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Financial stability, energy consumption and environmental quality: Evidence from South Asian economies

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ABSTRACT

A few studies are found on the relationship between financial instability, energy consumption and environmental quality in energy economics literature. The current study is an endeavor to fill this gap by investigating the relationship between financial stability, economic growth, energy consumption and carbon dioxide (CO_2) emissions in South Asian countries over the period 1980–2012 using a multivariate framework. Bounds test for cointegration and Granger causality approach are employed for the empirical analysis. Estimated results suggest that all variables are non-stationary and cointegrated. The results show that financial stability improves environmental quality; while the increase in economic growth, energy consumption and population density are detrimental for environment quality in the long-run. The results also support the environmental Kuznets curve (EKC) hypothesis which assumes an inverted U-shaped path between income and environmental quality. Moreover, the study found the evidence of unidirectional causality running from financial stability to CO_2 emissions in two countries i.e. Pakistan and Sri Lanka. The findings of this study open up new insight for policy makers to design a comprehensive financial, economic and energy supply policies to minimize the detrimental impact of environmental pollution.

Contents

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1. Introduction

Financial sector is playing a significant role in the mobilization and utilization of savings, facilitation of transactions and monitoring of resources towards productive activities in developing countries. An efficient financial sector is expected to increase economic efficiency in general and growth process in particular. It can increase investment activities by issuing loans at cheaper rates, allocating resources toward productive channels, facilitating trade activities, managing risks, monitor the functioning of firms and informing the firms to use environment friendly techniques in their production process to stimulate the level of economic growth [24,72]. Schumpeter [101] was the first that explored the finance-growth relationship by analyzing the importance of finance in economic activities. The role of the financial sector in economic growth has received a great deal of attention with the advent of endogenous growth theory. However, the expansion in empirical literature started after the seminal paper of King and Levine [67] which stimulated the interest in this area.

Dasgupta et al. [30] noted that countries with efficient financial markets are more likely to enjoy a clean environment than countries with less developed financial markets. Economic literature suggests that sound and efficient financial sector attracts foreign direct investment in a country and encourages the economic growth. Foreign firms are more energy efficient and use environment friendly techniques than domestic firms of less developed countries [36]. Developed financial structure encourages firms to adopt modern technologies in the energy sector that result in lower emission of energy pollutants [68] and stable financial system helps to improve environmental conditions by encouraging investment on environmental friendly techniques. Under the rejunctive remedies financial system also punishes the firms on the releasing more wastage in water and air through restricting their access to easy credit [97,19,48]. This act of financial markets not only increases the market value of the firms and productivity but also reduces environmental pollution. In contrast, Tamazian et al. [115] pointed out that financial sector development may over all enhance economic growth which may result in more industrial pollution and environmental degradation.

Banks dominate the financial sector in South Asian region while capital markets are relatively underdeveloped [120]. The size of banking sector is three times more than the stock market in all South Asian economies. Government bonds are leading indicator in region's bond markets as compared to corporate bonds. In some South Asian countries like India and Sri Lanka, public sector banks control more than 50% of commercial banking assets while in Bangladesh and Pakistan, the role of private sector banks is more prominent [113]. The banking sector of South Asian economies is relatively more stable as compared to other developing economies of the world. Capital adequacy ratio is found to be greater than statutory requirements in all countries except Nepal. The amount of gross nonperforming loans, although rising, has not reached the alarming situation and most countries have displayed satisfactory levels of provisions. The performance of banks is also satisfactory, with higher interest margins and cost efficiencies [120].

South Asian countries have introduced financial sector reforms in early 1980s. Early reform programs included initiatives to privatize and restructure public sector, banks and develop capital markets. These were followed by reforms to liberalize the financial sector, strengthen prudential norms, revamp laws, build regulatory capacity, improve corporate governance, and develop market infrastructure and payment systems. While countries have undertaken varying degrees of reforms, in most cases the reform programs have strengthened their financial systems and especially their banking sectors [113]. Banks have become dominant players in the region's financial sectors and strong contributors to economic growth. The main motive of initial reforms was to increase competition in financial sector, particularly banking sector and improve prudential regulations [113]. Not only financial development contributed to growth through enhancing the benefits of FDI in South Asia rather improvement in political rights and civil liberties also enhanced the benefits of financial development [10]. In recent years, countries have taken steps to bring their local auditing and accounting standards in line with international accounting standards, improve technological infrastructure, modernize payment systems and introduce corporate governance guidelines. These reforms increase the stability of financial system [120] and in turn economic growth. Table 1 shows key financial sector indicates of South Asian economies for the year 2012.

South Asian economies have tremendous potential for economic growth. For nearly two decades, until the onset of the global financial crisis in 2008, South Asian economies enjoyed rapid economic growth. Growth rate was greater than 9% in India; 7% in Pakistan; 6% in Bangladesh; 4% in Nepal and 6% in Sri Lanka in the past decade. Due to high economic growth and reduction in poverty, GDP per capita increased sharply in all South Asian countries from 2000 onward (see Table 2).

Energy consumption reflects the life style trends of a country. Economic prosperity is usually accompanied by a higher energy demand; especially the demand for renewable energy sources and their consumption (see e.g. [25,27]). This can be seen in the case of India, Pakistan and Sri Lanka. Energy consumption was lower in the year 1990, but increase in per capita income in the following years, increased energy consumption in all three countries. Nepal which is a small country with medium low development has high energy consumption. The energy consumption figures of Nepal are comparable to Pakistan and India, both of which are relatively bigger and more populous than Nepal (see Table 2). The enormous economic growth and demand for energy consumption has been accompanied with the problem of environmental pollution. India accounts for about 75% of total regional emissions, though per capita emissions remain low; there is considerable potential for further increase with economic growth. The average annual CO_2 emissions per capita has been estimated at 1.91 metric tons in India, 0.94 metric tons in Pakistan, 0.39 metric tons in Bangladesh, 0.14 metric tons in Nepal and 0.63 metric tons in Sri Lanka in the year 2012 (see Table 2).

The objective of the study is to investigate the relationship between financial stability, energy consumption and CO_2

Table 1
Key financial sector indicators of South Asian economies in 2012.

Indicator	Pakistan	India	Bangladesh	Nepal	Sri Lanka
Domestic credit provided by financial sector (% of GDP)	45.8	75.9	69.0	67.9	48.4
Bank deposits to GDP (%)	28.79	61.98	50.48	58.68	31.60
Stock Market Capitalization (% of GDP)	19.4	68.0	15.0	21.9	28.7
Bank return on assets (%)	2.10	1.00	1.3	1.77	1.56
Bank Z-score (%)	13.57	36.02	9.67	8.02	14.23
Capital adequacy ratio (%)	15.4	14.6	10.5	11.5	12.3
Central bank assets (% of GDP)	8.85	4.61	5.14	2.73	2.72
Deposit interest rate (%)	8.0	8.25	11.7	4.0	8.7
Lending interest rate (%)	13.5	10.6	13.0	8.0	13.3
Exchange rate/US$	93.40	53.44	81.86	85.20	127.60
Commercial banks	36	82	43	31	24
Specialized banks	4	7	5	58	14
Non-bank financial institutions	43	346	30	78	56

Source: World Bank, World Development Indicators database.

Table 2
Trends in GDP, energy consumption and CO_2 emissions in South Asian economies (1980–2012).

Year	Pakistan	India	Bangladesh	Nepal	Sri Lanka
	GDP per capita (US $)				
1980	296.17	271.24	219.85	135.27	272.91
1990	360.15	375.89	283.97	200.29	472.08
2000	514.15	457.28	355.97	236.98	854.92
2010	1024.5	1419.1	664.06	596.37	2400.0
2011	1213.9	1533.6	731.89	704.18	2835.9
2012	1256.6	1489.2	752.15	690.20	2923.2
Year	**Energy consumption per capita (Kg of oil equivalent)**				
1980	309.55	293.51	101.84	317.12	307.50
1990	385.78	364.53	118.59	319.64	324.19
2000	445.42	438.65	140.43	349.70	435.90
2010	486.92	600.30	203.51	380.62	476.66
2011	481.61	613.71	204.72	382.63	499.33
2012	479.44	645.00	212.29	384.95	516.52
Year	**CO_2 emissions per capita (metric tons)**				
1980	0.400	0.498	0.092	0.037	0.225
1990	0.617	0.794	0.144	0.035	0.221
2000	0.740	1.138	0.210	0.139	0.531
2010	0.932	1.666	0.371	0.139	0.615
2011	0.937	1.808	0.380	0.134	0.624
2012	0.938	1.906	0.395	0.138	0.630

Source: World Bank, World Development Indicators database.

emissions in five South Asian countries namely, Pakistan, India, Bangladesh, Nepal and Sri Lanka, from a long run perspective, in a multivariate framework by employing ARDL bounds testing approach. The study extends the existing literature on the environment and finance in three distinct ways. Firstly, we have developed an Aggregate Financial Stability Index (AFSI) for South Asian economies (Pakistan, India, Bangladesh, Nepal and Sri Lanka) using annual data over the period 1980–2012. Similar to the methodology employed by Morris [72] and Albulescu [4], the AFSI involves the aggregation of sub-indices covering financial sector development, vulnerability and soundness. Secondly, this is the first study that has developed AFSI to test the link between financial stability and environmental quality in South Asian economies. Third, econometric techniques such as structural break unit root tests and ARDL bound testing approach to cointegration are applied to highlight the relationship between financial stability, energy consumption and environmental quality in five South Asian economies.

The following section of the study provides the literature on financial stability, energy consumption and environmental degradation. Section 3 shows the development of AFSI for South Asian economies; Section 4 presents econometric modeling and data sources; Section 5 depicts econometric techniques; Section 6 reports empirical analysis and their interpretations and Section 7 provides conclusions and policy implications.

2. Review of literature

2.1. Economic Growth and CO_2 emissions

Rapid economic growth and its impact on environment have generated a heated debate in the last two decades. The pioneering work of Kuznets [69] on inverted U-shaped relationship between growth and income inequality has been reformulated to test the inverted U-shaped relationship between income growth and the environment. This relationship has become known as environmental Kuznets curve (EKC) after the seminal work of Grossman and Kruger [42]. Environmental Kuznets Curve (EKC) states that environmental degradation increases with the economic growth of countries but up to a certain level as marked in the transition stage of development, and then declines after this threshold level [42]. In the initial stage of development, economies often rely on heavy infrastructure projects, and less efficient energy sources [16], which lead to environmental degradation due to emissions of various pollutants such as carbon dioxide, sulfur, and nitrogen oxides [29,60]. However, after a threshold level, high sustained economic growth coupled with efficient and renewable energy sources [116] and environment management practices [31] recovers the quality of life and reduces emission of various pollutants. Hence, over the passage of time, the effluence absorption intensity turns down. Numerous empirical studies such as Shafik and Bandyopadhyay [107], Grossman and Krueger [43], Holtz-Eakin et al. [51], Selden and Song [102], Panayotou [83], Panayotou et al. [84], Galeotti et al. [39], Apergis and Payne [12], Arouri et al. [11], Friedl and Getzner [38] and others have attempted to test the validity of EKC for different economies and for different regions. The results of such studies are, however contradictory and failed to reach any definite conclusion regarding the validity of EKC using real life data.

Studies of long-run equilibrium relationship, which are often complementary to the EKC studies, focus on long-run causal relationship between economic growth and CO_2 emissions. Empirical findings by Apergis and Payne [12] confirmed the validity of inverted U-shaped EKC in the long-run and the unidirectional causality running from economic growth to CO_2 emissions for six Central American countries. Later on, Apergis et al. [13] found the bidirectional causality between GDP and CO_2 emissions in a panel of 16 developed and developing countries. Al-Mulali and Sab [6] also found long-run relationship between economic growth and CO2 emissions and Granger causality between CO2 emissions and economic growth in both short run and long run in MENA countries. In a global panel of 69 countries Sharma [108] showed that per capita GDP has positive and significant effect on CO_2 emissions. In the case of Pakistan, Nasir and Rehman [74] confirmed the validity of EKC hypothesis and one-way causal relationship running from economic growth to CO_2 emissions. The similar findings were obtained by Shahbaz et al. [104].

On contrary, Jaunky [63] empirical results failed to provide evidence in favor of the EKC hypothesis but indicated that over the time, CO_2 emissions are declining in high-income countries. The unidirectional causality running from real per capita GDP to per capita CO_2 emissions was not supported both in the short run and long run. Similarly, Acaravci and Ozturk [1] study failed to found evidence in favor of EKC hypothesis in most of European countries. For BRIC countries, Pao and Tsai [86] found the unidirectional Granger causality running from CO_2 emissions to economic growth but Pao and Tsai [87] found just contrary results i.e. unidirectional causality running from economic growth to CO_2 emissions. Their results also show little support to the validity of EKC hypothesis. In another study, by Arouri et al. [11] provided poor evidence in support of the EKC hypothesis for MENA countries. However, Farhani et al. [37] verified the existence of EKC hypothesis for 11 MENA countries. Ozcan [82] study supported the U-shaped relationship in 5 Middle Eastern countries, whereas an inverted U-shaped curve is identified for 3 Middle Eastern countries.

Granger causality test results were unable to prove any evidence of long-run causality between economic growth and carbon emissions in the panel of Newly Industrialized Countries (NIC) [52]. Iwata et al. [62] findings confirmed the occurrence of the EKC in Finland, Japan, Korea and Spain. In OECD countries on average, the effects of CO_2 emissions on economic growth have declined significantly due to technological progress and providing indirect empirical support for the EKC hypothesis [47]. In case of 14 MENA countries, empirical results show that there is bidirectional causality between CO_2 emissions and economic growth [78] but for the global panel and for the Europe and Central Asia region empirical results supported evidence of the unidirectional causality running from CO_2 emissions to economic growth [79]. Using data for the United Arab Emirates, Shahbaz et al. [105] found that the EKC is present and economic growth Granger causes CO_2 emissions. Similarly, Kasman and Duman [65] provided evidence in support of EKC in EU member countries.

2.2. Economic growth, energy consumption and CO_2 emissions

In recent years, numerous empirical studies examined the relationship between economic growth, energy consumption and environmental quality within Granger causality multivariate framework. Most of these studies are on individual country analysis. For example, Ang [9] empirical findings are on France, Soytas et al. [110] on United States, Zhang and Cheng [122] on China, Halicioglu [45] on Turkey, and Shahbaz et al. [104] on Pakistan. The findings of these studies are contradictory. For instance, Soytas et al. [110], Zhang and Cheng [122] observed long-run unidirectional causality running from energy consumption to environmental pollution. Halicioglu [45] found feedback relation between energy consumption, income growth and CO_2 emissions in long-run. On contrary, Ang [9] reported unidirectional long-run causality running from economic growth to energy consumption and CO_2 emissions. Shahbaz et al. [104] demonstrated that energy consumption Granger-cause pollution emissions both in the short-run and long-run while economic growth Granger-cause pollution emissions only in long-run. Sari and Soytas [111] found conflicting results in five OPEC countries, namely, Algeria, Indonesia, Nigeria, Saudi Arabia and Venezuela. Hossain [52] study results showed significant impact of energy consumption on carbon emissions in both short-run and long-run. However, Cong and Shen [26] found the negative impact of energy price shocks on the macroeconomic performance in China.

Cho et al. [22] found that energy consumption is the major determinant of CO_2 emissions in MENA countries. In a study on Turkey, Yavuz [121] found that there is positive and long-run relationship among per capita CO_2 emission, per capita income, and per capita energy consumption. Onafowora and Owoye [81] reported that energy consumption Granger-causes both CO2 emissions and economic growth in Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa. Magazzino [71] empirical results showed that there is no long-run relationship between CO_2 emissions, energy consumption and economic growth in Italy. Moreover, the Toda and Yamamoto Granger non-causality test showed a bidirectional causality between CO_2 emissions and economic growth, as well as between CO_2 emissions and energy consumption.

In recent studies, Begum et al. [15] reported a long-term positive impact of GDP per capita and energy consumption on CO_2 emissions in Malaysia. Kasman and Duman [65] study results revealed that there is a short-run unidirectional panel causality running from energy consumption to carbon emissions and from GDP to energy consumption in new EU member and candidate countries. Shahbaz et al. [106] found the evidence of bidirectional causality between energy consumption and CO_2 emissions and unidirectional causality running from economic growth to energy consumption in a panel of 99 countries. In another study, Joo et al. [64] found the evidence of unidirectional causality from energy consumption to economic growth, from CO_2 emissions to economic growth, and from energy consumption to CO_2 emissions in Chile. However, there was no unidirectional causality from economic growth to energy consumption, from CO_2 emissions to energy consumption, and from economic growth to CO_2 emissions.

2.3. Economic growth, energy consumption, financial instability/stability and CO_2 emissions

There are some studies on energy economics that have examined the impact of financial instability/stability on environmental degradation by incorporating economic growth and energy consumption. For example, Richard [98] explored the link between financial instability and CO_2 emission using the sample of 16 developed and 20 developing countries. The results estimated by applying static and dynamic models demonstrated the positive impact of financial instability on environmental degradation. The economic growth and population density were the main contributing factors to increase environmental pollution in sample countries. The results also confirmed the validity of EKC hypothesis. In contrast, Brussels [17] study did not find any detrimental impact of financial crisis on the environment. Further, Brussels noted that financial crisis reduced carbon emissions by 24% in Estonia, 22% in Romania, 16% in Italy and Spain and 13% in UK. Similarly, Enkvist et al. [35] empirical findings demonstrated little impact of global crisis on carbon emissions. Cong et al. [28] found the insignificant impact of oil price shocks on real stock returns of most Chinese stock market indices.

Shahbaz [103] investigated the link between financial instability and environmental pollution in the case of Pakistan. Empirical findings confirmed the positive impact of financial instability, economic growth and energy consumption on environmental degradation in long-run. The results showed that energy consumption is a dominant factor to harm environmental quality and EKC also exist in this particular case. Ziaei [123] investigated the effects of financial indicator shocks on energy consumption and carbon dioxide (CO_2 emissions) and vice versa for 13 European and 12 East Asia and Oceania countries from 1989 to 2011. Although energy consumption and CO_2 emission shocks on financial indicators such as private sector credit is not very pronounced in both groups of countries, the strength of energy consumption shock on stock return rate in European countries was greater than East Asian and Oceania countries. Conversely shocks to stock return rate influenced energy consumption especially in long horizon in case of East Asia and Oceania countries.

The above mentioned literature shows that only a few empirical studies analyzed the relationship between CO_2 emissions, economic growth, energy consumption and financial stability. The present study is an attempt to fill this gap by providing empirical evidence for the relationship between CO_2 emissions, economic growth, energy consumption and financial stability using linear and non-linear models in the context of South Asian countries.

3. The construction of aggregate financial stability index for South Asian economies financial system

Financial stability is a multi-dimensional phenomena which is difficult to grasp and measure. As stated in the OeNB's Financial Stability Reports, financial stability can be defined as a situation in which "(…) the financial system (…) is capable of ensuring the efficient allocation of financial resources and fulfilling its key macroeconomic functions even if financial imbalances and shocks occur. Under conditions of financial stability, economic agents have confidence in the banking system and have ready access to financial services (…)." [77].

Due to multi-dimensional nature of the financial system, financial stability indices are comprised of indicators that reflect the varied dimensions of financial stability. Unlike the bi-variate nature of indicators used in the literature, the index provided a single measure of macroeconomic financial stability which is allowed to vary over a continuum of values, where extreme values reflect crises. Many researchers like Illing and Liu [54], Hanschel and Monnin [49], Gersl and Hermanek [40], Van den End [118], Rouabah [100], Morris [72], Cheang and Choy [21], Albulescu et al., [5]; Park and Mercado [85] have developed a financial instability index, but it coined more popularity and acceptability when it was used by the International Monetary Fund (IMF) in 2008 or European Central Bank (ECB) in 2010.

Our objective is to construct a contemporary measure of Aggregate Financial Stability Index (AFSI) for the South Asian financial system. Similarly to the literature, we design the AFSI as a composite index covering various indicators relating to financial sector development, vulnerability and soundness. Equal weights are assigned to all three segments. A higher AFSI signals periods of imbalances in the financial system, peaking during times of acute financial distress. Albulescu [3] mentioned various reasons that justify the importance of aggregate financial stability index. Firstly, it can compare stability level between different periods and different financial systems. Secondly, it has numerous advantages such as high transparency, easier access to statistical data, simple calculation procedure and the likelihood to forecast financial stability level.

Based on empirical literature, (see e.g. [3,5,21]), we have selected 15 individual indicators covering financial sector development, vulnerability and soundness over the period 1980–2012. The selected financial stability indicators are reported in Table 3.

The financial development indicators measure financial deepening of South Asian region. The first indicator is *'domestic credit to GDP'*. The higher value of this indicator represents more developed and more mature financial system. The second indicator '*stock market capitalization to GDP*' measures the development and the magnitude of capital market. '*Interest rate spreads*' is the final indicator and is equal to the difference between lending rate and deposit rate. The upward trend in interest rate spread indicates the high profitability of banking system but at the same time it signals about alarming situation that this sector has immature and poorly developed.

The indicators; considered for 'financial vulnerability' measure macroeconomic conditions and funding structure of banking institutions. The sound macroeconomic condition captures the soundness of financial system and its capability against potential shocks. 'General budget to GDP ratio' is the first indicator in this category which represents the macroeconomic stability. The high value of budget deficit negatively impacts sustainable economic growth and investment decision to undertake risky projects [2,119]. The second macroeconomic indicator is 'current account deficit to GDP'. Deficit in current account disturbs macroeconomic stability and in turn affecting financial stability. The third indicator is '*real effective exchange rate (REER)*' excessive appreciation or depreciation. The high volatility in exchange rate demands major correction in the fluctuation of exchange rate which negatively affect the financial market stability [99]. The next indicator is '*public debt to GDP*' that can distrub governmnet balance sheet and can influence on future fiscal cost. High levels of debt should also affect policies designed to mitigate higher inflation rates. '*International reserve to import ratio'* is the next indicator and high value of this ratio is a major device for handling domestic financial instability as well as exchange rate instability in the wave of increasing global financial libalization. '*Non-government credit to total credit*' ratio reflect bank funding to private sector and its use for productive investment projects. The second last indicator is '*M2 to foreign exchange reserve*' and excess growth of money supply over foreign reserves gives indication of reserve adequacy. This ratio enhances capability to suppress external shocks and ensures the convertibility of local currency. The last indicator in this category is '*M_2 multiplier*' and is defined as ratio of M_2 to monetary base indicating how much expansion in money supply can be observed through the increase in monetary base by the banking system.

Table 3
Financial stability indicators.

Individual indicators		Expected impact on financial stability
(i) Financial market indicators		
Domestic credit to GDP (%)	X_{m1}	+
Interest rate spread	X_{m2}	–
Stock market capitalization to GDP (%)	X_{m3}	+
(ii) Financial vulnerability indicators		
Fiscal deficit (% of GDP)	X_{v1}	–
Current account deficit (% of GDP)	X_{v2}	–
Real effective exchange rate (change)	X_{v3}	–
Public debt to GDP ratio	X_{v4}	–
International reserve to import ratio	X_{v5}	+
Non-government credit to total credit	X_{v6}	+
M2 to Foreign exchange reserve ratio	X_{v7}	+
M2 multiplier	X_{v8}	+
(iii) Financial soundness indicators		
Return on assets	X_{f1}	+
Bank capital to asset ratio	X_{f2}	+
Liquid asset to total asset	X_{f3}	+
Bank regulatory capital to risk weighted assets	X_{f4}	+

The banking system fragility can be measured by analyzing the financial soundness indicators proposed by the IMF and used by various international financial institutions see [41,18,76] to access the soundness of financial system. The first soundness indicator is '*return on assets (ROA)*'. The high value of this indicator represents the profitability and efficiency of banking system and low value indicates the fragility of banking sector. The profit obtained by the banks must reduce the extent of risk in the market. The second indicator is '*bank capital to asset ratio'* measuring the capitalization level of banking system. The next indicator represented by the '*ratio of liquid asset to total assets'* provides signal about financial system instability because an unstable financial system does not meet the liquidity requirements. The next final indicator in this category is "*regulatory capital to risk weighted assets ratio*". This indicator does not only represents the structure of banking sector capitalization but also provides most important information relating to banking institutions' solvability (balance sheet).

Before aggregating all individual indicators into a single aggregate index, it is necessary to put them on a common scale. For this purpose, all individual indicators are normalized so that they have common variance. In this study, we use statistical normalization procedure. This procedure converts indicators into a common scale with a mean of zero and variance of one. Zero mean value of indicators eliminates the problem of aggregation distortions risen due to differences in indicators' mean. Standard deviation is used for scaling the indicators.

Statistical normalization is computed by applying the following formula:

$$Z_t = \frac{(X_t - \bar{X})}{S} \tag{1}$$

Z_t is called standard normal distribution with zero mean and unit variance, N(0,1). X_t is the value of indicator at time t. $\bar{X}$and S is the value of mean and standard deviation respectively of indicator x analyzed in the period t. All individual indicators are normalized so that a positive value indicates improvement in financial stability and negative value indicates deterioration in financial stability.

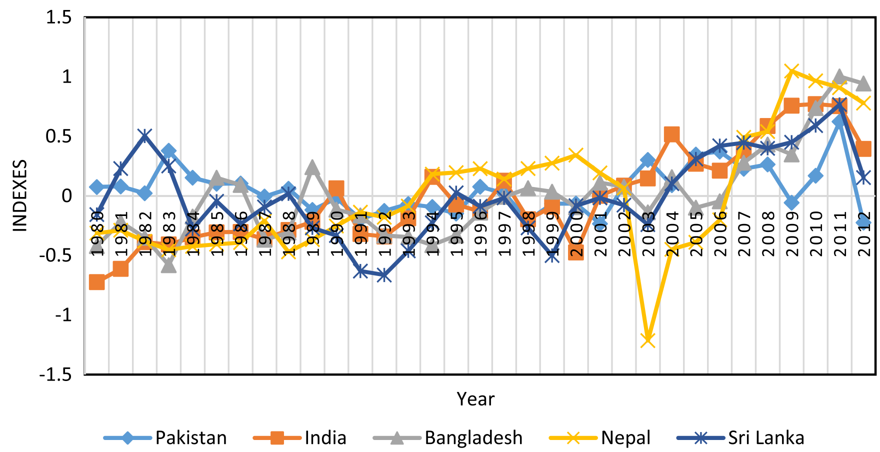

Fig. 1. AFSI using variance equal weighting method.

The literature does not agree on one single method of aggregation the variables in a composite index (see [54] for detail). The most common weighting methods are variance-equal weights, principal component analysis and aggregation with the use of empirical cumulative distribution function [46,54,88,109]. All the methods mentioned are characterized by the fact that the weights set by them do not have economic importance [54]. In addition, in the selection of variables for the construction of an index one has to pay attention to potential constraints deriving from the method by which it is aggregated. To form the AFSI for South Asian economies, we consider the most common weighting methods used in previous literature (e.g. [14,20,58,85]), that is, variance-equal weighting method.

Variance Equal Weights (VEW) is the most straightforward and perhaps the most intuitive weighting method. In this approach, the financial instability index is generated by giving equal importance to each component in the index. The variables are assumed to be normally distributed and the selected indicators are first transformed using the standardization approach described earlier. The division of the indicators by their respective variances can be interpreted as a risk or a variance-equal weight and it avoids the over weighting of more volatile stress indicators (see, e.g., [55,61,75]). In other words, the approach adjusts the stress indicators for differences in volatility. The transformed indicators are used to form sub-indexes by taking simple averages. The final AFSI is simply the arithmetic average of the financial development, vulnerability and soundness indicators at each point in time. It is calculated by the following formula

$$\text{AFSI} = \frac{\sum_{i=1}^{3} s_i}{n} \quad (2)$$

where s_i represents the sub-indexes (financial development index, financial vulnerability index and financial soundness index) and n refers to the number of sub-indexes in the final AFSI. Fig. 1 shows the trends in AFSI of five South Asian economies, namely, Pakistan, India, Bangladesh, Sri Lanka and Nepal for the period 1980–2012. Negative values of the indexes correspond to the periods of financial instability.

For sensitivity analysis, we have used Principal Component Analysis (PCA), applied by Hakkio and Keeton [44], Park and Mercado [85], Dumicic [33] and others. PCA is used to transform a large number of correlated variables into a smaller number of uncorrelated variables, that is, principal components, the highest degree of variation being retained, which makes it easier to use the data [8,33]. In other words, this is a technique used to determine a small number of factors responsible for the correlation of a large number of variables, reducing the amount of data, while retaining the maximum amount of information from them. The correlations of the variables in the groups identified are greater within the groups than among the groups. AFSI calculated with the PCA method is determined as the first principal component that explains the greatest part of the combined movement of the variables used for the construction of the index:

$$AFSI = X_i a \quad (3)$$

Here a is the weight vector (of the individual indicators $\times 1$) and X_i is the vector of the values of the indicator on the basis of which the indices are evaluated. The loadings determine the variables that make the greatest contribution to the explanation of the joint movement of all the components of the aggregated index. Fig. 2 shows that AFSI calculated by principal components analysis are similar in long-run trend. Looking to certain sub-sample period, that is 2002–2006, this research found that PCA shows decreasing trend, while fluctuation also occur in Aggregation with variance-equal weighting method. This implies that there is no much difference in the results obtained by applying both weighting methods.

In addition to check the robustness of the results, coefficient of correlation is checked between indices calculated by the aggregation of weights based on variance-equal weighting method and principal components analysis. The coefficients of correlation between the indices show a greater degree of positive correlation among the indices, for they range from 0.81 to 0.97, which also confirms the robustness of the results (see Table-A1 presented in Appendix).

4. Econometric modeling and data sources

The review of empirical studies leads us to formulate the following empirical model:

$$CO_t = f(AFSI_t, YP_t, EC_t, PD_t) \quad (4)$$

The regression model that examines the impact of financial stability and energy consumption on environmental quality is specified as follows:

$$\ln CO_t = \gamma_0 + \gamma_1 AFSI_t + \gamma_2 \ln YP_t + \gamma_3 \ln EC_t + \gamma_4 \ln PD_t + \varepsilon_t \quad (5)$$

where CO is CO_2 emissions proxy for environmental degradation, $AFSI$ is aggregate financial stability index, YP is income per capita proxy for economic growth, EC is energy consumption, PD is population density, ε is error term, ln is natural logarithm and t are years.[1]

[1] Summary statistics of all the selected variables is presented in Appendix Table A2.

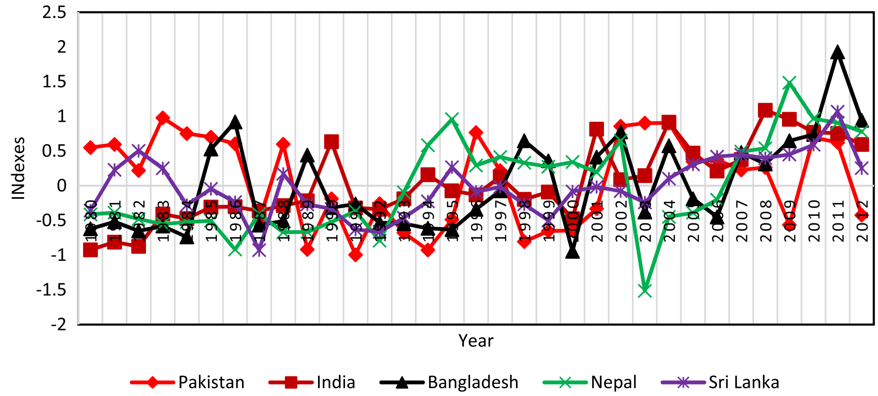

Fig. 2. AFSI using principal components analysis.

Following Richard [98], Tamazian and Rao [114] and Shahbaz [103], we also test the validity of EKC hypothesis in the presence of financial stability. The regression model in the presence of EKC is following:

$$\ln CO_t = \tau_0 + \tau_1 AFSI_t + \tau_2 \ln YP_t + \tau_3 \ln YP_t^2 + \tau_4 \ln EC_t + \tau_5 \ln PD_t + \varepsilon_t \quad (6)$$

For econometric specification, the study uses time-series data over the period 1980–2012 of South Asian economies. The data on CO_2 emission (measured in metric tons per capita), GDP per capita (measured in constant 2005 US$), energy consumption (measured in kilo tons oil equivalent per capita), population density (people per square Km of land area) is collected from World Bank, World Development Indicators database while the data on financial stability indicators is obtained from World Bank financial structure dataset, International Financial Statistics of IMF, State Bank of Pakistan, Reserve Bank of India, Central Bank of Bangladesh, Central Bank of Sri Lanka and Nepal Rastra Bank. Table A2 reports the summary statistics for the country level variables.

5. Econometric methodology

5.1. Unit root tests

In applied econometrics, the classical methods of estimation are based on the assumption that mean and variance of the series does not vary over time. However, means and variances of many macroeconomic variables are not constant and change over time. These variables are called non-stationary or unit root variables. When classical estimation techniques such as ordinary least squares (OLS) are applied to unit root variables it leads to spurious estimates. A number of earlier studies on environmental economics have employed the conventional unit root tests. Perron [89] criticized the conventional unit root tests as they did not address the structural changes in unit roots and null hypothesis of unit root can be equivocally accepted or rejected if there are structural breaks in the data series. To overcome this weakness we applied both the conventional unit root tests [Augmented Dickey Fuller (ADF) [32], Phillips Perron (PP) [92], Dickey Fuller-Generalized Least Squares (DF-GLS) 1996 and Kwiatkowski et al. (KPSS) [70], following Cong et al. [28], Cong and Shen [26] and structural break unit root tests [Zivot-Andrews (ZA), 1992 and Clemente-Montanes-Reyes (CMR), [23] to check the integrated properties of variables.

5.1.1. Conventional unit root tests

The ADF is a simple conventional unit root test that allows higher order auto-regressive dynamics in the case that an AR (1) process is inadequate to render error term white noise. The general form of ADF regression with or without time trend is following:

$$\Delta z_t = \theta + \delta z_{t-1} + \sum_{i=1}^{m} \pi_i \Delta z_{t-i} + \varepsilon_t \quad (7)$$

$$\Delta z_t = \theta + \beta t + \delta z_{t-1} + \sum_{i=1}^{m} \pi_i \Delta z_{t-i} + \varepsilon_t \quad (8)$$

The null and alternative hypotheses for a unit root in z_t are: H_0: $\delta = 0$ and H_1: $\delta < 0$. It is a well known fact that ADF test does not provide efficient results in the case of small sample due to its size and power properties. Phillips and Perron [96] introduced an alternative unit root tests that deal with serial correlation and heteroskedasticity in the errors. The test equation for PP test is

$$\Delta z_t = \beta' D_t + \pi z_{t-1} + u_t \quad (9)$$

where u_t is I(0) and may be heteroskedastic. This test is more powerful than ADF test but same critical values are used in both cases. One advantage of PP test over the ADF test is that the PP test is robust to general form of heteroskedasticity in the error term u_t.

The DF-GLS developed by Elliot et al. [34] is also called de-trending test. The order of integration of variable z_t is calculated from de-trending procedure developed by Elliot et al. [34]. The general equation of DF-GLS test is as under:

$$\Delta z_t^d = \delta^* z_{t-1}^d + \delta_1^* \Delta z_{t-1}^d + \ldots\ldots + \delta_{p-1}^* \Delta z_{t-p+1}^d + \eta_t \quad (10)$$

where z_t^d is the de-trended series and null hypothesis of this test is that z_t has a random walk trend:

$$z^d{}_t = z_t - \hat{\theta}_0 - \hat{\theta}_1 t \quad (11)$$

Basically this test proposed two hypotheses. First, z_t is stationary with a linear time trend and second, it is stationary without linear time trend with a mean greater than zero. DF-GLS test is performed first by estimating the intercept and trend by utilizing the generalized least square technique in alternative hypothesis. This estimation is investigated by generating the following variables:

$$\bar{Z} = [z_t, (1 - \bar{\beta} L) z_2, \ldots\ldots\ldots, (1 - \bar{\beta} L) z_T] \quad (12)$$

$$\bar{Y} = [z_t, (1 - \bar{\beta} L) Y_2, \ldots\ldots\ldots\ldots, (1 - \bar{\beta} L) Y_T] \quad (13)$$

and

$$Y_t = (1, t)\bar{\beta} = 1 + \frac{\bar{\alpha}}{T} \quad (14)$$

where "T" representing number of observation for z_t and $\bar{\alpha}$ is fixed.

OLS estimation is followed by following equation:

$$\bar{Z} = \varphi_0\bar{Y} + \phi_1 Y_t + \varepsilon_t \quad (15)$$

OLS estimators φ_0 and ϕ_1 are utilized for the removal of trend from z_t above. OLS is employed on the transformed variable by fitting the following regression:

$$\Delta z_t^d = \lambda_0 + \rho z_{t-1}^d + \sum_{i=1}^{m}\gamma_i \Delta z_{t-i}^d + u_t \quad (16)$$

Finally, ADF regression is employed on new transformed variables to test the null hypothesis: H_0: $\rho = 0$.

KPSS test differ from the above mentioned unit root tests in that it tests the null hypothesis of stationary against the alternative hypothesis of a unit root. KPSS test is based on the residuals from the OLS regression of z_t on the exogenous variable y_t:

$$z_t = y'_t\delta + v_t \quad (17)$$

The approximate critical values for the KPSS test can be found in KPSS [70]. Hobijn et al. [50] provided the updated routines for the KPSS test; particularly the automatic bandwidth selection routine. In such applications, the evaluation of the test statistics for various lags is not required.

5.1.2. Structural break unit root tests

Zivot and Andrews [124] proposed the variation in Perron's [93] unit root tests in which the break point is estimated on the basis of t-statistics. The break point is endogenously determined and the test allows a single break in the intercept and trend of the series. The Zivot and Andrews (ZA) model including break in intercept and trend is written as:

$$\Delta Z_t = \upsilon + \gamma t + \varphi DU_t(\vartheta) + \phi DT_t(\vartheta) + \beta Z_{t-1} + \sum_{i=1}^{m} c_i\Delta Z_{t-i} + \varepsilon_t \quad (18)$$

where $DU_t(\vartheta)$ is a dummy variable capturing a shift in the intercept and $DT_t(\vartheta)$ is another dummy variable capturing a shift in the trend occurring at time $TB(\vartheta)$. TB is the break date and dummy variables are specified as follows:

$$DU_t(\vartheta) = \begin{cases} 1 & if \quad t > TB(\vartheta) \\ 0 & if \quad t \le TB(\vartheta) \end{cases} and\ DT_t(\vartheta) = \begin{cases} t - TB(\vartheta) & if \quad t > TB(\vartheta) \\ 0 & if \quad t \le TB(\vartheta) \end{cases}.$$

The test allows no break under the null hypothesis while the alternative hypothesis assumes that Z_t can be a trend stationary process with one break in the trend that occurs at any point in time. The goal of this test is to find the break points that mostly support the alternative hypothesis. The time of the break is identified if β coefficient is statistically significant. This occurs at a point where the t-statistics from the ADF unit root test is at minimum, that is, break date is selected at a point where strongest evidence are found to reject the null hypothesis.

Some variables show more than one structural breaks. In this case, the application of Zivot Andrews unit root test is not appropriate. Clemente-Montanes-Reyes [23] extend the methodology of Perron and Vogelsang [94] to test the two structural breaks in the mean of the series. The null and alternative hypotheses of Clemente-Montanes-Reyes (CMR) unit root test are following:

$$H_0\text{: } Z_t = Z_{t-1} + \gamma_1 DTB_{1t} + \gamma_2 DTB_{2t} + \varepsilon_t \quad (19)$$

$$H_1\text{: } Z_t = \nu + d_1 DU_{1t} + d_2 DU_{2t} + \mu_t \quad (20)$$

In the null hypothesis DTB_{it} (pulse variable)=1 if $t = TB_i + 1$ and zero otherwise. Further, $DU_{it}=1$ if $t > TB_i$ and zero otherwise. TB_i represents the time period when mean is being modified. For simplicity, assume that $TB_i = \lambda_i T (i = 1, 2)$ where $0 < \lambda_i < 1$ and $\lambda_2 > \lambda_1$ [23].

If two breaks are better described by innovational outlier (IO), the unit root hypothesis is tested by estimating following model:

$$Z_t = \nu + \rho Z_{t-1} + \gamma_1 DTB_{1t} + \gamma_2 DTB_{2t} + d_1 DU_{1t} + d_2 DU_{2t} + \sum_{i=1}^{m} c_j \Delta Z_{t-i} + e_t \quad (21)$$

From this estimation, the minimum value of the simulated t-statistics is obtained and this value can be used for testing if the autoregressive parameter is one for all break point combinations. If time breaks are better described by additive outliers (AO) the null hypothesis can be tested through a two steps procedure. In the first step, the deterministic part of the variable is eliminated by estimating the following model:

$$Z_t = \nu + d_1 DU_{1t} + d_2 DU_{2t} + \bar{Z} \quad (22)$$

In the second step, the minimal t-ratio is estimated by testing the hypothesis that $\rho = 1$ in the following model:

$$\bar{Z}_t = \sum_{1=0}^{m}\omega_{1i} DTB_{i=t-1} + \sum_{1=0}^{m}\omega_{2i} DTB_{i=t-2} + \rho\bar{Z}_{t-1} + \sum_{i=1}^{m} c_i \Delta\bar{Z}_{t-i} + \mu_t \quad (23)$$

The dummy variable DTB_{it} is included in the model to make sure that minimum $t_{\hat{\rho}}^{AO}(\lambda_1, \lambda_2)$converges to the distribution.

5.2. The ARDL bound testing approach to cointegration

This study employed the autoregressive distributed lag (ARDL) approach to cointegration developed by Pesaran et al. [90,91,95] to examine the long-run association between financial stability, economic growth, energy consumption, population density and environmental degradation. This technique has certain advantages. This technique can be applicable to examine long-run relationship either the variables are integrated of order I(0), I(1) or I(0)/I(1). Second, estimation of ARDL with appropriate lags can correct both serial correlation and endogeneity problem. Third, in ARDL approach both long-run and short-run coefficients are estimated simultaneously. Fourth, this approach performs better than Engle Granger or Johansen cointegration technique in small sample size. Therefore, this approach is considered to be very suitable for estimating the underlying relationship. An ARDL representation of selected variables can be described as follows:

$$\Delta \ln CO_t = \lambda_0 + \lambda_1 \ln CO_{t-1} + \lambda_2 AFSI_{t-1} + \lambda_3 \ln YP_{t-1} + \lambda_4 \ln EC_{t-1} + \lambda_5 \ln PD_{t-1} + \sum_{i=1}^{k}\theta_1 \Delta \ln CO_{t-i} + \sum_{i=0}^{k}\theta_2 \Delta AFSI_{t-i} + \sum_{i=0}^{k}\theta_3 \Delta \ln YP_{t-i} + \sum_{i=0}^{k}\theta_4 \Delta \ln EC_{t-i} + \sum_{i=0}^{k}\theta_5 \Delta \ln PD_{t-i} + e_t \quad (24)$$

where Δ is first difference operator; long-run coefficients are determined by λ_s and short-run coefficients are indicated by θ_s and e_t is error term.

The joint null hypothesis of no co-integration relationship is

$$H_0\text{: } \lambda_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0 \quad (25)$$

Alternative hypothesis of the existence of co-integration relationship is

$$H_1\text{: } \lambda_0 \ne \lambda_1 \ne \lambda_2 \ne \lambda_3 \ne \lambda_4 \ne \lambda_5 \ne 0 \quad (26)$$

The ARDL procedure starts with conducting the bounds test for the null hypothesis of no co integration. Pesaran et al. [91] has developed two sets of critical bonds called lower critical bound and upper critical bound for the co-integrating relationship. The lower critical bound assumes that all variables are I(0) and the upper critical bound assumes that all variables are I(1). The calculated F-statistic will be compared with the critical values tabulated by Pesaran et al. [91]. If calculated F-statistic exceeds the upper critical bound the null hypothesis of no cointegration may be rejected regardless of whether the order of integration of the variables are I(0) or I(1). Similarly, if calculated F-statistics fall below the lower critical value, the null hypothesis will not be rejected. If calculated F-statistic fall between lower and upper bounds, the results will be inconclusive. When the long run relationship is established among the variables then there is an error correction representation. The error correction model of the series is specified as follows:

$$\Delta \ln CO = \alpha_0 + \sum_{i=1}^{k} \gamma_i \Delta \ln CO_{t-i} + \sum_{i=0}^{m} \delta_i \Delta AFSI_{t-i} + \sum_{i=0}^{m} \eta_i \Delta YP_{t-i} + \sum_{i=0}^{m} \phi_i \Delta EC_{t-i} + \sum_{i=0}^{m} \varphi_i \Delta PD_{t-i} + \zeta EC_{t-1} + u_t \quad (27)$$

The coefficient of lagged error correction term ζ is expected to be negative and statistically significance for further confirmation of co-integration relationship. The goodness of the fit of the selected ARDL model will be examined by applying serial correlation, functional form, normality and heteroscedasticity tests.

5.3. Causality analysis

Causality is tested by applying Toda and Yamamoto (TY) causality technique [117]. This technique has improvement over traditional Granger Causality technique in that TY statistics follows a standard asymptotic distribution [112]. Further, this technique does not depend on the integration and cointegration properties of the system. In this technique, vector auto-regression, (VAR)($m+d_{max}$, where m is the lag-length and d_{max} is the maximum order of integration that occurs in the model) was estimated to use the Modified Wald (MWALD) test by applying linear restriction on the parameters of VAR(m).

To exemplify, we consider the hypothesis that there is a relationship between CO_2 emissions, economic growth, financial stability, energy consumption and population relationship. Following four-equation VAR model is used for empirical estimation:

$$\begin{bmatrix} \Delta \ln CO_t \\ \Delta AFSI_t \\ \Delta \ln YP_t \\ \Delta \ln EC_t \\ \Delta \ln PD_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \\ a_{40} \\ \alpha_{50} \end{bmatrix} + \begin{bmatrix} a_{11}(l) & a_{12}(l) & a_{13}(l) & a_{14}(l) & a_{15}(l) \\ a_{21}(l) & a_{22}(l) & a_{23}(l) & a_{24}(l) & a_{25}(l) \\ a_{31}(l) & a_{32}(l) & a_{33}(l) & a_{34}(l) & a_{35}(l) \\ a_{41}(l) & a_{42}(l) & a_{43}(l) & a_{44}(l) & a_{45}(l) \\ \alpha_{51}(l) & a_{52}(l) & a_{53}(l) & a_{54}(l) & a_{55}(l) \end{bmatrix} \times \begin{bmatrix} \Delta \ln CO_{t-m} \\ \Delta AFSI_{t-m} \\ \Delta \ln YP_{t-m} \\ \Delta \ln EC_{t-m} \\ \Delta \ln PD_{t-m} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \\ \mu_{5t} \end{bmatrix} \quad (28)$$

where Δ is the first difference operator; m is the optimal number of lag; parameters a_{i0} representing intercept terms; $a_{ij}(l)$ are the polynomials in the lag operator l and u_{it} are white noise error terms.

In TY causality test, optimal lag length is selected by minimizing the value of the Schwartz Bayesian Criterion (SBC) criterion. Suppose we take a VAR model with a lag length of two and estimate Eq. (28), a particular variable does not Granger-cause Z if and only if all the coefficients of $a_{ij}(l)$ are equal to zero. In the reverse case, Z does not Granger- cause the variable if and only if all the coefficients of $a_{ji}(l)$ are equal to zero. Therefore, in a five equation model, the hypotheses can be tested as:

$$H_0: a_{1j}(1) = a_{1j}(2) = 0$$
$$H_1: a_{j1}(1) = a_{j1}(2) = 0$$

where $a_{1j}(i)$ are the coefficients of the given variables in the first equation and $a_{j1}(i)$ are the coefficients of Z in the jth equation in the VAR model of Eq. (2).

6. Empirical findings and their interpretations

A preliminary step before conducting cointegration is to check the integrated properties of the variables in question. The study has applied two types of unit root test: traditional unit root tests (ADF, PP, DF-GLS and KPSS) and structural break unit root tests (ZA and CMR). The results of ADF, PP, DF-GLS and KPSS at level and first difference are presented in Appendix (Table A3 to A6). The results of both these tests indicate that the variables are level non stationary and difference stationary in all five countries. Thus, we conclude that our selected variables $AFSI_t$,[2] $\ln CO_t$, $\ln YP_t$, $\ln YP_t^2$, $\ln EC_t$ and $\ln PD_t$ are integrated of order one, i.e. I(1).

In modern econometric literature, along with conventional unit root tests, structural breaks unit root tests are also applied. The period covered in the current study is 1980–2012. There is a possibility that series may suffer from endogenous structural breaks since they consist of annual figures of more than thirty years. Therefore, we employ the Zivot Andrews (ZA) and Clemente-Montanes-Reyes (CMR) unit root tests. The ZA test results reported in Appendix (Table A7) show that most of the variables are stationary at first difference except for the $\ln CO_t$ in Bangladesh and $AFSI_t$ in Nepal which are stationary at level. CMR test results with AO model and IO model are presented in Appendix (Tables A8 and A9). The results reveal that all variables are first stationary at difference except for the $AFSI_t$ of Pakistan which is stationary at level in AO model.

The bound *F*-test results are presented in Table 4. Schwarz Bayesian Criterion (SBC) is used to select the optimal lag order of the ARDL models. Estimated results show that with $\ln CO_t$ as the dependent variable, the computed F-statistics exceeds the upper critical bound of 1% in all countries. As a result, we reject the null hypothesis of no cointegration between variables and conclude that a long-run relationship exist between $AFSI_t$, $\ln CO_t$, $\ln YP_t$, $\ln EC_t$ and $\ln PD_t$ in South Asian countries.

Several Diagnostic tests such as Breusch- Godfrey serial correlation LM test, Jacque-Bera normality test, White heteroscedasticity test and Ramsey RESET specification test are applied to check the stability of the ARDL model. All these tests reveal that the model has a correct functional form, residuals are serially uncorrelated, normally distributed and homoscedastic in selected South Asian countries.

Once the bound testing approach confirms the existence of cointegration between carbon emissions and its covariates in all countries, the long-run and short-run coefficients may be estimated. Table 5 describes the result of long-run coefficients of ARDL model. The coefficient of financial stability index is negative and significant in all countries. For example, a 1% increase in financial stability ceteris paribus, will decrease CO_2 emissions by 16.3% in Pakistan, 8.2% in India, 5.4% in Bangladesh, 1.3% in Nepal and 18.8% in Sri Lanka. The effect of economic growth on carbon emissions is found to be positive in all countries except Nepal where increase in economic growth will improve environmental quality. The finding of a positive impact of economic growth on CO_2 emissions is in line with the work of Jalil and Mahmud [59], Islam and

[2] The AFSI calculated by variance equal weighting method is used for empirical analysis. The same results are obtained by using AFSI calculated by PCA method. The results will be available on request.

Table 4
ARDL bounds test results for cointegration.

Estimated equation $\ln CO_t = F(AFSI_t, \ln YP_t, \ln EC_t, \ln PD_t)$					
	Pakistan	**India**	**Bangladesh**	**Nepal**	**Sri Lanka**
Optimal Lag Order	(3,1,3,3,4)	(3,3,2,1,2)	(4,1,1,2,1)	(2,1,2,1,3)	(4,1,1,3,2)
F-Statistics (Wald Test)	7.176*	8.728*	11.098*	4.965*	7.802*
Significance Level		**Lower Bounds, I(0)**		**Upper Bounds, (1)**	
1%		3.29		4.37	
5%		2.56		3.49	
10%		2.20		3.09	
Diagnostics tests					
R^2	0.916	0.869	0.873	0.825	0.836
Adj. R^2	0.765	0.709	0.764	0.684	0.697
F-statistics	6.061 (0.003)	5.414 (0.002)	7.968 (0.000)	3.581 (0.042)	4.441 (0.005)
Durbin Watson Test	2.358	2.003	2.210	2.082	2.218
J-B Normality Test	1.421 (0.491)	2.604 (0.272)	0.484 (0.784)	0.699 (0.705)	1.146 (0.563)
Ramsey RESET	1.070 (0.312)	0.821 (0.427)	1.436 (0.250)	0.202 (0.842)	0.051 (0.959)
Breusch–Godfrey LM Test	1.300 (0.324)	(0.589) (0.571)	0.771 (0.482)	0.766 (0.482)	0.496 (0.621)
White Heteroscedasticity Test	1.639 (0.214)	0.430 (0.943)	1.284 (0.318)	0.790 (0.655)	0.606 (0.824)

* Represent significance at 1% level. Values in parentheses () are P-values.

Table 5
Estimated long-run coefficients for the ARDL model (Dependent Variable: $\ln CO_t$).

Country	Variable	$AFSI_t$	$\ln YP_t$	$\ln YP_t^2$	$\ln EC_t$	$\ln PD_t$	Constant	Turning point (log)
Pakistan	Coefficient	−0.163	0.168	–	2.070	0.106	−15.025	5.86
	P-value	0.021	0.076	–	0.010	0.844	0.020	
	Coefficient	−0.103	0.297	−0.011	1.892	0.053	−13.674	
	P-value	0.003	0.059	0.046	0.000	0.751	0.001	
India	Coefficient	−0.082	0.061	–	1.243	2.503	−13.875	6.67
	P-value	0.038	0.035	–	0.006	0.000	0.000	
	Coefficient	−0.084	0.707	−0.023	1.002	0.046	−10.712	
	P-value	0.041	0.043	0.024	0.005	0.783	0.006	
Bangladesh	Coefficient	−0.054	0.172	–	0.922	1.749	−14.116	6.24
	P-value	0.013	0.007	–	0.000	0.019	0.000	
	Coefficient	−0.066	1.696	−0.059	1.127	0.706	−17.660	
	P-value	0.034	0.055	0.082	0.000	0.016	0.000	
Nepal	Coefficient	−0.034	−0.129	–	0.335	0.226	15.778	6.38
	P-value	0.013	0.014	–	0.095	0.015	0.035	
	Coefficient	0.040	−3.204	0.109	0.012	0.499	6.837	
	P-value	0.067	0.040	0.042	0.982	0.034	0.276	
Sri Lanka	Coefficient	−1.878	0.216	–	1.140	2.116	−9.027	5.83
	P-value	0.014	0.097	–	0.081	0.018	0.025	
	Coefficient	−0.223	1.773	−0.066	1.007	3.548	−5.108	
	P-value	0.020	0.003	0.002	0.072	0.021	0.041	

Shahbaz [53] and Shahbaz [103]. Moving on energy consumption, the result indicates a positive and significant impact of energy consumption on environmental degradation in all South Asian countries. Our empirical evidence supports the commonly held view that energy consumption is the main source of environmental pollution. This result is a confirmation of empirical evidence found by other studies, for example, Khan and Qayyum [66], Jalil and Mahmud [59], Halicioglu [45] and Hossain [52]. With respect to population density, result indicates that increasing population density has a positive and significant impact on carbon emissions, suggesting that more inhabitants per square kilometer leads to more environmental degradation in the long run [73].

The results of non-linear relationship between economic growth and environmental degradation are also reported in Table 5. The evidence shows that the coefficient of economic growth ($\ln YP_t$) and squared of economic growth ($\ln YP_t^2$) in the regression for Pakistan, India, Bangladesh and Sri Lanka are positive and negative respectively; and all are statistically significant. The positive-negative coefficient pattern in these four countries suggests an inverted U-shaped path between economic growth and environmental degradation. The estimated turning point (measured in logarithms) at which CO_2 emissions start to decline are 5.86, 6.67, 6.24 and 5.83 for Pakistan, India, Bangladesh and Sri Lanka respectively. The predicted level of per capita income where the turning points occur in these countries are lie within the sample size minimum and maximum income values (see Table A1 for descriptive analysis). Given these findings we conclude that the conventional EKC hypothesis hold for Pakistan, India, Bangladesh and Sri Lanka over the study period.

In the case of Nepal, the coefficient of $\ln YP_t$ is negative and $\ln YP_t^2$ is positive and each coefficient is statistically significant. The negative-positive coefficient pattern suggests a U-shaped pattern between CO_2 emissions and per capita income for Nepal. As can be seen from Table 5, Nepal's U-shaped curve has the turning point at per capita income of 6.38 (in logarithms). The estimated turning point is lying between minimum value (5.26) and maximum value (6.62) of income per capita. Given this finding, we conclude that the U-shaped EKC exists for Nepal over the sample period.

The results of short-run error correction estimates are presented in Table 6. The significant and smaller than unity lagged error correction term (EC_{t-1}) shows the existence of long-run causality between CO_2 emissions and financial stability, economic growth, energy consumption and population density. These estimates provide further support to the existence of long-run relationship among variables estimated by bound testing procedure. More importantly the negative sign of error correction term indicate that 59%, 77%, 78%, 52% and 48% long-run disequilibrium in CO_2 emissions will be corrected in the each short-run period in Pakistan, India, Bangladesh, Nepal and Sri Lanka respectively. The value of R^2, which measures the overall goodness of the fit of model, is well defined in all countries.

Table 7 presents the result of Toda Yamamoto casualty analysis. The empirical findings reveal that a unidirectional causality running from financial stability to CO_2 emissions exists in the case of Pakistan and Sri Lanka. It implies that during the periods of financial disturbances, the firms do not care much about environment and increase their output in order to raise profits at any environmental cost. The neutrality hypothesis are reported in the case of India, Bangladesh and Nepal. The result also shows unidirectional causality running from income to CO_2 emissions in the case of Pakistan, India, Nepal and Sri Lanka and feedback causality between income and CO_2 emissions in Bangladesh. The evidence of bidirectional causality between energy consumption and CO_2 emissions is found in India, Bangladesh and Sri Lanka. A unidirectional causality running from population density to CO_2 emissions is derived in Pakistan, India and Bangladesh while feedback relation between population density and CO_2 emissions is observed in Sri Lanka.

Parameter stability is necessary to ensure reliability of policy simulations based on the empirical findings over the sample period. To test for parameter stability, we applied the CUSUM and

Table 6
Estimated short-run coefficients for the ARDL model (Dependent Variable: $\Delta \ln CO_t$).

Variable	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
	Pakistan		India		Bangladesh	
$\Delta \ln CO_{t-1}$	0.518	0.080	0.455	0.081	0.036	0.921
$\Delta \ln CO_{t-2}$	0.094	0.764	0.047	0.835	0.059	0.838
$\Delta \ln CO_{t-3}$	–	–	–	–	−0.071	0.727
$\Delta AFSI_t$	−0.018	0.498	−0.003	0.897	0.023	0.683
$\Delta AFSI_{t-1}$	–	–	−0.016	0.544	–	–
$\Delta AFSI_{t-2}$	–	–	−0.007	0.783	–	–
$\Delta \ln YP_t$	0.234	0.061	−0.131	0.102	−0.079	0.789
$\Delta \ln YP_{t-1}$	0.379	0.010	0.028	0.653	–	–
$\Delta \ln YP_{t-2}$	0.126	0.338	–	–	–	–
$\Delta \ln EC_t$	0.200	0.543	1.255	0.002	0.774	0.130
$\Delta \ln EC_{t-1}$	0.192	0.642	–	–	0.300	0.634
$\Delta \ln EC_{t-2}$	0.896	0.037	–	–	–	–
$\Delta \ln PD_t$	0.076	0.031	3.109	0.184	0.375	0.865
$\Delta \ln PD_{t-1}$	0.073	0.098	4.637	0.336	–	–
$\Delta \ln PD_{t-2}$	0.024	0.490	–	–	–	–
$\Delta \ln PD_{t-2}$	0.007	0.814	–	–	–	–
ET_{t-1}	−0.589	0.034	−0.774	0.022	−0.784	0.064
Constant	−0.048	0.118	−0.045	0.276	0.047	0.460
Diagnostics tests						
R^2	0.782		0.561		0.506	
Adj. R^2	0.565		0.293		0.272	
Durbin Watson Test	1.872		2.071		2.005	

Variable	Coefficient	P-value	Coefficient	P-value
	Nepal		Sri Lanka	
$\Delta \ln CO_{t-1}$	0.025	0.906	−0.044	0.849
$\Delta \ln CO_{t-2}$	–	–	0.330	0.140
$\Delta \ln CO_{t-3}$	–	–	0.039	0.858
$\Delta AFSI_t$	0.017	0.872	−0.164	0.049
$\Delta \ln YP_t$	2.818	0.646	−0.215	0.489
$\Delta \ln YP_{t-1}$	−0.201	0.730	0.214	0.504
$\Delta \ln YP_{t-2}$	−0.286	0.591	–	–
$\Delta \ln EC_t$	4.664	0.097	1.364	0.032
$\Delta \ln PD_t$	0.009	0.969	0.922	0.803
$\Delta \ln PD_{t-1}$	0.200	0.439	1.046	0.767
$\Delta \ln PD_{t-2}$	0.222	0.304	–	–
ET_{t-1}	−0.522	0.027	−0.481	0.062
Constant	0.072	0.201	0.099	0.866
Diagnostics tests				
R^2	0.608		0.644	
Adj. R^2	0.395		0.431	
Durbin Watson Test	2.004		1.894	

Table 7
Toda and Yamamoto causality tests results.

Null Hypothesis	Chi-Sq. test Pakistan	P-value	Inference	Chi-Sq. test India	P-value	Inference	Chi-Sq. test Bangladesh	P-value	Inference
$AFSI_t \rightarrow \ln CO_t$	11.069	0.025	Yes	5.536	0.562	No	6.775	0.245	No
$\ln CO_t \rightarrow AFSI_t$	3.833	0.429	No	4.300	0.230	No	0.647	0.957	No
$\ln YP_t \rightarrow \ln CO_t$	10.427	0.036	Yes	30.839	0.000	Yes	82.180	0.000	Yes
$\ln CO_t \rightarrow \ln YP_t$	1.169	0.881	No	2.655	0.447	No	51.491	0.000	Yes
$\ln EC_t \rightarrow \ln CO_t$	7.593	0.107	No	14.277	0.002	Yes	21.008	0.000	Yes
$\ln CO_t \rightarrow \ln EC_t$	7.340	0.118	No	19.605	0.000	Yes	16.856	0.002	Yes
$\ln PD_t \rightarrow \ln CO_t$	1.305	0.860	Yes	23.715	0.000	Yes	23.491	0.000	Yes
$\ln CO_t \rightarrow \ln PD_t$	19.741	0.000	No	4.115	0.249	No	1.856	0.760	No
Null Hypothesis	**Nepal**			**Sri Lanka**					
$AFSI_t \rightarrow \ln CO_t$	7.174	0.127	No	16.976	0.002	Yes			
$\ln CO_t \rightarrow AFSI_t$	4.717	0.317	No	7.110	0.118	No			
$\ln YP_t \rightarrow \ln CO_t$	9.452	0.078	Yes	38.387	0.000	Yes			
$\ln CO_t \rightarrow \ln YP_t$	5.308	0.257	No	4.369	0.358	No			
$\ln EC_t \rightarrow \ln CO_t$	0.941	0.918	No	35.496	0.000	Yes			
$\ln CO_t \rightarrow \ln EC_t$	0.867	0.929	No	54.119	0.000	Yes			
$\ln PD_t \rightarrow \ln CO_t$	4.828	0.305	No	35.364	0.000	Yes			
$\ln CO_t \rightarrow \ln PD_t$	6.600	0.158	No	68.301	0.000	Yes			

CUSUMSQ test statistics to the recursive residuals of the models. Plots of the CUSUM and CUSUMSQ test statistics reveal no evidence of parameter instability in the selected model at 5% critical bounds. Stability of the estimated parameters suggests that the models can be considered stable enough for policy analysis.

6.1. *Results on the relationship between economic growth, financial stability and environmental quality*

Following Shahbaz [103] and Omri et al. [80], an important relationship exists between financial stability, economic growth and environmental quality. For this purpose following model was formulated:[3]

$$\ln YP_t = \gamma_0 + \gamma_1 CO_t + \gamma_2 \ln AFSI_t + \gamma_3 \ln EC_t + \gamma_4 \ln PD_t + \varepsilon_t \quad (29)$$

Results of long-run coefficients estimated by applying ARDL approach are presented in Table 8.[4] Empirical results show that CO_2 emissions have negative and significant impact on economic growth for Pakistan, India and Sri Lanka. This finding explains that economic growth is elastic with respect to CO_2 emissions, and a 1% increase in CO2 emissions decreases economic growth within a range of 6.705% (India) to 1.586% (Sri Lanka). Insignificant relationship exists in the case of Bangladesh and Nepal. This result supports the findings of Jayanthakumaran et al. [56] and Omri et al. [80].

The coefficient of financial stability is found to be positive and significant in all selected South Asian countries. This explains that an appropriate level of financial stability is essential for the sustainable level of economic growth because the underdeveloped or overdeveloped financial systems both are not conducive to economic growth. An underdeveloped financial system is usually associated with financial instability while an overdeveloped financial system may have a crowding-out effect on real economy by attracting too much resources. In other words, both of these financial systems are harmful for economic growth [57].

In addition, the effect of energy consumption on economic growth is found to be positive and significant in Pakistan, India and Sri Lanka. The coefficient of energy consumption is found to be insignificant in the case of Bangladesh and Nepal. This result is in line with the findings of Apergis et al. [13], Anees et al. [7] and Omri et al. [80]. Finally the coefficient of population density is positive in all countries but statistically significant only in Pakistan, India and Bangladesh. The results of short-run error correction model are presented in Appendix Table A10.

Table 8
Estimated long-run coefficients for the ARDL model (Dependent Variable: $\ln YPC_t$).

Country	Variable	$AFSI_t$	$\ln CO_t$	$\ln EC_t$	$\ln PD_t$	Constant
Pakistan	Coefficient	1.212	−3.103	3.640	1.266	22.82
	P-value	0.010	0.011	0.046	0.048	0.042
India	Coefficient	0.039	−6.705	9.064	5.229	18.27
	P-value	0.084	0.018	0.003	0.097	0.013
Bangladesh	Coefficient	0.425	−0.384	−2.142	1.425	7.690
	P-value	0.010	0.803	0.121	0.098	0.713
Nepal	Coefficient	0.212	0.040	1.063	0.688	2.954
	P-value	0.019	0.813	0.750	0.265	0.871
Sri Lanka	Coefficient	2.254	−1.586	4.035	1.336	16.49
	P-value	0.001	0.008	0.012	0.378	0.000

The study also examines the impact of financial stability and environmental quality on economic growth by incorporating two important factors of production labor (L)[5] and capital (K)[6] by affectively exploring the benefit of these two interactions into growth process.

$$\ln YP_t = \gamma_0 + \gamma_1 CO_t + \gamma_2 \ln AFSI_t + \gamma_3 \ln EC_t + \gamma_4 L_t + \gamma_4 K_t + \varepsilon_t \quad (30)$$

Results of long-run coefficients estimated by applying ARDL approach are presented in Table 9. The results show that capital and labor both are positively correlated with economic growth. These results are consistent with classical theory. The results further explain the positive impact of financial stability and energy consumption on economic growth while negative impact of CO2 emissions on growth process. The results of short-run error correction model are reported in Appendix Table A11.

[3] Detail of all these variables and methodology is described in Section 5.
[4] Results of bound *F*-test and can be provided upon request.
[5] Population growth (annual % growth) a proxy for labor force
[6] Gross capital formation (% of GDP) a proxy for capital.

Table 9
Estimated long-run coefficients for the ARDL model (Dependent Variable: ln YPC_t).

Country	Variable	$AFSI_t$	ln CO_t	ln EC_t	L_t	K_t	Constant
Pakistan	Coefficient	0.638	−4.584	6.345	0.121	0.037	6.760
	P-value	0.047	0.002	0.036	0.683	0.059	0.022
India	Coefficient	0.206	−1.131	2.501	−0.429	0.039	9.115
	P-value	0.025	0.097	0.092	0.557	0.013	0.324
Bangladesh	Coefficient	0.094	−0.325	1.720	0.049	0.037	1.327
	P-value	0.006	0.042	0.000	0.536	0.000	0.502
Nepal	Coefficient	0.025	−0.217	0.786	0.035	0.247	1.203
	P-value	0.174	0.000	0.132	0.000	0.000	0.697
Sri Lanka	Coefficient	0.023	−4.436	0.336	2.718	0.272	2.574
	P-value	0.005	0.000	0.009	0.000	0.007	0.432

7. Conclusion and policy implications

The objective of this study was to examine the association between financial stability, energy consumption and environmental degradation in South Asian countries using annual data over the period 1980–2012. Although a few studies examined the relationship between financial instability and environmental degradation, there is no study that has investigated this relationship in the case of South Asian countries. Empirical analysis is carried out by applying ARDL bound testing approach to cointegration.

The bounds *F*-test confirmed cointegration relationships between financial stability, economic growth, energy consumption, population density and CO_2 emissions in all the selected countries. The significance and signs of variables in the cointegration vector space are according to economic theory. Our result shows negative and statistically significant relationship between financial stability and environmental degradation in all countries, providing evidence that sound and stable financial sector is vital for improving environmental quality in South Asian economies over long-run. The coefficients of income growth, energy consumption and population density are statistically significant in all selected countries, indicating that income growth, energy consumption and population density are main factors in deteriorating environmental quality in South Asia. Our result also indicates that the signs of estimated long run coefficients of income and squared income satisfy the inverted U-shaped EKC in four countries: Pakistan, India, Bangladesh and Sri Lanka. In Nepal, the long run relationship between economic growth and CO_2 emissions follows a U-shaped path while the estimated turning point is within the sample data size. The results further explain that financial stability, CO_2 emissions, labor and capital are important determinants of economic growth. Causality analysis indicates unidirectional causality running from financial stability to CO_2 emissions in Pakistan and Sri Lanka and bidirectional causality between energy consumption and CO_2 emissions in India, Bangladesh and Sri Lanka.

According to the results obtained from this study, the following policy implications are suggested to policy decision makers. First, to strengthen the relationship between financial stability and environmental quality, there is a need to improve financial sector reforms especially, in the issuing of funds for productive purpose. Financial sector has the right to punish those firms that release more wastage in the air and water by restricting their access to easy credit. Second, an integrated energy policy that increases energy efficiency and lower energy consumption should be announced and applied by these countries for reducing the negative effects of environmental degradation. Third, population density is one of several major components affecting environmental quality. Well planned, properly managed and density settled towns and cities can help to reduce environmental deterioration. Finally, a wide range of policy initiatives that would induce increased demand for better environmental quality and its sustainability should be explored.

Appendix

See Table A1–A11.

Table A2
Summary statistics.

Variable	$AFSI_t$	ln CO_t	ln YP_t	ln EC_t	ln PD_t
Pakistan					
Mean	0.058	−0.397	6.225	8.023	5.129
Std. Dev.	0.198	0.271	0.426	0.147	0.310
Min.	−0.233	−0.914	5.690	5.735	4.642
Max.	0.623	0.021	7.136	6.233	6.206
India					
Mean	−0.016	−0.042	6.181	6.017	5.748
Std. Dev.	0.401	0.360	0.539	0.214	0.204
Min.	−0.723	−0.695	5.603	5.681	5.112
Max.	0.770	0.510	7.335	6.419	6.036
Bangladesh					
Mean	0.001	−1.685	5.807	4.913	6.854
Std. Dev.	0.375	0.462	0.369	0.233	0.269
Min.	−0.580	−2.384	5.258	4.616	6.451
Max.	1.002	−0.927	6.622	5.357	7.900
Nepal					
Mean	−0.0004	−2.539	5.507	5.821	4.965
Std. Dev.	0.495	0.540	0.443	0.067	0.210
Min.	−1.214	−3.524	4.907	5.751	4.611
Max.	1.048	−1.923	6.557	5.969	5.279
Sri Lanka					
Mean	−0.0002	−0.979	6.625	5.934	5.657
Std. Dev.	0.354	0.419	0.677	0.169	0.105
Min.	−0.663	−1.600	5.609	5.728	5.460
Max.	0.766	−0.461	7.980	6.247	5.819

Table A1
Coefficients of correlation between indices calculated by VEW and PCA.

	Pakistan		**India**		**Bangladesh**	
	AFSI_VEW	AFSI_PCA	AFSI_VEW	AFSI_PCA	AFSI_VEW	AFSI_PCA
AFSI_VEW	1.000	–	1.000	–	1.000	1.000
AFSI_PCA	0.912	1.000	0.962	1.000	0.895	–
	Sri Lanka		**Nepal**			
AFSI_VEW	1.000	–	1.000	1.000		
AFSI_PCA	0.820	1.000	0.859	–		

Table A3
ADF unit root test results.

variable	η_i **Pakistan**	η_t	η_i **India**	η_t	η_i **Bangladesh**	η_t	η_i **Nepal**	η_t	η_i **Sri Lanka**	η_t
At level										
$AFSI_t$	−1.472	−1.321	−0.963	−2.707	0.507	−0.705	−1.716	−2.565	−1.755	−2.749
$\ln CO_t$	−1.312	−2.403	−1.208	−2.279	0.138	−2.363	−1.669	−1.543	−0.346	−2.900
$\ln YP_t$	1.422	−1.175	0.900	−0.943	1.707	−0.103	2.480	0.579	1.191	−1.082
$\ln YP_t^2$	−1.836	0.125	1.156	−0.653	1.836	0.125	2.755	0.875	1.511	−0.655
$\ln EC_t$	−1.076	−1.270	−0.379	−3.178	2.458	−1.418	1.546	−1.132	0.735	−1.843
$\ln PD_t$	−0.735	−2.067	−0.087	−1.945	0.544	−2.996	−0.116	−2.880	−1.485	−1.665
At 1st difference										
$\Delta AFSI_t$	−3.640**	−3.685**	−4.196*	−4.096**	−3.902*	−4.057**	−3.589**	−6.535*	−3.916*	4.095**
$\Delta \ln CO_t$	−3.287**	−4.062**	−3.759*	−3.857**	−5.410*	−5.335*	−4.947*	−5.068*	−3.096**	−5.929*
$\Delta \ln YP_t$	−3.839*	−4.874*	−4.963*	−5.662*	−4.746*	−5.139*	−3.142**	−4.259**	−4.608*	−5.107*
$\Delta \ln YP_t^2$	−4.314*	−4.777*	−4.579*	−3.475**	−4.314*	−4.777*	−3.071**	−4.304*	−4.252*	−5.064*
$\Delta \ln EC_t$	−3.567**	−3.926**	−3.929*	−4.015**	−4.338*	−5.668*	−3.437**	−4.298**	−4.944*	−5.195*
$\Delta \ln PD_t$	−4.923*	−4.907*	−5.693*	−5.833*	−3.973*	−4.911*	−3.183**	−5.903*	−3.780*	−3.938**

Note: η_i represent intercept and η_t represent intercept and trend. The critical values for intercept and intercept and trend at 5% are −2.963 and −3.568 and at 1% are −3.679 and −4.309, respectively. ** and * denote significance at 5% and 1% level respectively.

Table A4
PP unit root test results.

variable	η_i **Pakistan**	η_t	η_i **India**	η_t	η_i **Bangladesh**	η_t	η_i **Nepal**	η_t	η_i **Sri Lanka**	η_t
At level										
$AFSI_t$	−3.960*	−3.996**	−1.844	−3.674**	−0.775	−2.215	−1.665	−2.550	−2.140	−2.333
$\ln CO_t$	−1.499	−2.699	−1.399	−2.012	0.105	−5.520*	−1.046	−2.070	−0.275	−1.686
$\ln YP_t$	1.311	−0.821	1.690	−0.833	2.011	−1.044	2.783	0.078	1.647	0.565
$\ln YP_t^2$	2.361	−0.675	1.979	−0.642	2.361	−0.675	2.551	0.377	2.414	−0.084
$\ln EC_t$	−2.219	−1.464	0.191	−1.883	2.459	−1.811	1.872	−1.237	0.466	−1.853
$\ln PD_t$	−2.207	−5.122*	−2.277	−1.578	−2.807	−1.411	−2.462	−3.250	−1.990	−1.733
At 1st difference										
$\Delta AFSI_t$	−7.756*	−7.489*	−7.269*	−7.117*	−6.261*	−6.470*	−6.538*	−6.494*	−4.882*	−4.802*
$\Delta \ln CO_t$	−7.583*	−7.764*	−3.908*	−3.981**	−9.285*	−9.140*	−6.135*	−6.364*	−6.309*	−6.310*
$\Delta \ln YP_t$	−5.039*	−5.785*	−5.008*	−5.666*	−3.851*	−4.555*	−4.888*	−5.885*	−4.645*	−5.131*
$\Delta \ln YP_t^2$	−3.576**	−4.395*	−4.761*	−5.543*	−3.576**	−4.394*	−4.746*	−5.862*	−4.275*	−5.091*
$\Delta \ln EC_t$	−4.891*	−5.194*	−4.065*	−3.968**	−7.144*	−8.743*	−4.626*	−5.284*	−5.166*	−5.254*
$\Delta \ln PD_t$	−9.726*	−9.599*	−3.584**	−4.048**	−4.562*	−4.022**	−6.194*	−6.252*	−3.846*	−4.293*

Note: η_i represent intercept and η_t represent intercept and trend. The critical values for intercept and intercept and trend at 5% are −2.960 and −3.562 and at 1% are −3.661 and −4.284, respectively. ** and * denote significance at 5% and 1% level respectively.

Table A5
KPSS unit root test results.

variable	η_i **Pakistan**	η_t	η_i **India**	η_t	η_i **Bangladesh**	η_t	η_i **Nepal**	η_t	η_i **Sri Lanka**	η_t
At level										
$AFSI_t$	0.278	0.190**	1.015*	0.127	0.787*	0.177**	0.750*	0.104	0.459	0.220*
$\ln CO_t$	1.174*	0.238*	1.172*	0.226*	1.185*	0.074	1.043*	0.275*	1.075*	0.149**
$\ln YP_t$	1.079*	0.243*	1.048*	0.274*	1.108*	0.243*	1.035*	0.255*	1.156*	0.270*
$\ln YP_t^2$	1.095*	0.199**	1.030*	0.276*	1.096*	0.261*	1.021*	0.252*	1.139*	0.219*
$\ln EC_t$	1.155*	0.223*	1.161*	0.162**	1.162*	0.283*	1.103*	0.264*	1.149*	0.235*
$\ln PD_t$	1.039*	0.137	1.192*	0.302*	1.185*	0.296*	0.827	0.147**	1.177*	0.261*
At 1st difference										
$\Delta AFSI_t$	0.109	0.103	0.067	0.057	0.160	0.075	0.077	0.054	0.062	0.065
$\Delta \ln CO_t$	0.181	0.059	0.168	0.052	0.058	0.043	0.095	0.074	0.109	0.127
$\Delta \ln YP_t$	0.328	0.071	0.452	0.071	0.407	0.078	0.431	0.116	0.336	0.102
$\Delta \ln YP_t^2$	0.461	0.087	0.409	0.079	0.428	0.089	0.427	0.142	0.381	0.096
$\Delta \ln EC_t$	0.330	0.042	0.091	0.059	0.377	0.032	0.438	0.064	0.149	0.059
$\Delta \ln PD_t$	0.063	0.045	0.427	0.104	0.403	0.095	0.338	0.090	0.339	0.086

Note: η_i represent intercept and η_t represent intercept and trend. The critical values for intercept and intercept and trend at 5% are 0.463 and 0.146 and at 1% are 0.739 and 0.216, respectively. ** and * denote significance at 5% and 1% level respectively.

Table A6
DF-GLS unit root test results.

Variable	η_i Pakistan	η_t	η_i India	η_t	η_i Bangladesh	η_t	η_i Nepal	η_t	η_i Sri Lanka	η_t
At level										
$AFSI_t$	−1.330	−1.379	−0.339	−2.798	0.500	−1.362	−1.224	−2.664	−1.358	−2.586
$\ln CO_t$	0.550	−1.958	0.223	−2.060	0.596	−2.161	−0.747	−1.776	−0.122	−2.480
$\ln YP_t$	1.422	−1.175	−0.017	−1.359	0.435	−0.853	2.480	0.579	0.346	−1.658
$\ln YP_t^2$	0.364	−0.832	0.027	−1.262	0.364	−0.832	1.048	−1.029	0.339	−1.493
$\ln EC_t$	0.069	−1.586	−0.858	−2.466	0.756	−1.012	0.879	−1.111	0.909	−1.604
$\ln PD_t$	−0.544	−2.746	−1.019	−2.543	−1.033	−2.792	−0.942	−0.839	0.730	−1.225
At 1st difference										
$\Delta AFSI_t$	−2.518**	−4.938*	-4.298*	−3.536**	−3.603*	3.915*	−2.735*	−3.670**	−2.943*	−3.604**
$\Delta \ln CO_t$	−3.270*	−3.559**	−3.787*	−4.005*	−5.018*	−5.461*	−3.533*	−4.386*	−2.265**	−5.599*
$\Delta \ln YP_t$	−3.839*	−4.874*	−2.704*	−3.338**	−4.871*	−5.420*	−3.142**	−4.259**	−2.703**	−5.066*
$\Delta \ln YP_t^2$	−4.427*	−5.044*	−2.684*	−3.475**	−4.427*	−5.044*	−2.953*	−3.427**	−2.417**	−5.031*
$\Delta \ln EC_t$	−2.219**	−3.301**	−2.354**	−3.836**	−3.538*	−5.770*	−3.178*	−4.278**	−5.028*	−5.359*
$\Delta \ln PD_t$	−4.124*	−4.250*	−5.685*	−5.377*	−5.041*	−5.096*	−2.833*	−5.606*	−3.777*	−4.056*

Notes: η_i represent intercept and η_t represent intercept and trend. The critical values for intercept and intercept and trend at 5% are −1.952 and −3.190 and at 1% are −2.641 and −3.770, respectively. ** and * denote significance at 5% and 1% level respectively.

Table A7
Zivot Andrews unit root test results.

Variable	t-stat. Pakistan	B.D	t-stat. India	B.D	t-stat. Bangladesh	B.D	t-stat. Nepal	B.D	t-stat. Sri Lanka	B.D
At level										
$AFSI_t$	−2.874	1991	−5.094	1998	−4.452	2005	−6.658*	2003	−4.303	1991
$\ln CO_t$	−4.229	1997	−4.158	2000	−6.168*	1998	−4.381	2002	−2.780	1992
$\ln YP_t$	−3.735	2001	−3.452	2000	−3.380	2006	−5.015	2002	−3.881	2001
$\ln YP_t^2$	−3.735	2006	−3.688	2000	−3.735	2006	−5.019	2003	−4.063	2001
$\ln EC_t$	−2.803	2006	−4.877	2001	−4.887	1999	−3.496	1999	−4.086	1996
$\ln PD_t$	−3.966	1994	−3.266	1996	−4.902	1992	−4.263	1991	−3.473	2001
At 1st difference										
$\Delta AFSI_t$	−8.199*	2002	−7.710*	2001	−7.613*	1987	−7.618	2007	−5.103	2004
$\Delta \ln CO_t$	−8.358*	2004	−6.533*	2003	−8.401*	1987	−6.615*	1991	−8.112*	1990
$\Delta \ln YP_t$	−6.510*	2003	−5.169**	2007	−5.977*	1999	−6.894*	1992	−6.124*	2005
$\Delta \ln YP_t^2$	−5.767*	1999	−6.419*	2003	−5.767*	1999	−6.832*	1992	−6.275*	2005
$\Delta \ln EC_t$	−5.920*	2003	−5.009**	2007	−8.139*	2001	−5.874*	2002	−6.332*	2006
$\Delta \ln PD_t$	−7.055*	2001	−6.463*	1994	−6.065*	1993	−7.123*	1996	−6.333*	2000

Notes: B.D. represent break date. All t-statistics are estimated from a break in intercept and trend model. Critical values at 1% and 5% are −5.57and −5.08, respectively. ** and * denote significance at 5% and 1% level respectively.

Table A8
Clemente-Montanes-Reyes unit root test results.

At level (AO Model)										
Variable	t-stat. **Pakistan**	B.D	t-stat. **India**	B.D	t-stat. **Bangladesh**	B.D	t-stat. **Nepal**	B.D	t-stat. **Sri Lanka**	B.D
$AFSI_t$	−6.586*	1986 2003	−4.656	1998 2005	−2.825	1997 2003	−3.327	1991 2008	−4.086	1989 2001
$\ln CO_t$	−2.944	1991 2003	−2.190	1992 2005	−3.142	1991 2003	−4.091	1989 2008	−3.953	1992 1997
$\ln YP_t$	−3.990	1992 2004	−3.195	1989 2000	−2.750	1991 2005	−2.900	1996 2005	−2.781	1992 2004
$\ln YP_t^2$	−2.682	1991 2005	−3.096	1996 2004	−2.682	1991 2005	−2.771	1996 2005	−2.598	1992 2004
$\ln EC_t$	−3.590	1989 2000	−2.982	1992 2005	−2.431	1991 2002	−2.084	1996 2001	−4.948	1997 2001
$\ln PD_t$	−2.603	1989 1997	−4.702	1994 2006	−3.394	1993 2003	−3.702	1993 2002	−2.713	1992 2004
At 1st difference										
$\Delta AFSI_t$	−8.379*	2001 2007	−6.223*	1992 1998	−8.685*	1990 2003	−3.558	2001 2004	−4.959	1985 1989
$\Delta \ln CO_t$	−8.871*	1992 2002	−5.964*	1998 2005	−6.518*	1996 2004	−7.624*	1989 1996	−8.137*	1990 2001
$\Delta \ln YP_t$	−7.197*	2003 2006	−5.835**	1989 2000	−5.652*	1999 2004	−7.229*	1990 2003	−7.102*	1997 2003
$\Delta \ln YP_t^2$	−6.950*	1999 2004	−5.622**	1989 2000	−6.950*	1999 2004	−7.224*	1990 2003	−7.257*	2003 2006
$\Delta \ln EC_t$	−6.322*	2000 2005	−5.714**	2001 2006	−6.510*	1993 1999	−5.670**	1996 2004	−6.724*	1992 2003
$\Delta \ln PD_t$	−5.586**	1997 2000	−6.642*	2006 2009	−6.509*	2003 2006	−7.899*	1988 1994	−6.889*	1999 2003

Notes: B.D. represent break dates. Critical values at 5% and 1% are −5.49 and −5.95 respectively. ** and * denote significance at 5% and 1% level respectively.

Table A9
Clemente-Montanes-Reyes unit root test results.

At level (IO Model)										
Variable	t-stat. **Pakistan**	B.D	t-stat. **India**	B.D	t-stat. **Bangladesh**	B.D	t-stat. **Nepal**	B.D	t-stat. **Sri Lanka**	B.D
$AFSI_t$	−3.866	1985 2000	−4.378	1998 2002	−3.599	1996 2005	−4.309	2001 2005	−3.410	1998 2002
$\ln CO_t$	−2.944	1991 2003	−3.075	1983 2005	−2.250	1983 1999	−4.758	1988 1993	−3.158	1990 1994
$\ln YP_t$	−3.018	2002 2008	−2.750	1992 2002	−1.321	1993 2006	−1.969	1992 2003	−3.062	1988 2003
$\ln YP_t^2$	−1.893	1993 2006	−2.533	1992 2002	−1.893	1993 2006	−1.669	1992 2003	−2.558	1988 2003
$\ln EC_t$	−4.139	1985 2002	−1.302	2003 2008	−1.484	1986 1999	−4.147	1997 2007	−3.155	1994 1998
$\ln PD_t$	−2.740	1997 2000	−4.291	2003 2007	−3.280	1987 2004	−2.598	1994 1998	−4.550	1999 2002
At 1st difference										
$\Delta AFSI_t$	−8.353**	2000 2007	−7.785**	1993 1999	−8.451**	1991 2004	−12.50**	2000 2002	−5.686**	1986 1990
$\Delta \ln CO_t$	−8.871**	1992 2002	−5.526**	1992 2005	−8.137**	1997 2005	−7.229**	1988 1999	−8.918**	1988 2001
$\Delta \ln YP_t$	−8.489**	1989 2008	−7.072**	1990 2001	−6.881**	2001 2006	−8.095**	1991 2002	−6.562**	1996 2003
$\Delta \ln YP_t^2$	−6.950	1999 2004	−6.924**	1990 2001	−6.290**	2001 2006	−7.782	1991 2002	−6.807	1996 2003
$\Delta \ln EC_t$	−6.974	2001 2006	−5.871**	2002 2008	−8.427	1994 1999	−5.601**	1997 2003	−6.576**	1994 2002
$\Delta \ln PD_t$	−5.938**	1998 2002	−7.098**	2001 2008	−6.095**	1988 2004	−6.872**	1993 1996	−9.989**	1998 2000

Notes: B.D. represent break dates. Critical values at 5% is −5.490.

** Denote significance at 5% level.

Table A10
Estimated error correction model[a] (Dependent Variable: ln YPC_t).

Variable	Pakistan ET_{t-1}	India ET_{t-1}	Bangladesh ET_{t-1}	Sri Lanka ET_{t-1}	Nepal ET_{t-1}
Coefficient	−0.258	−0.629	−0.720	−0.444	−0.777
P-value	0.034	0.062	0.012	0.004	0.049

[a] Detail results of error correction model will be provided upon request.

Table A11
Estimated error correction model[a] (Dependent Variable: ln YPC_t).

Variable	Pakistan ET_{t-1}	India ET_{t-1}	Bangladesh ET_{t-1}	Sri Lanka ET_{t-1}	Nepal ET_{t-1}
Coefficient	−0.210	−0.439	−0.686	−0.179	−0.215
P-value	0.004	0.001	0.000	0.009	0.000

[a] Detail results of error correction model will be provided upon request.

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