implying positive persistence. The significance test involves breaking the sample into sub-samples (namely, pre-bubble, during-bubble and post-bubble period) and then estimating a Chow test on the null that the sub-periods possess identical slopes.

(iii) Nonlinearity Test

We test for nonlinearity of the VAR residual series in two stages. The first is to remove ARCH effects. Engle (1982) the nonlinear variance dependence measure of autoregressive conditional heteroskedasticity (ARCH) as

$$X_t = \delta_t \mu_t \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

$$\delta_t^2 = \alpha_0 + \sum_{i=0}^{n} \alpha_i X_{l-i}^2 \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

with μ is i.i.d. and the α_I's different lags. We use a three period lag and, as expected, significant ARCH effects in all series, available on request from the authors.

The second stage involves removing variability attributable to the estimated ARCH effects from the VAR residual series for both models. The remaining residual series is run through the BDS (Brock-Dechert-Scheinkman) test due to Brock, Dechert, LeBaron, and Scheinkman (1997), with useful guidance on certain aspects in Brock, Hsieh, and LeBaron (1991). This statistic tests for generalised nonlinear structure but does not test for any specific form such as alternative ARCH forms or chaos.

The correlation integral for a data series x_t, $t = 1, \ldots$, T results from forming m-histories such that $x = [x_t, x_{t+1}, \ldots, x_{t+m+1}]$ for any embedding dimension m. It is

$$c_m T(\varepsilon) = \sum_{t<s} I_\varepsilon \left(X_t^m, X_s^m\right)\left[\frac{2}{T_m(T_m - 1)}\right] \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

with a tolerance distance of ε, conventionally measured by the standard deviation divided by the spread of the data, $I_\varepsilon(x_t^m, x_s^m)$ is an indicator function equaling 1 if $|ix_t^m - x_s^m I| < \varepsilon$ and equaling zero otherwise, and $T_m = T - (m - 1)$.

The BDS statistic comes from the correlation integral as

$$BDS\,(m, \varepsilon) = T^{1/2}\{c_m(\varepsilon) - [c_1(\varepsilon)]^m\}/b_m \qquad \ldots \quad \ldots \quad \ldots \quad (15)$$

where b_m is the standard deviation of the BDS statistic dependent on the embedding dimension m. The null hypothesis is that the series is i.i.d., meaning that for a given ε and an $m > 1$, $c_m(\varepsilon) - [c_1(\varepsilon)]^m$ equals zero. Thus, sufficiently large values of the BDS statistic indicate nonlinear structure in the remaining series. This test is subject to severe small sample bias with a cutoff of 500 observations sufficient to overcome this, a minimum both of our daily series easily achieve.

Results

The results of the empirical tests are reported in Tables 2–5 and are summarised below.

(i) *Regime Switching Test:* Results are reported in Table 2. The critical value for rejecting the null of no trends is $\chi^2 = 3.84$. Clearly, the null of no trends is strongly rejected, given the reported value of 4076.68 for the test.

(ii) *Hurst Persistence Test:* Table 3 presents the results of this test, for which the critical F-value for the Chow test is 6.4. Table 3 consists of four sub-tables. The first, 3A, is for the entire sample period. The remaining three are for sub-periods, with 3B for the period of steep decline between April 18, 2008 and January 26, 2009, with 3C being for a sub-period prior to that between

February 1992 and December 2001, while 3D is for the period from January 2001 to November 2013. These break the sample approximately between the period before the regional effects of the U.S. reaction to the 9/11 attacks happened and after they started happening. For all of these cases, the estimated *F*-values easily exceed the critical value. Thus, the Hurst persistence test for both the entire sample as well as the three sub-samples significantly rejects the null of a value of 0.50, which would indicate no persistence.

Again, we emphasise that the validity of these tests are subject to the caveat that we have estimated reasonably well the fundamental series for the asset time series process.

(iii) *Nonlinearity Test:* Table 4 present the results of this test for embedding dimensions, m = 2 to 4 (m = 3 is conventional). The critical value for rejecting the null of i.i.d. ranges from 4.70 to 6.92 for those three cases. Based on the estimated BDS statistics null is rejected as these estimated numbers range from 24.87 to 32.81. Thus, there appears to be remaining nonlinearity beyond basic ARCH in the VAR residual series.

Of course, just as our earlier tests are subject to the validity of our original VAR specifications and the broader misspecified fundamental problem, likewise so is this test, which is further limited by our modification of the basic result with a basic ARCH adaptation. Thus, we also emphasise that the nature of the remaining nonlinearity remains unknown.

Table 2

Wald Test Results on Residuals from the VAR Model
VAR Variables: (i) KSE100 Index Returns, (ii) Exchange Rate, (iii) Pakistan Repo 30 Day Middle Rate, and (iv) World Stock Index

Sample Period	H_0: P_1=1-P_2
February 28, 1992-November 25, 2013	4076.68

Critical Value $\chi^2(1)$=3.84

Table 3

Hurst Coefficients and Related Chow Tests
Hurst Coefficients and Chow Test Results on Residuals from Four-Variable VAR Model of Pakistani Stock Returns, Exchange Rate, Pakistan Repo 30 Day Middle Rate and World Stock Index

	Hurst Coefficient	Computed F
Table 3a		
Full Sample Period February 28, 1992-November 25, 2013	0.59	1569*
Table 3b		
Sample Period April 18, 2008-January 26, 2009	0.83	920*
Market Peaked and Crashed in April 2008. Hit through January 2009		
Table 3C		
Sample Period February 1992-December 2001	0.63	4398*
Table 3D		
Sample Period January 2002-November 2013	0.59	2911*

*Computed Value of F>Critical Value of F 4.31; Reject the hypothesis of no persistence in the entire sample. We reject the hypothesis that this selected sample is the same full sample.

Table 4

BDS/SD Results
Sample Period February 28, 1992-November 25, 2013

No. of Dimensions	No. of Observations	BDS/SD Results
2	5673	24.87
3	5673	28.84
4	5673	32.81

Critical Value (for sample >1000, with m2) is approximately 4.70-6.92.

Table 5

ARCH Test Based on Residuals from VAR Procedure
Dependent Variable: RESID01; Method: ML – ARCH
Sample (adjusted): 2/28/1992 11/25/2013; Included observations: 5672
Convergence achieved after 64 iterations. Coefficient covariance computed using outer product of gradients; Pre-sample variance: back-cast (parameter = 0.7)
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*RESID(-2)^2 + C(5)*RESID(-3)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000276	0.000145	1.900344	0.0574
	Variance Equation			
C	4.29E-06	3.59E-07	11.9715	0.0000
RESID(-1)^2	0.1756	0.01256	13.9730	0.0000
RESID(-2)^2	–0.0099	0.0182	–0.5454	0.5855
RESID(-3)^2	–0.0638	0.0146	–4.3673	0.0000
GARCH(-1)	0.8819	0.0063	139.7810	0.0000
Adjusted R-squared	–0.0003	Akaike info criterion		–5.8968
Log Likelihood	16729.27	Schwarz criterion		–5.8898
Durbin-Watson stat	2.0006	Hannan-Quinn criterion		–5.8943

CONCLUSIONS

We have tested daily data for the Karachi stock exchange since 1992, including some appropriate sub-period tests, and reject the hypothesis of the absence of bubbles in the market, and also of nonlinearities beyond ARCH. We did this by estimating a hypothesised fundamental value time series for daily data from a Vector Autoregressive (VAR) model with daily data on the stock market world stock market prices, the Pakistani foreign exchange rate, and the middle 30-day Repo interest rate. Residuals from this VAR were tested for divergence using Hamilton regime switching tests and Hurst rescaled range statistics, with nonlinearity beyond ARCH being tested for using BDS statistics.

While we have not specifically compared the KSE to other emerging and frontier markets with our tests, available data suggests that indeed this market has exhibited greater volatility than most others, certainly more so than the average performance of such markets. While this performance may be partly due to technical issues, particularly regarding the measurement of the KSE index, it would be unwise to argue that such factors fully explain this. The KSE market simply appears to be highly volatile.

Such volatility makes it harder to sustain long-term investment for growth in the Pakistani economy. Indeed, one of the reasons to believe that speculative behaviour is a major factor in the market's high volatility is that the market's recent rise seems to be much greater relative to its GDP growth than one observes in other emerging and frontier economies. It is unclear what the best policy to deal with this problem is. Engaging in excessively strict monetary policy risks dragging down an economy that is already not growing as rapidly as many would like and is a blunt instrument for such a policy anyway [Rosser, Rosser, and Gallegati (2012)]. There is also recent evidence that monetary policy may well have a surprisingly weak influence on stock market bubbles [Galí and Gambetti (2015)]. Other policies that might be used might include tighter regulation of margin requirements and other more specific actions directed at micro details of the functioning of the markets. Of course, the fact that Pakistan faces serious problems due to terrorism and warfare in its region underscore the difficulty of making economic policy more generally in the nation.

REFERENCES

Ahmed, E., R. Koppl, J. B. Rosser, Jr. and M. V. White (1997) Complex Bubble Persistence in Closed-End Country Funds. *Journal of Economic Behaviour and Organisation* 32:1, 19–37.

Ahmed, E., J. B. Rosser, Jr. and J. Y. Uppal (1910) Emerging Markets and Stock Market Bubbles: Nonlinear Speculation? *Emerging Markets, Finance, and Trade* 46:4, 73–91.

Ahmed, E., J. B. Rosser, Jr. and J. Y. Uppal (2014) Are There Speculative Bubbles in Commodities Prices? *Journal of Post Keynesian Economics* 36:3, 425–438.

Baumol, W. J. (1957) Speculation, Profitability, and Instability. *Review of Economics and Statistics* 34: 3, 263–271.

Black, F. (1986) Noise. *Journal of Finance* 41:3, 529–542.

Blanchard, O. and M. W. Watson (1982) Bubbles, Rational Expectations, and Financial Markets. In P. Wachtel (ed.) *Crises in the Economic and Financial Structure*. Lexington: Lexington Books. pp. 295–315.

Bouchaud, J.-P. and M. Potters (2003) *Theory of Financial Risk and Derivatives Pricing*. Cambridge, UK: Cambridge University Press.

Brock, W. A., W. D. Davis, J. A. Scheinkman, and B. LeBaron (1997) A Test for Independence Based on the Correlation Dimension. *Econometric Reviews* 15:3, 197–235.

Brock, W. A., D. Hsieh, and B. LeBaron (1991) *Nonlinear Dynamics, Chaos, and Instability: Statistical Theory and Economic Evidence*. Cambridge, MA: MIT Press.

Canova, F. and T. Ito (1991) The Time Series Properties in the Risk Premium of the Yen/Dollar Exchange Rate. *Journal of Applied Econometrics* 22:2, 213–223.

Chiarella, C., M. Gallegati, R. Leombruni, and A. Palestrini (2003) Asset Price Dynamics using Heterogeneous Interacting Agents. *Computational Economics* 22:2, 213–223.

Davidson, P. (2004) *Financial Markets, Money, and the Real World*. Cheltenham: Edward Elgar.

DeLong, J. B., A. Shleifer, L. H. Summers, and R. Waldmann (1991) The Survival of Noise Traders in Financial Markets. *Journal of Business* 64:1, 1–19.

The Economist (2013) The Karachi Stock Exchange, Inefficient Frontier, Stocks Soar, Suspicious Swirl. July 27. Available at http://www.economist.com/news/finance-and-economics/21582307-stocks-soar-suspicions-swirl-inefficient-frontier .

Elwood, S. K., E. Ahmed, and J. B. Rosser, Jr. (1999) State-Space Estimation of Rational Bubbles in the Yen/Deutschemark Exchange Rate. *Weltwirtschaftliches Archiv* 135:2, 317–331.

Engel, R. and J. D. Hamilton (1990) Long Swings in the Dollar: Are They in the Data and Do Markets Know It? *American Economic Review* 80: 4, 689–713.

Engle, R. F. (1982) Autoregressive Conditional Heteroskedasticity with Estimation of the Variance of United Kingdom Inflation. *Econometrica* 50: 4, 251–276.

Feller, W. (1951) The Asymptotic Distribution of the Range of Sums of Independent Random Variables. *Annals of Mathematical Statistics* 22:3, 427–432.

Flood, R. P. and P. M. Garber (1980) Market Fundamentals versus Price Level Bubbles: The First Tests. *Journal of Political Economy* 88:4, 745–776.

Föllmer, H., U. Horst, and A. Kirman (2005) Equilibria in Financial Markets with Heterogeneous Agents: A Probabilistic Approach. *Journal of Mathematical Economics* 41:1-2, 123–155.

Galí, J. and L. Gambetti (2015) The Effects of Monetary Policy on Stock Market Bubbles: Some Evidence. *American Economic Journal: Macroeconomics* 7:1, 233–257.

Gallegati, M., A. Palestrini, and J. B. Rosser, Jr. (2011) The Period of Financial Distress in Speculative Markets: Interacting Heterogeneous Agents and Financial Constraints. *Macroeconomic Dynamics* 15:1, 60–79.

Gurkayanak, R. S. (2008) Econometric Tests of Asset Bubbles: Taking Stock. *Journal of Economic Surveys* 33:1, 166–186.

Hamilton, J. D. (1989) A New Approach to the Economic Analysis of Non-stationary Time Series and the Business Cycle. *Econometrica* 57: 2, 357–384.

Homm, U. and J. Breitung (2012) Testing for Speculative Bubbles in Stock Markets: A Comparison of Alternative Methods. *Journal of Financial Econometrics* 10:1, 193–231.

Houreld, K. (2013) Insight: Pakistan's Booming Market No Black and White Matter. Thomson Reuters, April 10, Available at http://reuters.com/article/2013/04/10us-pakistan-stockmarket-insight-idUSBRE93813Z20130410 .

Hurst, H. E. (1951) Long-term Storage Capacity of Reservoirs. *Transactions of the American Society of Civil Engineers* 116, 770–799.

Iqbal, J. (2008) Is KSE 100 Index Inflated? SSRN Working Paper Series, Available at http://dx.doi.org/10.2139/ssrn.1530752 .

Kindleberger, C. P. (2000) *Manias, Panics, and Crashes: A History of Financial Crashes*. (4th ed.). New York: Wiley.

Lo, A. W. (1991) Long Memory in Stock Prices. *Econometrica* 59:5, 1279–1313.

Mandelbrot, B. B. (1972) Statistical Methodology for Nonperiodic Cycles: From Covariance to R/S Analysis. *Annals of Economic and Social Measurement* 1: 3, 259–290.

Minsky, H. P. (1972) Financial Instability Revisited: The Economics of Disaster. *Reappraisal of the Federal Reserve Discount Mechanism* 3, 97–136.

Rosser, J. B., Jr., M. V. Rosser, and M. Gallegati (2012) A Minsky-Kindelberger Perspective on the Financial Crisis. *Journal of Economic Issues* 45:2, 449–458.

Shiller, R. J. (2015) *Irrational Exuberance* (3rd ed.). Princeton: Princeton University Press.

Sornette, D. and W.-X. Zhou (2005) Predictability of Large Future Changes in Financial Market Indices. *International Journal of Forecasting* 22:1, 154–168.

Tirole, J. (1982) On the Possibility of Speculation under Rational Expectations. *Econometrica* 50:5, 1163–1181.

Tirole, J. (1985) Asset Bubbles and Overlapping Generations. *Econometrica* 53: 6, 1499–1528.

Zeeman, E. C. (1974) On the Unstable Behaviour of the Stock Exchange. *Journal of Mathematical Economics* 1: 1, 39–44.