Financial development and environmental quality: The way forward

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Abstract

The present paper re-examines the asymmetric impact of financial development on environmental quality in Pakistan for the period 1985Q1 to 2014Q4. A comprehensive index of financial development is generated using Bank- and Stock market-based financial development indicators. The results show that inefficient use of energy adversely affects the environmental quality. This suggests adoption of energy efficient technology at both production and consumption levels. These technologies would be helpful to improve environmental quality, enhance the productivity in long-run and save energy. Bank-based financial development also impedes the environment. The government should encourage lenders to ease the funding for energy sector and allocate financial resources for environment friendly businesses rather than wasting them in consumer financing.

Keywords: Financial development, Growth, Energy, CO_2 emissions

1. Introduction

Economic development is a long process that promises a high standard of living but also causes environmental degradation. A large body of literature is available on the association between environmental degradation and economic development, known as the Environmental Kuznets curve (EKC), which was proposed by Grossman and Krueger (1991)[1]. The EKC hypothesis posits that economic growth is initially accompanied by environmental degradation but that environmental quality begins to improve as the economy achieves the threshold level of the per capita income (for details, see Stern 2004 and Carson 2010). This notion has been empirically supported by various studies, such as Aldy (2005) for US states, Acaravci and Ozturk (2010) for European countries, Apergis and Ozturk (2015) for Asian economies, and Jebli et al. (2016) for OECD nations. Similarly, in the energy economics literature provides, many studies have investigated the EKC hypothesis by using time-series data for individual countries. For instance, Akbostanci et al. (2009), Iwata et al. (2010), Shahbaz et al. (2012), Tiwari et al. (2013), Lau et al. (2014) and Ozturk and Al-Mulali (2015) have validated the EKC for Turkey, France, Pakistan, India, Malaysia and Cambodia, respectively. Tamazian et al. (2009) argue that the omission of financial development from carbon dioxide emissions functions leads to erroneous empirical results. In a later study, Tamazian et al. (2009) report that financial development is a potential factor for economic growth, energy consumption and carbon dioxide emissions and disagree that financial sector development affects environmental quality via the scale effect (domestic output expansion), business effect (increase in investment activities) or wealth effect (developed efficient stock market).

[1] Achieving sustainable economic development as well as better living standards with positive environmental outcomes has been the desire of developing countries.

The rationale of the present study is to examine the link between financial development and carbon dioxide emissions rather than to empirically investigate the EKC hypothesis. In a study on this topic, Tamazian et al. (2009) empirically investigate whether financial development affects carbon emissions for BRIC countries. They argue that developed financial markets help reduce financing costs and channel financial resources in order to purchase fresh equipment and fund new projects, which in turn, creates energy demand and affects CO_2 emissions. Furthermore, their analysis indicates that financial development supports energy efficient technologies and hence shrinks carbon dioxide emissions. Tamazian and Rao (2010) examine the association between financial development and environmental degradation by incorporating institutional quality into carbon dioxide emissions functions, and they find that financial development increases environmental quality by lowering CO_2 emissions in countries with strong institutions and vice versa. Similarly, Frankel and Romer (1999) state that financial development attracts foreign direct investments, and consequently, advanced research and development activities lead to better environmental conditions. Wang and Jin (2007) and Bello and Abimbola (2010) confirm that financial development induces listed companies to use energy-efficient technology, which consequently helps reduce carbon emissions. Zhang and Lin (2011) contribute to the ongoing debate about the financial development-CO_2 emissions nexus by separating efficiency and scale effects.

In contrast, according to Sadorsky (2010) and Zhang (2011), financial development may contribute to carbon dioxide emissions. Stock market development assists public companies in reducing financial costs, enlarging financial channels, sharing operational risks and finding a balance between assets and liabilities to acquire new installations and allocate resources for the implementation of new projects, which ultimately increases energy consumption and carbon dioxide emissions. Zhang (2011) documents that financial intermediation allows for the purchase of household items (i.e., cars, houses, air conditioners, washing machines, etc.), which consume energy and add to carbon dioxide emissions. Al-Mulali et al. (2016) empirically investigate the nexus between financial development and carbon dioxide emissions for European countries; they note that financial development devastates environmental quality by increasing carbon dioxide emissions.

In the existing literature, studies also find a insignificant effect of financial development on carbon dioxide emissions (for example, Ozturk and Acaravci 2013, Dogan and Turkekul 2016, Omri et al. 2015 and Ziaei 2015). In the case of Pakistan, Javid and Sharif (2016) follow Shahbaz et al. (2012) and incorporate financial development as additional factor in their EKC function. Their results indicate a positive effect of energy consumption on carbon dioxide emissions, providing support for the EKC hypothesis in Pakistan. Their empirical analysis further shows that financial development degrades environmental quality by increasing carbon dioxide emissions, and the analysis of causation indicates the presence of response effect of financial development on carbon dioxide emissions. In a recent study, Abbasi and Riaz (2016) re-estimate the association of financial development with carbon dioxide emissions by including foreign direct investment in the carbon dioxide emissions equation. They use total credit, domestic credit and market capitalization as an indicator of financial development[2]. Their results indicate that financial development indicators have insignificant impact on carbon dioxide emissions in the full sample (1971-2011); however, in the reduced sample (1988-2011), total credit is negatively associated with carbon dioxide emissions. They also note that economic

[2] Using these indicators together in a regression may create a multicollinearity problem because of the high correlation between the indicators. The presence of multicollinearity leads to erroneous empirical results (Polat et al. 2015).

growth increases environmental degradation by stimulating carbon dioxide emissions. For more details, a summary of the studies on the financial development-CO_2 emissions nexus is provided in Table-1.

Moreover, inappropriate proxies for financial development have provided biased empirical results from studies investigating the financial development-carbon dioxide emissions nexus. For example, Khan et al. (2014) explore the link between carbon dioxide emissions and financial and economic variables such as (M_2) and (M_3), domestic credit to private sector, and FDI in South Asia and find a positive effect of these factors on carbon dioxide emissions in the long run. Lee and Chen (2015) explore the link between financial development and carbon dioxide emissions by employing data from OECD economies through a panel FMOLS approach. They use domestic credit to the private sector as a proxy for financial development and find that financial development is a catalyst to improved environmental quality. Ziaei (2015) use domestic credit to the private sector and the stock market turnover ratio as indicators of financial development and find a conflicting effect on energy consumption and hence on CO_2 emissions. Chang (2015) use five indicators of financial development[3] to examine their effects on carbon dioxide emissions and obtain biased results. Thus, a compound measure of financial development must be used to avoid multicollinearity and obtain unbiased empirical evidence.

Over time, Pakistan has implemented numerous economic policies, such as the structural adjustment program (SAP), to provide support during periods of slower economic growth, budget deficits and poverty alleviation, and the implementation of SAP has gradually affected our fiscal policies. Pakistan has also faced geopolitical tensions, such as terrorism, because of its

[3] These indicators include domestic credit to the private sector, domestic credit provided by the banking sector, total value of stocks traded, ratio of total value of stocks traded to stock market capitalization, and net inflows of foreign direct investment.

collaboration with the USA during the Afghan war. Further, structural changes in business cycles have occurred in Pakistan because of the implementation of numerous economic policies and external shocks that have also affected Pakistan's economy as a result of economic, social and political globalization. Pakistan's inflation is sensitive to the exchange rate, and production costs are affected by crude oil prices in the international oil market. Because of these factors, nonlinearity (asymmetries) may be found in macroeconomic variables. Such asymmetries may arise in macroeconomic variables because of interest rate differentials across countries, economic phases (booms or depressions, recessions or recovery periods), the oil price mechanism in the international oil market, international trade, and the supply and demand of domestic products in local and international markets. The allocation of credit to the private sector to stimulate business at low, medium and high levels is also conditional on the interest rate in the local market. Finally, many hidden factors may engender asymmetries in time-series data.

The literature also shows that ignoring the presence of asymmetries or nonlinearity in macroeconomic variables may provide biased empirical results. This study provides a comprehensive effort to fill this gap in the existing literature in the field of energy economics. The contribution of the present study is fourfold: (i) Using quarterly data from 1985 to 2014, the study generates a composite index of financial development by considering three indicators from the banking sector (M_2, M_3 and domestic credit to the private sector) and three indicators from the stock market (stock market capitalization, stock market traded value and stock market turnover) in Principal Component Analysis (PCA). (ii) The Fourier ADF (Enders and Lee, 2012) is used to analyse the level of integration of the variables to accommodate possible nonlinearities. (iii) The nonlinear autoregressive distributed lag (NARDL) cointegration approach developed by Shin et al. (2014) is used to examine the asymmetric long-run association between the variables. (iv) The asymmetric causality (Hatemi-J, 2012) approach is applied to determine the causal link between the variables.

[Insert Table 1 here]

2. Financial Development and CO_2 Emissions in Pakistan

Under the SAP of the IMF, Pakistan began introducing financial reforms in the late 1980s. Pakistan took out a Financial Sector Adjustment Loan in 1989 and 1997, and in 1995, another set of loans amounting to $216 million was provided to Pakistan under the Financial Sector Deepening and Intermediation Project. In 2001, World Bank also issued $300 million under the Financial Structure Restructuring and Privatization Project. The core objective of these reforms was to move toward a market-based exchange rate system and market-based management of a credit and monetary system. Furthermore, to improve the regulation, competition, efficiency and productivity of the financial sector, banks were privatized, and new commercial banks and investment and microfinance banks were opened in Pakistan. In this regard, liberalized policy was adopted to grow private domestic banks and foreign banks. These reforms were also enacted to rationalize the rate of interest for three instruments: public debt, concessional rates, and caps on lending and deposit rates. Federal Investment Bonds were introduced and later replaced by Pakistan Investment Bonds of five and ten years (Zaidi, 2005). With regard to Monetary and Credit Management, the credit ceiling was replaced by the Credit Deposit Ratio (CDR) in 1995. Open Market Operation became effective through market-based monetary management, and reserve repo transactions were performed to correct deviations in the money supply (Hanif, 2002). Prudential regulations were settled for prescribed credit and for limits of risk exposure, and regulations to check money laundering and dividend payment were formulated.

Capital market reforms ensured the presence of competition and a broadened market base. After financial liberalization, tremendous growth and instability in the stock market were observed. Only one stock market, the Karachi Stock Exchange (KSE), existed for a long period of time before financial liberalization. Following political unrest in the 1970s and the nationalization policy, the KSE gained momentum when more companies began listing on the KSE. However, enduring political unrest and the martial law regime badly affected the stock market in Pakistan. The 1990s were a recovery period for the stock market; new doors for investment opened, but the performance of stock market was inconsistent owing to continuing political instability, inflation, unemployment, terrorism, budget deficits, and so forth. Volatility in the financial sector badly affected the investment environment, economic growth and, hence, CO_2 emissions. Pakistan's cooperation with the US on the war against terror after 9/11 aggravated tensions and increased the volatility of financial variables. The average behaviour of financial variables in other developing countries encouraged Pakistan to develop its financial sector.

Notably, Pakistan has ranked 31st in CO_2 emissions in the world. According to the US Energy Information Administration, Pakistan has increased its CO_2 emissions eightfold since 1971. Further, recent information from the World Health Organization (2015) indicates that among the 20 most polluted cities in the world, Karachi is ranked 5th, Peshawar is 6th, and Rawalpindi is 7th. Pakistan has been a signatory of the Kyoto Protocol since 2005 and has thus pledged to implement the Clean Development Mechanism to alleviate GHGs.

2.1 Financial Development Index

Many researchers, including Gantman and Dabós (2012), Karima and Ken (2008), Masih et al. (2009), Liang and Jian-Zhou (2010) and Narayan and Narayan (2013), have studied various indicators of financial development, such as domestic credit provided by the banking sector as a share of GDP, liquid liabilities as a share of GDP, domestic credit to the private sector as a share of GDP, market capitalization as a share of GDP, turnover ratio as a share of GDP and the value of share trade as a share of GDP, commercial bank assets (commercial central bank assets) and broad money/narrow money. All these measures have been found to be inappropriate for capturing financial sector development, as they may be highly correlated and provide biased empirical results (Tyavambiza and Nyangara, 2015).

For an appropriate measure of financial sector development, we apply PCA to generate a financial development index by using bank-based and stock market-based financial development measures, as PCA appears to overcome the multicollinearity problem. The money supply in the economy is captured by money and quasi-money (M_2); the volume of the financial sector is indicated by liquid liabilities as a share of GDP (M_3); domestic credit to the private sector shows the allocation of savings to the private sector for investment ventures; stock market size is captured by stock market capitalization; and stock market traded value and stock market turnover illustrate profitability in stock markets. We transform all these variables into real terms. As these variables may create a multicollinearity problem if they are used together in a regression (Polat et al. 2015), we use PCA to transform correlated variables into small uncorrelated variables while preserving the original data as is.

Table-2 (lower segment) reports the pair-wise correlations. The results show a positive correlation of M_2 and M_3 with DC. Similarly, the correlation of SM, ST and TR with DC is positive. Further, SM, ST and TR are positively correlated with M_2 and M_3, and a positive correlation also exists between SM and ST and between ST and TR. The presence of high correlations between variables may cause a multicollinearity problem, which leads to erroneous empirical results. We resolve this problem by employing PCA to formulate a comprehensive financial development index. The results are reported in Table-2. The first principal component explains 57.94% of the standard deviation in all variables, while the second principal explains 26.32% of the overall standard deviation.

[Insert Table 2 here]

3. Model Construction, Methodological Framework and Data

3.1. Model Construction

Numerous studies estimate the link between financial development and carbon dioxide emissions but provide mixed empirical results. In the case of Pakistan, the present study extends the CO_2 emissions function used by Nasir and Rehman (2011) and Shahbaz et al. (2012) by including financial development as a supplementary determinant of economic growth and hence CO_2 emissions. The general form of the carbon dioxide emissions function is as follows:

$$C_t = f(F_t, E_t, Y_t) \tag{1}$$

All the variables are transformed into logarithmic form. The log-linear functional form of the empirical equation is as follows:

$$\ln C_t = \beta_1 + \beta_2 \ln F_t + \beta_3 \ln E_t + \beta_4 \ln Y_t + \mu_t \tag{2}$$

where $\ln$, C_t, F_t, E_t and Y_t represent natural log, CO_2 emissions, financial development, energy consumption and economic growth. μ_t is the error term *at* time t. All series except the financial development indices have been converted into per capita units.

3.2. Unit Root Tests

For an empirical investigation of the dynamic relationship among financial development, energy consumption, economic growth and CO_2 emissions, we follow the FADF unit root test. This test applies the procedure recommended by Enders and Lee (2012) by using a chosen frequency component of a Fourier ADF function to estimate the deterministic component of the model. This estimation can be used to explore the unknown multiple breaks in nonlinear ways (Enders and Lee, 2012), and it avoids the problem of losing power from the use of several dummy variables in the model. The nonlinear Fourier ADF test (τ_{DF}) can be represented as follows:

$$\Delta X_t = \rho X_{t-1} + c_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{l} c_i \Delta X_{t-i} + e_t \qquad (3)$$

In equation (3), γ and k represent the parameters and frequency, respectively, for the estimation of the Fourier test. The Fourier ADF (τ_{DF}) test establishes a null hypothesis for the t-statistics as $\rho = 0$ and incorporates the standard ADF stationary process as a special case by taking trigonometric terms equal to zero, i.e., $\gamma_1 = \gamma_2 = 0$. We can use F-statistics when trigonometric terms are included in the model (Enders and Lees, 2012). The null hypothesis of nonlinearity is tested by using the F-test, and the optimal lag length is selected by using the Akaike Information Criterion (AIC). The acceptance and rejection of F-statistics determines the selection of the nonlinear or linear ADF unit root test. If the null hypothesis is rejected, we select a nonlinear Fourier ADF test; otherwise, we use the ADF test (Enders and Lee, 2012).

3.3. Nonlinear ARDL Specifications

This study investigates the short- and-long-run asymmetric link among financial development, energy consumption, economic growth and carbon dioxide emissions by using the NARDL approach, which was developed by Shin et al. (2014), with positive and negative partial sum decompositions of the explanatory variables. This approach has the advantage of differentiating between short- and long-run asymmetric responses of changes in CO_2 emissions to the explanatory variables under consideration. The change in the examined variable is expressed as the first difference of the logarithmic transformation of this variable. The asymmetric cointegrating relationship can be expressed as follows:

$$Y_t = \beta_1 C_t^+ + \beta_2 C_t^- + \beta_3 F_t^+ + \beta_4 F_t^- + \beta_5 E_t^+ + \beta_6 E_t^- + \beta_7 Y_t^+ + \beta_8 Y_t^- + \mu_t \qquad (4)$$

where Y_t represents economic growth, C_t represents CO_2 emissions, F_t is financial development (bank based, stock market based, and overall), and E_t is energy consumption. The $^+$ and $^-$ show the partial sum process of negative and positive changes in CO_2 emissions, financial development, energy consumption and economic growth, while β_s comprises the long-run parameters of the associated asymmetric effects. The extension of the proposed ARDL model by Shin et al. (2014) represents the asymmetric error correction model, and it is expressed as follows:

$$\begin{aligned}\Delta Y_t = \vartheta + pY_{t-1} + \theta^+ \sum X_{i,t-1}^+ + \theta^- \sum X_{i,\,t-1}^- + \sum_{i=1}^{p-1} \gamma_i Y_{t-1} + \sum_{i=1}^{p-1} \varphi_i X_{i,\,t-1} \\ + \sum_{i=0}^{q-1} (\varphi_i^+ \Delta \sum X_{t-1}^+ + \varphi_i^- \Delta \sum X_{t-1}^-) + \mu_t\end{aligned} \qquad (5)$$

In equation (5), p and q represent lag orders for the variables, which can be estimated through regression and further decomposed into the partial sum process of negative and positive changes. We can test the long-run association between the dependent and independent variables with the levels of Y_t *and* $\theta^+ \sum X_{t-1}^+ + \theta^- \sum X_{t-1}^-$, i.e., ($Y_t$ *and* $C_t^+ + C_t^- + F_t^+ + F_t^- + E_t^+ + E_t^- + Y_t^+ + Y_t^-$). ($\rho = \theta^+ = \theta^- = 0$) uses the F_{PSS}- statistic as proposed by Pesran et al. (2001) and Shin et al. (2014). To test the null hypothesis of $\rho = 0$ against $\rho < 0$, we use the t_{BDM} statistic proposed by

Banerjee et al. (1998). The long-run asymmetric coefficients are estimated on the basis of $L_{mi^+} = \hat{\theta}^+/\rho$ and $L_{mi^-} = \hat{\theta}^-/\rho$. Furthermore, we apply the Wald test to estimate long-run asymmetry $\theta = \theta^+ = \theta^-$ and short-rum asymmetry from the two alternative forms, i.e., $\varphi_i^+ = \varphi_i^-$ for all $i = 1,\dots,q-1$ or $\sum_{i=0}^{q-1}\varphi_i^+ = \sum\_(i = 0)\hat{}(q-1)$. For the estimation of the asymmetric dynamic multiplier effects, we can use the following equation.

$$m_h^+ = \sum_{j=0}^{h}\frac{\partial cr_{t+j}}{\partial mi_t^+} \text{ and } m_h^- = \sum_{j=0}^{h}\frac{\partial cr_{t+j}}{\partial mi_t^-} \text{ for } h = 0,1,2\dots$$
$$\text{as } h \to \infty, \text{ then } m_h^+ \to L_{mi^+} \text{ and } m_h^- \to L_{mi^-}.$$

3.4. Asymmetric Causality Test

To determine the direction of causation between the examined variables, we use the asymmetric causality test proposed by Hatemi-J (2012). This test uses Toda-Yamamoto (1995) as the basis for the causality analysis by considering nonlinear effects and distinguishes between the effect of negative and positive shocks. Hatemi-J (2012) believes that integrated variables may be expressed as a random walk process in the following general form:

$$Y_t = Y_{t-1} + e_{1t} = Y_0 + \sum_{t=1}^{t} e_{1i} \text{ and } X_t = X_{t-1} + e_{2t} = X_0 + \sum_{t=1}^{t} e_{2i} \tag{6}$$

where $t = 1,2,\dots,T$, Y_0 and X_0 show the initial values and e_{1t} and e_{2t} are the error terms. $e_{1i}^+ = max(e_{1i},0)$ and $e_{2i}^+ = max(e_{2i},0)$ represent positive shocks, and $e_{1i}^- = min(e_{1i},0)$ and $e_{2i}^- = min(e_{2i},0)$ represent negative shocks. This is further demonstrated by $Y_t = Y_{t-1} + e_{1t} = Y_0 + \sum_{t=1}^{t} e_{1i}^+ + \sum_{t=1}^{t} e_{1i}^-$ and $X_t = X_{t-1} + e_{2t} = X_0 + \sum_{t=1}^{t} e_{2i}^+ + \sum_{t=1}^{t} e_{2i}^-$. To capture the effects of the positive and negative shocks of all variables, the function can be expressed in a cumulative form as follows:

$$Y_t^+ = \sum_{i=1}^{t} e_{1i}^+, Y_t^- = \sum_{i=1}^{t} e_{1i}^-, C_t^+ = \sum_{i=1}^{t} e_{2i}^+ \text{ and } C_t^- = \sum_{i=1}^{t} e_{2i}^-, F_t^+ = \sum_{i=1}^{t} e_{3i}^+$$
$$F_t^- = \sum_{i=1}^{t} e_{3i}^-, \sum_{i=1}^{t} e_{5i}^- E_t^+ = \sum_{i=1}^{t} e_{6i}^+ , \; E_t^- = \sum_{i=1}^{t} e_{6i}^-.$$

The positive and negative components indicate asymmetric causality between the variables (Hatemi-J, 2012). This test can be applied by using a Vector autoregressive (VAR) model with an order of p, and the optimal lag length can be selected by using criteria suggested by Hatemi-J (2003, 2008).

$$\text{HJC} = \ln\left(\left|\hat{A}_j\right|\right) + q\left(\frac{n^2 \ln T + 2n^2 \ln(\ln T)}{2T}\right), q = 0, \ldots, p \qquad (7)$$

where $\left|\hat{A}_j\right|$ is a determinant in the VAR model of the obtained variance-covariance matrix of the error terms with lag order q and shows the number of equations and T is the number of observations in the VAR model. The null hypothesis can be represented by the kth element, where $\sum X_{it}^+$ does not affect ωth Y_t^+, and it is defined as H_0: the row ω and column k elements in A_r equal zero for $r = 1, \ldots, p$. This hypothesis can be by tested using the Wald test (Hatemi-J, 2012).

3.5. Data Sources and Construction

This study covers the period 1985-2014. Follow the method of Sbia et al. (2014), we employ a quadratic match-sum method to convert the annual frequency data into quarterly data. The data on CO_2 emissions (metric tons per capita), energy consumption (kg of oil equivalent per capita), real GDP (per capita), money and quasi money (M_2), liquid liabilities (M_3), domestic credit to the private sector, stock market capitalization, stock market traded value and stock market turnover have been compiled from the World Development Indicators (CD-ROM, 2015)[4]. The time trends of the variables are shown in Figure-1.

[Insert Figure 1 Here]

4. Findings and Discussion

Table-3 reveals the descriptive statistics and pair-wise correlations. The results show that economic growth more highly volatile than CO_2 emissions, and the bank-based financial development indicator is less volatile than the stock market-based financial development indicator and overall financial development index. Further, the standard deviation is higher for energy consumption than for CO_2 emissions. The distribution is considered symmetric if the distribution of data looks identical on both sides of the centre point, i.e., a bell-shaped curve[5]. Skewness and kurtosis show potential asymmetry in the data distribution. Hence, we rely on asymmetric rather than symmetric empirical analyses. The J-B Statistic indicates that the distribution of the data is nonnormal. The asymmetric ARDL solves the issue of nonnormality by capturing the nonlinearities occurring in time-series data (Shin et al. 2014). The correlation analysis indicates a positive correlation between CO_2 emissions and economic growth, energy consumption, and financial development (bank based and stock market based). In addition, energy consumption and financial development (bank based and stock market based) are also positively correlated with economic growth, and financial development is positively correlated with energy consumption. There is a possibility of multicollinearity between energy consumption and economic growth. Shin et al. (2014) argue that the issue of multicollinearity can be solved by applying a nonlinear ARDL approach with the appropriate lag order.

[4] All financial indicators have been transformed into real terms.
[5] We could not find a bell-shaped distribution of data. The results are available upon request from the authors.

[Insert Table 3 here]

Although an asymmetric ARDL is not a necessary condition to test the order of integration of the variables, it is necessary to ensure that none of the variables are stationary at the 2nd difference, i.e., I(2). The ADF unit root is unable to capture the unknown multiple structural breaks and nonlinearity occurring in time-series data, which leads to erroneous empirical results owing to the low explanatory power. This problem is solved by applying the FADF unit root test. We apply both the ADF and FADF unit root tests, and the results are presented in Table-4. As described in the methodology section, we follow a two-step procedure to identify the unit root properties of the data. First, the FADF test is applied, and possible nonlinearity is tested though $F(\tilde{k})$ statistics. The F-statistic of the FADF test fails to reject the null hypothesis, i.e., the time series is linear. Second, the findings of the FADF test allow us to discuss the empirical results reported by the ADF unit root test. We find that CO_2 emissions, energy consumption, economic growth and financial development have unit roots at level and that they are stationary at the first difference, i.e., I(1).

[Insert Table 4 here]

After confirming that none of the variables are integrated at I(2), we apply the NARDL approach to investigate the effect of financial development, energy consumption and economic growth on carbon dioxide emissions. The results of models 1, 2 and 3, where use banking, stock and overall financial development, are reported in Tables 5, 6 and 7, respectively. In the long run, we find that positive shocks in economic growth mainly increase CO_2 emissions and that the positive shocks in economic growth add to CO_2 emissions. The effect of negative shocks in economic growth on CO_2 emissions is positive but statistically insignificant. Overall, economic growth is positively linked to CO_2 emissions, which indicates that domestic output is enhanced without concern for the environmental rules and regulations that lead the deterioration in environment quality (Shahbaz, 2013). Energy consumption (positive and negative shocks) also adds to CO_2 emissions. This empirical outcome is similar to those of Nasir and Rehamn (2011), Shahbaz et al. (2012), Ahmed et al. (2015), and Javid and Sharif (2016), who find that energy consumption is a main contributor to environmental degradation. The positive shocks in bank-based financial development positively and significantly affect CO_2 emissions at the 10% level. The negative shocks in financial development (bank-based) have positive but negligible effects on CO_2 emissions. This finding is consistent with that of Javid and Sharif (2016), who report that the allocation of domestic credit to the private sector impedes the preservation of environmental quality by increasing CO_2 emissions. In contrast, Abbasi and Riaz (2016) document that total credit, domestic credit to the private sector and stock market capitalization have negative and positive but insignificant effects on CO_2 emissions. The impact of positive and negative shocks in stock market-based financial development on CO_2 emissions is positive and negative, respectively, but the effects are statistically insignificant (Table-6). Similarly, we use overall financial development (bank based and stock market based) to examine its impact on CO_2 emissions, and the results show that financial development (composite index) has a positive but insignificant effect on carbon dioxide emissions (see Table-7).

These results show that improved bank-based financial development has an incremental effect on environmental degradation. We note that in the case of Pakistan, banks are mostly involved in allocating financial resources to firms/investors at lower costs and to households for purchasing household items via consumer financing. Furthermore, auto financing is a more lucrative product of consumer financing to sell to the emerging middle class in Pakistan. Owing to the lax environmental regulations, firms/investors employ technology to enhance their production, which leads to more energy consumption and increased environmental degradation.

In the short run, the lagged terms of CO_2 emissions (lagged 1 and 2) contribute to environmental degradation in the future. A positive shock in economic growth (lagged 2) reduces CO_2 emissions, but a negative shock in economic growth adds to CO_2 emissions. Further, a positive shock in energy consumption decreases CO_2 emissions, but a negative shock in energy consumption increases CO_2 emissions. The relationships between positive shocks in bank-based financial development and CO_2 emissions and between stock market-based financial development and CO_2 emissions are positive and significant at the 1% level. Moreover, the empirical results indicate that there is an asymmetric impact of economic growth, energy consumption and financial development (bank-based) on environmental degradation. Furthermore, as the results of models 1, 2 and 3, which use a bank-based index, stock market-based index and overall index of financial development, 63.71%, 52.66% and 54.69% of CO_2 emissions is explained by economic growth, energy consumption and financial development. The empirical evidence favours the absence of serial correlation, the misspecification of the model and heteroscedasticity but nonnormally distributed values are present in the residual terms. There is also no autocorrelation problem in the empirical models. The F-bound test shows the presence of cointegration between economic growth, energy consumption, financial development (bank-based, stock market-based and overall index) and CO_2 emissions. This finding is confirmed by the results of asymmetric co-integration (see the lower panel of Tables 5, 6 and 7). Based on these results, we find that economic growth, energy consumption, financial development (bank based, stock market based and overall index) and CO_2 emissions show co-integration in the presence of asymmetries.

[Insert Table 5, 6 & 7 here]

Next, to identify the asymmetric adjustments from an initial long-run equilibrium to a new long-run equilibrium after a negative or positive unitary shock, we plot the dynamic multipliers for three models (a-c) in Figures 2, 3 and 4, respectively. In these figures, the predicted dynamic multipliers for the adjustment of CO_2 emissions under the three NARDL specifications are shown. The asymmetry curves depict the linear combination of the dynamic multipliers that are associated with positive and negative shocks, and they provide information about the asymmetric adjustment to positive and negative shocks at a given forecasting horizon. In the graphs, the lower and upper bands are represented by dotted lines and indicate symmetry at a 95% confidence interval.

The overall impression is that negative shocks in economic growth (Figure-2) have a more profound impact on CO_2 emissions in the short run, while there is positive asymmetry in the long run. The long-run equilibrium is achieved in two years (eight quarters). The response of CO_2 emissions to positive and negative shocks in energy consumption (both short and long run) is somewhat symmetric in all the models except for model 2; the gap in magnitude between the positive and negative shocks in energy consumption is negligible, especially in the short run. The response of CO_2 emissions to bank-based financial development is asymmetric (positive asymmetry) in both the short and long run, and the long-run equilibrium in response to bank-based financial development shocks is again achieved within two years. The response of CO_2 emissions to the stock market and overall financial development is within the -0.05 and +0.05 range and is hence negligible.

[Insert Figure 2, 3 & 4 here]

The results of asymmetric and nonasymmetric causality are reported in Table-8. We find that economic growth causes CO_2 emissions and that CO_2 emissions cause economic growth in the Granger sense. This finding confirms the presence of a response effect between economic growth and CO_2 emissions and reveals that Pakistan obtains growth at the cost of the environment. Thus, to preserve the environment more effectively, Pakistan must compensate for economic growth. The causality between energy consumption and CO_2 emissions is bidirectional. This empirical outcome is similar to that of Javid and Sharif (2016), who confirms the feedback effect between energy consumption and environmental degradation. The empirical result is also supported by the findings of Tiwari et al. (2013).

One-way causation from positive shocks in bank-based financial development to positive shocks in CO_2 emissions is found; this empirical evidence contradicts that of Javid and Shahrif (2016) and Abbasi and Riaz (2016). We also find no causal relationship between positive (negative) shocks in stock market-based financial development and positive (negative) shocks in CO_2 emissions, which indicates that stock market-based financial development and CO_2 emissions are independent. This empirical finding, which is corroborated by Abbais and Riaz (2016) along similar lines, indicates that the causality between positive (negative) shocks in energy consumption and positive (negative) shocks in CO_2 emissions is neutral, which suggests that there is no asymmetric causality between energy consumption and stock market-based (overall financial development) financial development. Furthermore, a neutral effect exists between stock market-based (overall financial development) financial development and CO_2 emissions.

[Insert Table 8 here]

5. Conclusion and Policy Implications

The present study re-examines the association between financial development and CO_2 emissions by incorporating energy consumption and economic growth as additional factors in the CO_2 emissions function. The study uses quarterly frequency data for the period 1985-2014. For empirical purposes, we apply the ADF and FADF tests to check the level of integration of the variables in order to accommodate multiple structural breaks and nonlinearities in the time series. Further, the asymmetric ARDL cointegration approach is applied to test the impact of positive and negative shocks in financial development, energy consumption and economic growth on CO_2 emissions, and the symmetric and asymmetric causality association between the variables is examined by applying the asymmetric Granger causality analysis.

On the basis of our empirical findings, we conclude that strong asymmetric cointegration exists among the examined variables, i.e., financial development, energy consumption, economic growth and CO_2 emissions. Positive shocks in economic growth positively affect CO_2 emissions, and energy consumption has a positive asymmetric effect on CO_2 emissions through positive and negative shocks. Financial development in the banking sector is also responsible for adding to CO_2 emissions via positive shocks. The asymmetric causality analysis explores the two-way symmetric causality between economic growth and CO_2 emissions, and the results show that unidirectional causality exists from positive shocks in bank-based financial development to CO_2 emissions.

Energy consumption is an unfortunate necessity for any economy to grow, and reductions in energy consumption are accompanied by declines in economic growth. To keep an economy on the path of development, exploration of renewable energy sources should be a priority, as the development of renewable energy sources may prevent reliance on foreign energy sources to meet domestic energy needs, increase energy efficiency, prevent energy crises, and improve environmental quality (Halkos and Tzeremes, 2013). Furthermore, economic growth is positively linked to CO_2 emissions via positive shocks, which indicates the negative consequences of economic growth in terms of environmental degradation. Such environmental degradation may affect human health, which decreases productivity in the long run and hence affects the pace of economic growth. Accordingly, energy-efficient technology should be adopted at not only the production level but also the transportation and household levels. The adoption of environmentally friendly technology would help improve environmental quality, improve productivity in the long run, and save energy for future generations. Furthermore, for long-run economic development, efforts must be made to plant trees instead of engaging in deforestation, and renewable energy sources such as wind power, hydropower, and solar power can be used to mitigate emissions. Strong legislation should also be proposed to impose a carbon tax and minimum fuel efficiency standards for vehicles.

We note that efficient technology plays a dual role, i.e., increasing productivity for long-run economic growth and reducing emissions to improve environmental quality. Financial development (bank-based) may help fund the purchase of advanced and energy-efficient technologies because financial resources can be obtained at a lower cost. However, our empirical evidence suggests that bank-based financial development impedes environmental quality via positive shocks occurring in bank-based financial sector development. In this regard, the financial system can also be developed with new instruments and regulations because it is concomitant with economic growth. For example, the government should direct the central bank of Pakistan to monitor the banking sector's financial resource allocation mechanism, and the banking sector should monitor the firms after financial resources are allocated to ensure that credit is not issued at the cost of environmental quality. If any firm is involved in increasing environmental degradation, it should be punished via reductions in tax holidays or increases in interest rate-allocated loans. The government should also encourage the banking sector to invest in the energy sector in general and the renewable energy sector in particular. In this regard, the banking sector should allocate financial resources for R&D for energy-efficient technologies and obtain patents for these technologies to generate a certain lifetime of profit rather than waste financial resources on consumer financing, i.e., car leases or household item loans.

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Table 1: Summary of Studies on Financial development-Emissions Nexus

No.	Authors	Time Period	Country	Methodology	FD Measure	Hypothesis	Causality
1.	Tamazian et al. (2009)	1992-2004	BRIC	SRM	SMC, DBA, FDI	FD decreases EQ	....
2.	Tamazian and Rao (2010)	1993-2004	24 TE	G MM	FL, FDI	FD decreases EQ	....
3.	Jalil and Feridun, (2010)	1953-2006	China	ARDL	LL, DC, FDI	FD improves EQ	....
4.	Zhang, (2011)	1980-2010	China	VAR	BL, SMC, SMB, FDI	FD decreases EQ	....
5.	Ozturk and Acaravci, (2013)	1960-2007	Turkey	ARDL, VECM	DC	Insignificant	FD $\rightarrow CO_2$
6.	Shahbaz et al. (2013a)	1971-2011	Malaysia	ARDL, VECM	DC, FDI	FD decreases EQ	FD $\leftrightarrow CO_2$
7.	Shahbaz et al. (2013b)	1965-2008	South Africa	ARDL, VECM	DC	FD improves EQ	....
8.	Boutabba, (2014)	1971-2008	India	ARDL, VECM	DC	FD decreases EQ	FD $\rightarrow CO_2$
9.	Salahuddin et al. (2015)	1980-2012	GCC	DOLS, FMOLS	DC	FD improves EQ	FD $\neq CO_2$
10.	Lee et al. (2015)	1971-2007	OECD	FMOLS	DC	FD improves EQ	....
11.	Omri et al. (2015)	1990-2011	12 MENA	PSE	DC, FDI	FD decreases EQ	....
12.	Ziaei (2015)	1989-2011	EU, EA, OC	IRF	DC, TR	Insignificant	....
13.	Charfeddine and Khediri (2016)	1975-2012	UAE	ARDL, VECM	DC	FD decreases EQ	FD $\rightarrow CO_2$
14.	Javed and Sharif (2016)	1972-2013	Pakistan	ARDL, VECM	DC	FD decreases EQ	FD $\leftrightarrow CO_2$
15.	Dogan and Turkekul, (2016)	1960-2010	USA	ARDL, VECM	DC	Insignificant	FD $\leftrightarrow CO_2$
16.	Al-Mulali et al. (2016)	1990-2013	EU	FMOLS, VECM	DC	FD decreases EQ	FD $\leftrightarrow CO_2$
17.	Shahbaz et al. (2016)	1971-2011	Portugal	ARDL, VECM	DC	FD improves EQ	FD $\rightarrow CO_2$

Note: DBA (deposit money bank assets), FL (financial liberalization), LL (Liquid liabilities), DC (domestic credit to private sector), FDI (Foreign direct investment), BL (sum of bank loans), SMC (stock market capitalization), SMB (bond in stock market), TR (stock market traded value), FD (financial development), EQ (environmental quality), CO_2 (CO_2 emissions), GMM (Generalized Moments Method), ARDL (autoregressive distributed lag model), VAR (vector auto-regression), VECM (vector error correction Granger causality), DOLS (dynamic ordinary least square), FMOLS (Fullimodified ordinary least square), UAE (United Arab Emirates), GCC (Gulf countries council), EU (European Union), EA (East Asia), OC (Oceania countries) and MENA (Middle East and North America).

Table 2: Principal Component Analysis

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	3.4762	1.8971	0.5794	3.4762	0.5794
2	1.5790	0.9605	0.2632	5.0553	0.8426
3	0.6185	0.3777	0.1031	5.6738	0.9456
4	0.2408	0.1864	0.0401	5.9146	0.9858
5	0.0543	0.0233	0.0091	5.9690	0.9948
6	0.0309	---	0.0052	6.0000	1.0000

a). Eigenvectors (loadings)

Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
DC	0.4644	-0.0890	-0.4379	0.6923	-0.0966	0.3095
M2	0.4473	0.4111	0.1463	0.0939	-0.3810	-0.6748
M3	0.2283	0.6766	0.3579	0.0485	0.4539	0.3917
SM	0.4786	0.0517	-0.3454	-0.7046	-0.2374	0.3098
ST	0.4531	-0.3998	-0.0172	-0.1077	0.7029	-0.3589
TR	0.3124	-0.4500	0.7341	0.0365	-0.2982	0.2655

b). Ordinary correlations

Variables	DC	M_2	M_3	SM	ST	TR
DC	1.0000					
M_2	0.6359	1.0000				
M_3	0.1859	0.8103	1.0000			
SM	0.7458	0.7290	0.3483	1.0000		
ST	0.7674	0.4339	0.0596	0.7307	1.0000	
TR	0.3791	0.2615	0.0740	0.3264	0.7532	1.0000

Note: DC, M2, M3, SM, ST and TR indicates domestic credit to private sector, money and quasi money, liquid liabilities, stock market capitalization, stock market traded value and stock market turnover respectively.

Table 3: Descriptive Statistics and Correlation Matrices

	$\ln C_t$	$\ln Y_t$	$\ln E_t$	$\ln FB_t$	$\ln FS_t$	$\ln F_t$
Mean	0.1877	11038.5	108.74	35.554	261.34	148.45
Maximum	0.2435	14754.0	127.70	51.358	1206.0	624.84
Minimum	0.1242	8157.2	84.682	23.968	23.969	23.967
Std. Dev.	0.0376	1836.7	11.620	7.4092	285.29	144.39
Skewness	-0.0349	0.3775	-0.4050	0.3480	1.7808	1.7613
Kurtosis	1.7216	1.9425	2.1769	1.8064	5.3230	5.2742
J-B Stats	8.1955**	8.4413**	6.6678**	9.5465***	90.414***	87.908***
	[0.0166]	[0.0146]	[0.0356]	[0.0084]	[0.0000]	[0.0000]
$\ln C_t$	1.0000					
$\ln Y_t$	0.9738***	1.0000				
	(46.516)					
$\ln E_t$	0.9634***	0.8921***	1.0000			
	(39.075)	(21.453)				
$\ln FB_t$	0.9455***	0.6659***	0.8674***	1.0000		
	(31.561)	(19.582)	(18.941)			
$\ln FS_t$	0.5119***	0.3961***	0.6262***	0.4623***	1.0000	
	(6.4731)	(4.6869)	(8.7259)	(5.6644)		
$\ln F_t$	0.5299***	0.4161***	0.6409***	0.4824***	0.8997***	1.0000
	(6.7885)	(4.9714)	(9.0700)	(5.9826)	(47.401)	

Note: J-B stands for Jarque-Bera test of normality. Numbers in () are the t values. *** indicate significance at 1% level.

Table 4: Unit root tests results

Variable	Nonlinear FADF						ADF	
	$\tilde{k}$	SSR	$\tilde{l}$	AIC	F($\tilde{k}$)	τ_{DF}	Level	First diff.
$\ln C_t$	2	0.0060	5	-6.8510	2.6195	-1.3720	-1.9121	-3.5525***
$\ln Y_t$	2	0.0012	5	-8.4071	2.5588	1.0522	-0.3253	-3.9773***
$\ln E_t$	1	0.0020	5	-7.9513	4.2160	-3.8771	-1.8919	-5.9436***
$\ln FB_t$	1	0.0149	5	-5.9437	0.6807	-1.2201	-0.4934	-4.3500***
$\ln FS_t$	1	1.2107	5	-1.5491	4.3038	-2.7571	-1.9158	-3.1708***
$\ln F_t$	1	0.8542	5	-1.8979	4.1903	-2.7803	-1.9374	-4.2002***

Note: In nonlinear FADF unit root test, the optimal frequency ($\tilde{k}$) was selected by using the data-driven grid-search method. The optimal lag ($\tilde{l}$) is the lag length that minimises the Akaike Information Criterion (AIC). The critical values are obtained from Table-1b in Enders and Lee (2012). For traditional ADF unit root test, critical values are based on MacKinnon (1996). All the variables assume intercept. *** indicates significance at 1% level.

Table 5: Dynamic Asymmetric Model – Financial Development Banks

Dependent variable: $\Delta ln\mathrm{C}_t$

Variables	Coefficients		S.E
Constant	-0.9296***		(0.1184)
$\ln C_{t-1}$	-0.4461***		(0.0566)
$\ln Y^{+}_{t-1}$	0.1406*		(0.0811)
$\ln Y^{-}_{t-1}$	0.2306		(0.1918)
$\ln E^{+}_{t-1}$	0.4311***		(0.0914)
$\ln E^{-}_{t-1}$	0.3995***		(0.0932)
$\ln FB^{+}_{t-1}$	0.0665**		(0.0255)
$\ln FB^{-}_{t-1}$	0.0044		(0.0243)
$\Delta \ln C_{t-1}$	0.3708***		(0.0755)
$\Delta \ln C_{t-2}$	0.2652***		(0.0804)
$\Delta \ln Y^{+}_{t-2}$	-0.7387***		(0.2411)
$\Delta \ln Y^{-}_{t}$	1.4835***		(0.4455)
$\Delta \ln E^{+}_{t-1}$	-0.5253**		(0.2339)
$\Delta \ln E^{-}_{t}$	0.7156**		(0.3115)
$\Delta \ln FB^{+}_{t-1}$	0.4548***		(0.0772)
R^2	0.6371		
Adj. R^2	0.5852		
DW stats	2.0909		
χ^2_{SC}	0.9379		[0.1823]
χ^2_{FF}	0.0545		[0.8157]
χ^2_{HET}	1.8839		[0.0609]
χ^2_{NORM}	14.011		[0.0020]
L^{+}_{y}	0.3151*	L^{-}_{y}	0.2899
L^{+}_{E}	0.9664***	L^{-}_{E}	0.8955***
L^{+}_{FB}	0.1492***	L^{-}_{FB}	0.0099
$W_{LR,y}$	2.1274 [0.0918]	$W_{SR,y}$	16.558 [0.0001]
$W_{LR,E}$	0.0484 [0.8262]	$W_{SR,E}$	9.5393 [0.0026]
$W_{LR,FB}$	3.8239 [0.0613]	$W_{SR,FB}$	34.657 [0.0000]
F-Bound	9.15530***		
Asymmetry	-7.8799***		

Note: The superscript "+" and "-" denote positive and negative cumulative sums, respectively. L^{+} and L^{-} are the estimated long-run coefficients associated with positive and negative changes, respectively, defined by $\hat{\beta} = -\hat{\theta}/\hat{\rho}$. χ^2_{SC}, χ^2_{FF}, χ^2_{HET}, and χ^2_{NORM} denote LM tests for serial correlation, normality, functional form and heteroscedasticity, respectively. W_{LR} and W_{SR} represents the Wald test for the null of long- and short-run symmetry for respective variable. Value in [] are p-values. S.E stands for standard errors.
***, ** & * indicate significance at 1%, 5% and 10% level, respectively.

Table 6: Dynamic Asymmetric Model – Financial Development Stock

Dependent variable: $\Delta \ln C_t$

Variables	**Coefficients**	**S.E**	
Constant	-0.6262***	(0.1117)	
$\ln C_{t-1}$	-0.3029***	(0.0535)	
$\ln Y^{+}_{t-1}$	0.2170***	(0.0680)	
$\ln Y^{-}_{t-1}$	-0.0605	(0.2105)	
$\ln E^{+}_{t-1}$	0.2062***	(0.0828)	
$\ln E^{-}_{t-1}$	0.4140***	(0.1557)	
$\ln FS^{+}_{t-1}$	0.0008	(0.0032)	
$\ln FS^{-}_{t-1}$	-0.0034	(0.0045)	
$\Delta \ln C_{t-1}$	0.4860***	(0.0798)	
$\Delta \ln Y^{+}_{t}$	1.2834***	(0.3220)	
$\Delta \ln Y^{+}_{t-1}$	-1.0487***	(0.3349)	
$\Delta \ln FS^{+}_{t}$	0.9509***	(0.3403)	
R^2	0.5266		
Adj. R^2	0.4771		
DW stats	2.2556		
χ^2_{SC}	0.8376	[0.3283]	
χ^2_{FF}	0.7364	[0.3928]	
χ^2_{HET}	1.2671	[0.2494]	
χ^2_{NORM}	14.776	[0.0000]	
L^{+}_{y}	0.7166***	L^{-}_{y}	0.1997
L^{+}_{E}	0.6807***	L^{-}_{E}	1.3668***
L^{+}_{FS}	0.0028	L^{-}_{FS}	-0.0113
$W_{LR,y}$	1.9164 [0.0872]	$W_{SR,y}$	12.762 [0.0023]
$W_{LR,E}$	1.6860 [0.0877]	$W_{SR,E}$	-
$W_{LR,FS}$	0.0142 [0.3491]	$W_{SR,FS}$	14.657 [0.0000]
F-Bound	5.1605***		
Asymmetry	-5.6605***		

Note: see notes to Table 5.

Table 7: Dynamic Asymmetric Model – Financial Development Overall

Dependent variable: ΔlnC_t

Variables	Coefficients	S.E	
Constant	-0.7825***	(0.1143)	
$\ln C_{t-1}$	-0.3766***	(0.0546)	
$\ln Y_{t-1}^{+}$	0.2291***	(0.0690)	
$\ln Y_{t-1}^{-}$	0.0883	(0.2053)	
$\ln E_{t-1}^{+}$	0.3742***	(0.0820)	
$\ln E_{t-1}^{-}$	0.2776*	(0.1562)	
$\ln F_{t-1}^{+}$	0.0039	(0.0037)	
$\ln F_{t-1}^{-}$	0.0024	(0.0050)	
$\Delta \ln C_{t-1}$	0.4205***	(0.0805)	
$\Delta \ln C_{t-2}$	0.3111***	(0.0888)	
$\Delta \ln Y_{t}^{+}$	0.7461**	(0.3015)	
$\Delta \ln Y_{t-1}^{+}$	-0.9559***	(0.3137)	
$\Delta \ln Y_{t}^{-}$	1.1528**	(0.4718)	
$\Delta \ln E_{t}^{+}$	0.7301***	(0.2440)	
$\Delta \ln E_{t-1}^{+}$	-0.5666**	(0.2500)	
R^2	0.5469		
Adj. R^2	0.4947		
DW stats	2.1523		
χ^2_{SC}	1.6402	[0.1023]	
χ^2_{FF}	0.0104	[0.9188]	
χ^2_{HET}	2.3050	[0.0797]	
χ^2_{NORM}	7.9381	[0.0080]	
L_y^{+}	0.6084***	L_y^{-}	-0.0954
L_E^{+}	0.7546***	L_E^{-}	0.7638*
L_F^{+}	0.0104	L_F^{-}	0.0063
$W_{LR,y}$	2.7039 [0.0969]	$W_{SR,y}$	4.4556 [0.0373]
$W_{LR,E}$	0.2391 [0.9857]	$W_{SR,E}$	9.6380 [0.0025]
$W_{LR,F}$	0.0717 [0.7242]	$W_{SR,F}$	-
F-Bound	7.4371***		
Asymmetry	-6.8857***		

Note: see notes to Table 5.

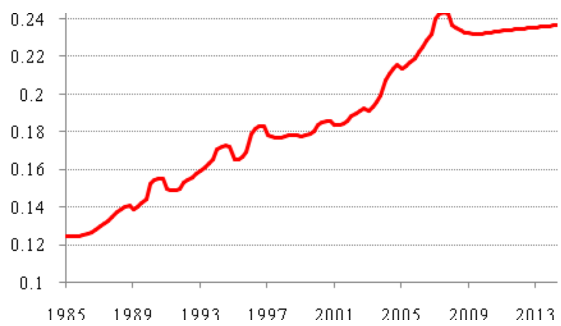
Table 8: The Asymmetric and Non-asymmetric Causality Analysis

Null hypothesis	Test value	Bootstrap CV at 1%	Bootstrap CV at 5%	Bootstrap CV at 10%
$lnY_t \neq> lnC_t$	90.047***	42.127	28.993	23.958
$lnY_t^+ \neq> CO_{2,t}^+$	0.057	13.397	7.281	5.352
$lnY_t^- \neq> CO_{2,t}^-$	0.048	17.069	5.348	1.955
$lnC_t \neq> lnY_t$	26.761**	35.572	25.038	20.833
$lnC_t^+ \neq> lnY_t^+$	0.951	15.534	7.686	5.631
$lnC_t^- \neq> lnY_t^-$	0.000	29.440	7.859	3.022
$lnE_t \neq> lnC_t$	29.668**	32.584	23.399	19.782
$lnE_t^+ \neq> lnC_t^+$	1.708	14.309	7.350	5.354
$lnE_t^- \neq> lnC_t^-$	0.075	14.752	4.711	2.422
$lnC_t \neq> lnE_t$	42.553***	39.315	25.357	20.869
$lnCO_t^+ \neq> lnE_t^+$	0.287	13.046	7.638	5.032
$lnC_t^- \neq> lnE_t^-$	0.000	16.032	6.199	3.149
$lnFB_t \neq> lnC_t$	8.722	20.321	14.774	12.499
$lnFB_t^+ \neq> lnC_t^+$	9. 345**	12.301	7.286	5.342
$lnFB_t^- \neq> lnC_t^-$	0.062	16.400	7.553	5.287
$lnC_t \neq> lnFB_t$	4.456	22.672	15.854	13.594
$lnC_t^+ \neq> lnFB_t^+$	2.360	20.114	9.657	5.581
$lnC_t^- \neq> lnFB_t^-$	4.647	14.499	7.672	5.074
$lnFS_t \neq> lnC_t$	4.449	37.854	25.121	20.343
$lnFS_t^+ \neq> lnC_t^+$	0.801	13.036	7.393	5.361
$lnFS_t^- \neq> lnC_t^-$	0.010	16.238	4.965	2.395
$lnC_t \neq> lnFS_t$	16.851	40.338	26.640	21.906
$lnC_t^+ \neq> lnFS_t^+$	0.640	14.370	7.532	5.222
$lnC_t^- \neq> lnFS_t^-$	0.016	20.294	6.417	2.821
$lnF_t \neq> lnC_t$	7.007	38.349	25.226	20.854
$lnF_t^+ \neq> lnC_t^+$	0.805	12.713	7.548	5.492
$lnF_t^- \neq> lnC_t^-$	0.016	16.349	4.780	2.311
$lnC_t \neq> lnF_t$	18.940	41.133	25.191	21.703
$lnC_t^+ \neq> lnF_t^+$	0.263	14.652	7.847	5.170
$lnC_t^- \neq> lnF_t^-$	0.001	19.782	6.918	3.096

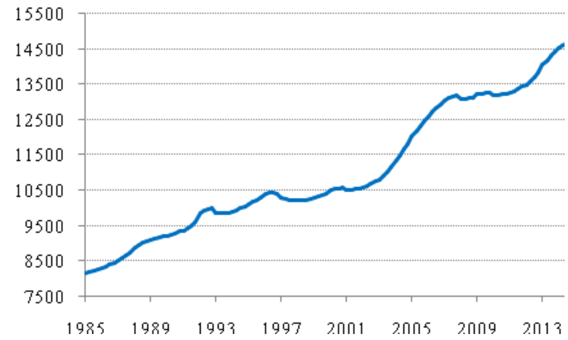
Note: The denotation CV is an abbreviation for the critical value. An extra unrestricted lag was included in the VAR model in order to account for the effect of a unit root as suggested by Toda and Yamamoto (1995).

Figure 1: Financial development, Economic growth, CO_2 emissions trends in Pakistan

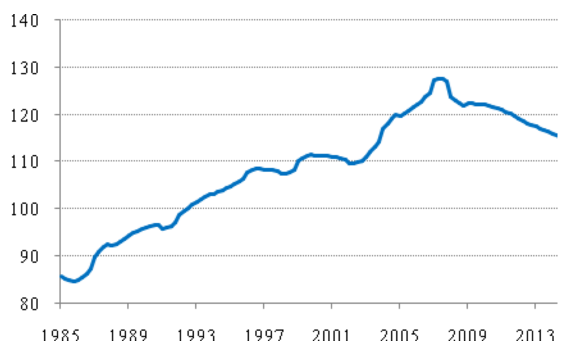
a). CO_2 Emissions



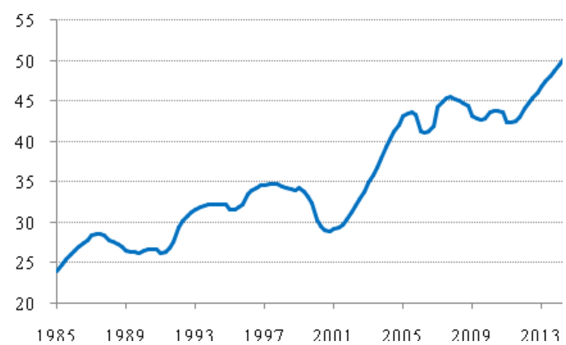
b). GDP per Capita



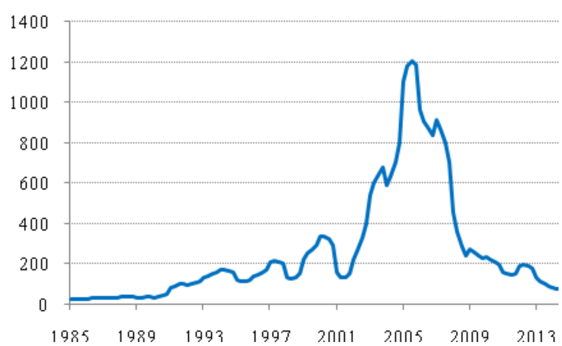
c). Energy Consumption



d). Financial Development (Bank-based)



e). Financial Development (stock market-based)



f). Financial Development (overall)

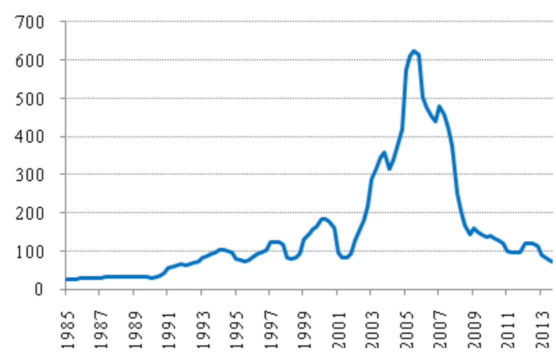
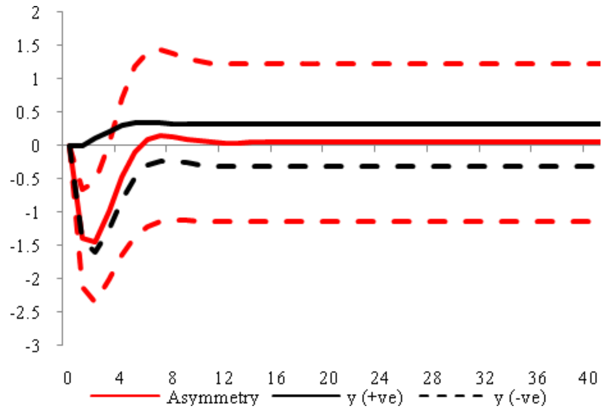
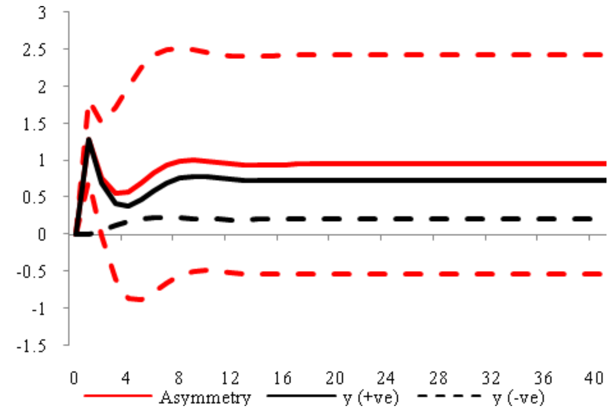


Figure 2: CO_2 Emissions–Economic Growth Dynamic Multipliers

a). Banks



c). Stock



c). Overall financial development

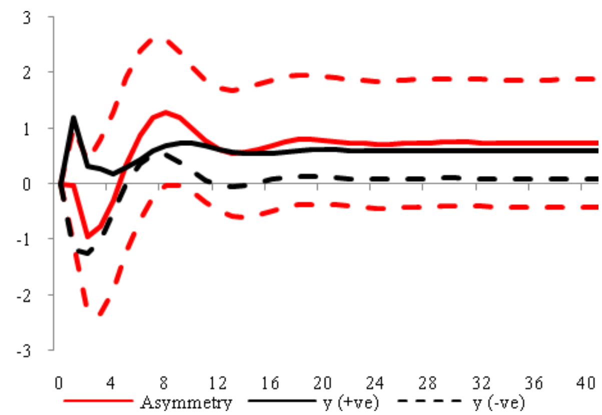
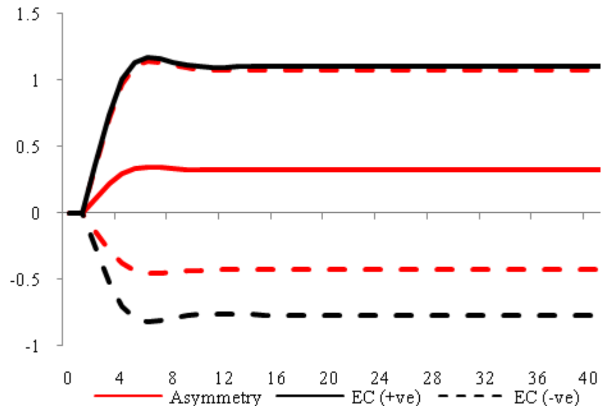
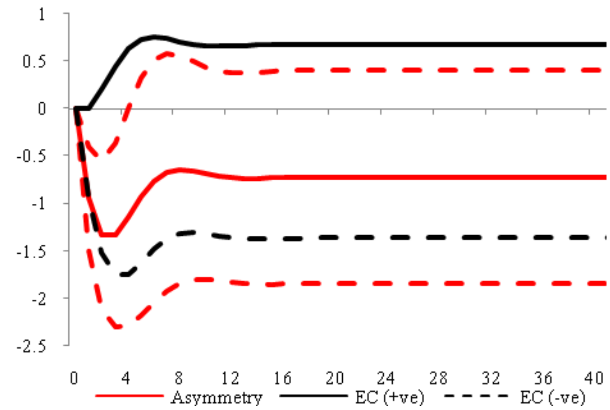


Figure 3: CO_2 Emissions–Energy Consumption Dynamic Multipliers

a). Banks



c). Stock



c). Overall financial development

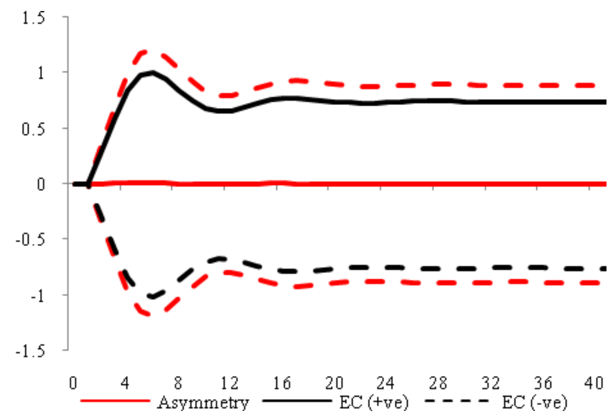
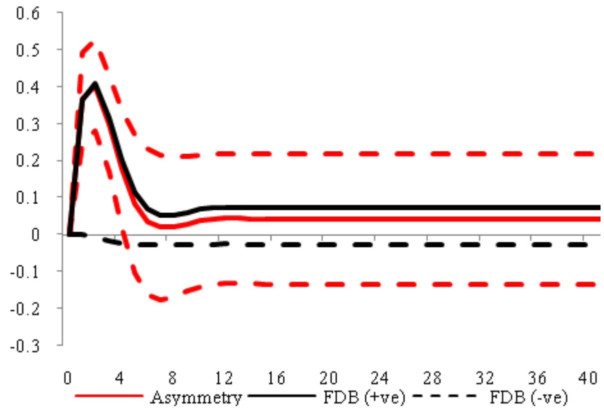
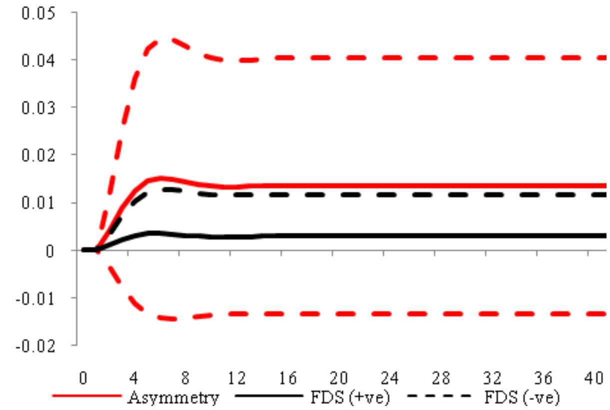


Figure 4: CO_2 Emissions–Financial Development Dynamic Multipliers

a). Banks



c). Stock



c). Overall financial development