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Do crude oil price changes affect economic growth of India, Pakistan and Bangladesh?

A multivariate time series analysis

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Abstract

This paper analyzes empirically the effect of crude oil price change on the economic growth of Indian-Subcontinent (India, Pakistan and Bangladesh). We use a multivariate Vector Autoregressive analysis followed by Wald Granger causality test and Impulse Response Function (IRF). Wald Granger causality test results show that only India's economic growth is significantly affected when crude oil price decreases. Impact of crude oil price increase is insignificantly negative for all three countries during first year. In second year, impact is negative but smaller than first year for India, negative but larger for Bangladesh and positive for Pakistan.

***Keywords*:** Oil price shocks, Economic growth, Vector Autoregressive, Impulse response function, Wald Granger causality test

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1. Introduction

Indian Subcontinent is a region known for its long cultural history. The three countries under study were a single country till 1947. They won independence from British rule in 1947 as two separate countries; India and Pakistan. Later in 1971, Pakistan was further divided into two parts, and Bangladesh appeared on global map as an independent country. These countries economically and culturally have some common features. They are developing and net oil importing countries. India is emerging as an industrialized country. The energy requirements of these countries are largely fulfilled through crude oil imports. They are active members of SAARC (South Asian Association of Regional Cooperation) organisation which claims that the region is energy deficient. The region doesn't produce enough oil and gas for its domestic requirements. It depends heavily on oil imports. Some of the SAARC countries are even unable to meet their domestic demand for electricity. Estimates suggest that energy demand of the region will increase three times in the next fifteen to twenty years (SAARC 2011).

Economists through empirical analysis of different economies have indicated that oil price volatility has significant impacts on economic growth (Hamilton 1983, Mork, et. al 1994, Carlton 2010). IEA (International Energy Agency) (2004) in its report concludes that the impacts are even more severe for developing economies. Report mentions that the reason behind these severe impacts is that use of energy in developing countries is inefficient. Alternative energy resources are not much developed for most of the developing countries as compared to developed countries. Further net oil-importing developing countries use oil in double quantity as compared to developed countries to produce a unit of economic output. Moreover, developing countries are less capable to deal with financial crises created by higher oil import costs.

The majority of empirical studies related to changes in crude oil price and its impact on economic growth had been conducted for developed economies (Burno and Sachs 1982, Hamilton 1983, Hooker 1996). This is mainly because of share of developing countries is small in overall world economy and data for developing countries is not easily available as it is for developed countries. But in recent years some studies have been carried out to analyse the impacts of crude oil price changes, energy consumption and economic growth for developing countries (Kumar 2009, Malik 2008, Hsieh 2008, Du et al 2010).

Bacon (2005) in a report for ESMAP (Energy Sector Management Assistance Program) and UNDP (United Nations Development Programme) analyzed the impacts of higher crude oil prices on population and economy of poor countries. In this report, it is observed that $10 per barrel increase in the price of crude oil, for some poor countries with per capita income below 300$, economic growth can decrease 4%. If oil price increase is $20 per barrel the shock can be double. In contrast, countries with higher foreign reserves and GDP per capita over 9000$, the decrease in GDP growth rate can be on average 0.4%. A sustain increase of $10 per barrel in crude oil price reduces world GDP by 0.5% over all and further 0.5% for net oil importing countries.

Keeping in view these reports about significant impacts of crude oil price on economic growth for developing countries it would be interesting to know the situation in Indian-Subcontinent. In last three decades oil prices are more volatile than time period before OPEC (Organization of the Petroleum Exporting Countries) started to play its role in world oil supply and pricing.

The purpose of this paper is to investigate the impact of crude oil price changes on the economic growth of India, Pakistan and Bangladesh using empirical data and econometric methods for last three decades (1981-2010). In our empirical analysis we use VAR (Vector Auto Regression) which is widely used by other researchers in studies on similar topics (Jimenez-Rodrigues and Sanchez 2004, Malik 2008, Kumar 2009, Du et al 2010). VAR estimation results are used for Wald Granger causality test to analyse weather oil price changes granger cause economic growth or not. VAR estimation results are also used to analyze quantitative impact from unit change in crude oil price on economic growth by IRF (Impulse Response Function). Estimations are carried out in Stata 10.1 (StataCorp 2007) software.

The rest of the paper is organised as follows. Section 2 gives a literature review. The literature review is followed by theoretical frame work in section 3. Empirical analysis is in section 4. Section 5 concludes the thesis.

2. Literature Review

Impact of oil price change on economic growth has received considerable attention in literature since early 1980s. Burno and Sachs (1982) analysed through theoretical and empirical analyses the impacts of input prices on economic growth with a focus on UK manufacturing in seventies. They concluded that higher prices of raw materials particularly oil had significantly affected the economic growth of UK.

Hamilton (1983) using VAR analysis concluded that recessions prior to 1973 would have been different in magnitude if oil price had not increased. He further mentioned that oil price increase may have been one of the reasons for post-war recessions.

Gisser and Goodwin (1986) tested three popular notions about oil price shocks. They analysed if impacts of oil prices shocks were in the form of Cost push inflation and also if the impact was different before and after 1973. They concluded that oil price shocks had both real and inflationary impacts on economic indicators.

Hooker (1996) showed that oil price shock of 1973 had larger impact on macroeconomy as compared to shock in 1979 for US economy.

Jimenez-Rodrigues and Sanchez (2004) conducted a study of oil price shocks on GDP growth of OECD countries. They concluded using VAR and Granger causality analysis that interaction between oil price shocks and macroeconomic variables are significant. Both linear and non-linear models showed that oil price increase significantly reduced the economic growth of majority of oil importing countries.

Blanchard (2007) with evidence from United States, France, Germany, United Kingdom, Italy and Japan economies concludes that effects of oil price shocks have changed over time. Impacts of crude oil price change have become smaller on prices, wages, employment and output over time.

Kilian (2008) empirically analyzed the effects of exogenous oil supply shocks on US real GDP growth and consumer price index (CPI). Study concluded that oil supply shock negatively affected real GDP growth after five quarters. At 68% confidence interval the negative growth prolonged up to seven quarters but at 95% level it lasted for one quarter.

Zhang (2008) finds through empirical analysis for Japan that there is negative relationship between crude oil price and economic growth in Japan. Author confirms non-linear and asymmetric relationship between oil prices and economic growth. Study concludes that oil price shocks may have immediate and postpone impact on economic growth of Japan. Growth has shown response to oil price changes in first quarter and fourth quarter.

Carlton (2010) revisited some previous studies with a different order of variables and measures of GDP for US. Author confirmed previous literature's findings. Non-linear negative relation between crude oil price shock and US economic growth was found by the author.

Earlier studies for crude oil price change and economic growth relationship were carried out mostly for developed countries. But in recent years studies for developing countries have also been carried out.

Abeysinghe (2001) carried out a study for 12 different countries. In a combination of developed and developing countries author included Hong Kong, South Korea, Singapore, Taiwan, China, Japan, Indonesia, Malaysia, Philippines, Thailand, USA and rest of OECD countries as a group. Results from this study showed that for oil importing developing countries like Philippines and Thailand direct impact of oil price increase by 50% GDP growth declined by 5.5 and 5.7 percent respectively in the long run. Direct impact on growth of developed countries like USA and rest of OECD was comparatively small. USA GDP growth declined by .7% and OECD growth was reduced by .2% in the long run.

Bacon (2005) conducted a study for 131 countries. The study concluded that impacts of higher crude oil prices were more severe for oil importing poorer countries as compared to developed countries. The findings showed that with $10 per barrel increase in the price of crude oil, for some poor countries with GDP per capita below 300 US$, economic growth could decrease up to 4%. If oil price increase was $20 per barrel the shock was doubled. In contrast, countries with higher foreign reserves and GDP per capita over 9000 US$, economic growth shock could be 0.4% on average.

Malik (2008) using IS-LM (Investment, Saving and Liquidity preference and Money Supply) model and augmented Philips curve technique concluded that oil prices and output in Pakistan is strongly related and non-linear. In authors opinion when crude oil price remained above a threshold level of US$22/bbl it had negatively affected the economic growth of Pakistan.

Hsieh (2008) conducted study for effect of real crude oil price on economic activity of Republic of Korea. Author concluded through empirical data analysis that crude oil prices and economic growth of Korea were negatively correlated. If crude oil price increases by 10% economic growth of Korea decreases 0.42%.

Kumar (2009) through linear and non-linear specifications concluded that increase in real oil prices affected the industrial growth of India negatively. Kumar used index of industrial production as proxy to measure the growth on quarterly basis. He concluded that a 100% increase in the real oil prices reduced industrial production of India by 1%.

Du *et al* (2010) conducted a study to investigate crude oil price shocks on macro-economic growth of China. Through VAR analysis authors concluded that oil price increase had positive significant impacts on macro-economic activity of China. Authors concluded that a 100% increase in crude oil price showed positive growth of Chinese's economy by 9% and CPI by 2.08 for linear model specification. The non-linear model specification results were asymmetric and different for different transformations. Results showed that a 100% decrease in world oil prices cumulatively decreased the growth rate of China's GDP by 17% for Mork (1989) transformation, 10% for Hamilton (1996) transformation and 1% for transformation suggested by Lee et al. (1995).

From the literature review it is difficult to draw a single conclusion about the impacts of crude oil prices on economic growth. It is different from economy to economy. The majority of researchers for developed countries agree upon the negative relationship between crude oil price and economic growth. Empirical findings for developing countries vary more in directions of impacts. Different model specifications, choice of variables and monetary policies can be the reasons of variations in results.

3. Theoretical Framework

Measurement of economic growth of a country is a complex issue. It comprises of different contributing channels and factors. Economic literature (Romer 2006) emphasizes that output is mainly a function of capital and effective labour.

In this study the econometric model is based on the following Cobb-Douglas aggregate production function:

$$Y_t = K_t^{\alpha} L_t^{\beta} OP_t^{\gamma} e^{\delta A_t} e^{\varepsilon_t} \qquad (1)$$

Where

Y_t is output in time period t measured by Real GDP per capita (*gdp*).

K_t is Capital in time period t measured by Gross Capital Formation (*gcf*).

L_t is labour in time period t measured by labour participation rate (*lpr*).

OP_t is real crude oil price in time period t measured in US$. *(op)*

A_t is technological growth in time period t we assume that in the region technology grows exponentially *(tg)*.

ε_t is the error term.

In parenthesis are the variable names used in the estimations and analysis.

Taking natural logarithms on both sides of (1), we have

$$\ln Y_t = \alpha \ln K_t + \beta \ln L_t + \gamma \ln OP_t + \delta A_t + \varepsilon_t \qquad (2)$$

Where $\varepsilon_t \sim$ iid $N(0,\sum)$ and $\sum$ is variance-covariance matrix of the error term.

Since there are no specific data measurements for technological growth in the region we have used a trend variable (*tg*) as a proxy in our estimations with the assumption that it grows exponentially over time.

Real GDP per capita is measured in constant 2000 US dollars. Gross Capital Formation is included to cover the capital sector. It consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Data are in constant 2000 U.S. dollars. Labour is measured through labour force participation rate. Labor force participation rate is the proportion of the economically active population aged 15 and above. Detailed definitions of GDP per capita, gross capital formation and labour participation rate from World Bank's Meta file are given in Appendix 1.

Crude oil is traded in different markets and it has different impacts on domestic economies due to different taxation and subsidies policies of the countries. We have used real crude oil price which is domestic crude oil price in US$ adjusted for CPI in the US. This formulation was used in several earlier studies as well (Burbidge and Harrison 1984, Hsing 2007; Gounder and Bartleet 2007).

In empirical studies different non-linear transformations of oil prices are used. Jimenez-Rodrigues and Sanchez (2004 cited Lee et al 1995) used scale transformation using AR (4) – GARCH (1, 1) representation of oil prices. Kummar (2009 cited Hamilton 1996) proposed net oil price increase (NOPI) in its non-linear transformation. NOPI is a percentage change in real oil price levels in past 4 and 12 quarters.

We have used asymmetric specification taking oil price change as two different variables which is also used as one of specification by other researchers (Kumar 2009, Jimenez-Rodrigues and Sanchez 2004). Two variables are defined as

$$op_t^{+} = \begin{cases} \Delta lop_t & \text{if } \Delta lop_t > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$op_t^{-} = \begin{cases} \Delta lop_t & \text{if } \Delta lop_t < 0 \\ 0 & \text{otherwise} \end{cases}$$

Where $\Delta lop_t = \ln(Op_t) - \ln(Op_{t-1})$

Based on our aggregate production function in (2) and transformation of oil price variable our econometric model is:

$$lgdp_t = \alpha lgcf_t + \beta llpr_t + \gamma_1 op_t^{+} + \gamma_2 op_t^{-} + \delta tg_t + \varepsilon_t \qquad (3)$$

lgdp, lgcf, llpr are natural logarithms of real GDP, real gross capital formation, labour participation rate respectively, and *tg* is a trend proxy for technological growth. α, β, γ_1, γ_2 and δ are parameters of independent variables to be estimated. Selection of real GDP per capita enables the model to take into account the population growth and inflation. Signs of coefficients are expected to be positive for all independent variables except op_t^{+}. This expectation about signs is based on the majority findings of previous literature and economic theory that an increase in input price affects the economic growth negatively. Other variables are expected to have positive impacts on economic growth.

4. Empirical Analysis

4.1 Data

One of the main obstacles for research about developing countries is the availability of data. To increase the sample size researchers have used different measures (Kumar 2009, Malik 2008) to convert annual data series into quarterly data series. Malik used Lisman and Sandee (1964) methodology. Ginsburgh (1973) is of view that this method doesn't work very well and even some time gives strange results. Kumar (2009) and Du et al (2010) used IIP (Industrial Index Production) as a proxy which itself is difficult to motivate as true representative of economic growth. Gross (2012) concludes that industry production index of output only represents 30% of overall economic activity. According to CIA's fact book 2011 estimates industry constitutes 26.3%, agriculture 18.1% and services 55.6% in India's GDP[1].

We use annual data which is available from authentic sources. We have tried to avoid imputation or regeneration of datasets for shorter interval (quarterly or monthly) to minimize chances of conflicts about different data generation procedures. Another reason for selecting annual data is critics about quarterly data of national accounts especially for GDP and its measurement. These developing economies have agriculture as one of the major

[1]These statistics are obtained from https://www.cia.gov/library/publications/the-world-factbook/geos/in.html

contributor to their GDP. The nature of agricultural products doesn't allow them to mature on monthly or quarterly basis. The majority of crops yield either once a year or it takes them a complete year to be produced.

Taking data on annual basis will result into relatively small sample in our analysis but the accuracy and authenticity of data is equally important. Even longer time period could have been included but Bangladesh became independent in 1971 so we decided to start almost a decade after its independence.

Data for all macroeconomic variables under consideration were obtained from World Bank's free database available on-line. Oil prices are annual average prices adjusted for consumer price index in US for December 2011. Historical prices are retrieved from http://inflationdata.com/inflation/inflation_rate/historical_oil_prices_table.asp . Prices given on this link are originated from IOGA (Illinois Oil & Gas Association).

All monetary valued variables except crude oil price are measured in US$ (2000 constant). It enabled us to account for single currency measurement to avoid multiple currency valuation differences. An output of summary statistics of the dataset for each country obtained from Stata is given in appendix 2.

4.2 VAR modelling

Sims (1980) considering theoretical restrictions imposed on structural simultaneous equations as 'incredible' introduced vector autoregressive modelling technique. Du et al (2010 cited Jones et al., 2004) "The VAR model has become one of the leading approaches employed in analysis of the dynamic economic systems, especially in research of the interactions between oil price shocks and macro-economy". Researchers have used this modelling technique frequently to investigate impacts of crude oil price shocks on the economic growth (Hamilton 1996, Hooker 1996, Rodrigues and Sanchez 2004).

A VAR model with two time series variables, Y_t and X_t consists of two equations where in one equation Y_t is the dependant variable and in the other equation X_t is the dependent variable. The independent variables in both equations are lagged values of both X_t and Y_t. In general terms a VAR model is a set of k time series regressions, in which the regressors are lagged values of all k series.

In notation form we can write bi-variate p lagged VAR model including a constant as

$$Y_t = \beta_{10} + \beta_{11}Y_{t-1} + \ldots\ldots + \beta_{1p}Y_{t-p} + \gamma_{11}X_{t-1} + \ldots\ldots + \gamma_{1p}X_{t-p} + \varepsilon_t^Y \quad (4)$$

$$X_t = \beta_{20} + \beta_{21}Y_{t-1} + \ldots\ldots + \beta_{2p}Y_{t-p} + \gamma_{21}X_{t-1} + \ldots\ldots + \gamma_{2p}X_{t-p} + \varepsilon_t^X \quad (5)$$

In our analysis we used VAR model of order (p) similar to Du et al (2010) with the small changes of no intercept and inclusion of an exogenous trend variable tg. For a set of k time series variables VAR (p) is

$$y_t = \sum_{i=1}^{p} \gamma_i y_{t-i} + \emptyset t g_{it} + \varepsilon_{it} \quad (6)$$

Where $y_t = (y_{1t}, y_{2t}, \ldots, y_{kt})$ is a $(k \times 1)$ vector of endogenous variables, y_{t-i} is the corresponding lag terms of order i. γ_i is the i^{th} $(k \times k)$ matrix of autoregressive coefficients of vector y_{t-i} for i=1,2,…,p. While $\emptyset$ is $(k \times 1)$ vector of coefficients of exogenous trend variable tg and $\varepsilon_{it} = (\varepsilon_{1t}, \varepsilon_{2t}, \ldots, \varepsilon_{kt})'$ is $(k \times 1)$ vector of a white noise process.

For VAR estimates to be consistent, the time series have to be stationary. If the time series in this study prove to be stationary at levels we use variables at level otherwise they are used first differenced. Possibility of using Vector Error Correction (VEC) model for the time series being first differenced stationary is not adopted because of a relatively small sample size. Baltagi (2008) suggests using simple VAR for small samples.

Number of parameters obtained through recursive VAR is generally large therefore they are used to determine the significance and direction of relationship from equation to equation. Results obtained from VARs are used frequently for further structural analysis. Two important functions of VARs are their use for testing Granger causality and impulse response analysis.

An important implication of VAR is their use for causality analysis. To test for the casual relationship between two variables in previous literature of this type of analysis researchers have used Granger Causality test. This test mentions that a time series variable x_t is Granger causal for y_t if x_t significantly contributes to predict y_t for some future period.

Second commonly used implication from VAR estimation is Impulse Response Function (IRF) values. These values help to estimate how a unit shock in impulse variable is responded by response variable keeping others constant. We analyze the impulse and response from crude oil price to GDP per capita.

4.2.1 Unit Root Test

In economic research, test for stationary condition for time series is becoming vital. It is generally observed that regression estimates generated through standard estimation for a non-stationary time series are misleading. Granger and Newbold (1974) concluded that in non-stationary time series analysis usual t and F tests will be misleading, while the estimates are characterized by high R^2 and low Durbin-Watson statistics. This phenomenon in literature is known as spurious or non-sense regression.

Different tests have been developed by researchers to test for unit root. Two popular tests for time series data are the Dickey-Fuller (DF) test proposed by Dickey and Fuller (1979) and the Phillips-Perron (PP) test proposed by Philips and Perron (1988). Null hypothesis of both PP and DF test is that unit root exists in time series with the alternative being no unit root. The main difference between these two tests is how they treat serial correlation in the test regressions.

In our analysis we have used Dickey-Fuller unite root test. The null hypothesis of the test is that the variable contains a unit root, and the alternative is that the variable is generated by a stationary process. If unit root is found on levels then test is applied on first difference and second difference until evidence of unit root vanishes. Unit root test results are presented in Tables 1(a), 1(b) and 1(c) for India, Pakistan and Bangladesh respectively.

Table 1(a): Augmented Dickey Fuller Unit Root test Results for Time Series – India

	Levels	**First Difference**	**Second Difference**
lgdp	3.734	-3.766***	-
lgcf	0.917	-6.298***	-
op^{+}	-4.281 ***	-	-
op^{-}	-6.141 ***	-	-
llpr	0.857	- 3.051**	- 9.605***

Critical values at 1%, 5% and 10% level of significance are - 3.736, - 2.994 and - 2.628.

*, **, *** indicate significant at 10%, 5% and 1% level respectively.

Table 1(b): Augmented Dickey Fuller Unit Root test Results for Time Series – Pakistan

	Levels	First Difference	Second Difference
lgdp	- 0.430	- 3.640**	-6.933***
lgcf	- 0.917	- 6.298***	-
op^+	-4.402***	-	-
op^-	-5.627***	-	-
llpr	0.320	-4.715 ***	-

Table 1(c): Augmented Dickey Fuller Unit Root test Results for Time Series – Bangladesh

	Levels	First Difference	Second Difference
lgdp	8.397	-2.251	-8.142***
lgcf	0.472	-3.362**	-6.684***
op^+	-4.402***	-	-
op^-	-5.627***	-	-
llpr	0.113	-1.877	-5.234***

4.2.2 Cointegration Test

Unit root tests in the previous section show that all the variables in our data sets are not stationary at levels. Next step is to examine their cointegration vectors. So we examined them if they are cointegrated or not.

Different approaches and test techniques have been developed for cointegration tests. The Engle-Granger (1987) developed a two-step residual-based cointegration test for time series with the null hypothesis that two series are non-cointegrated. Gregory and Hansen (1996) proposed a test for time series cointegration with regime shifts with the null hypothesis of no cointegration against the alternative of cointegration. We have used residual based cointegration test developed by Engle-Granger (1987) with H0: No Cointegration between variables. The results are given in table 2.

Table 2: Augmented Engle-Granger test for cointegration – By Country

Lags	India	Pakistan	Bangladesh
0	- 5.753*	- 4.203***	-5.078**
1	- 4.805**	- 3.513***	-3.857 ***
2	- 3.211***	- 2.009***	-3.247***

MacKinnon (2010) critical values for 1%, 5% and 10% are - 5.830, - 4.952 and - 4.535. symbols *, ** and *** in above table indicate that test statistics is significant at 10%, 5% and 1% level of significance respectively. Hence we can significantly reject the null hypothesis at 5% level from 1st lag onward. Thus series are cointegrated in all three countries.

4.2.3 VAR order selection

After analyzing the data for Unit Root and Cointegration an important step for VAR analysis is to determine the lag length for the model. Different tests are being used in the literature for VAR lag order selection purposes. Popular are the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), the Hannan and Quinn information criterion (HQIC) and Likelihood Ratio (LR) test. Each test has its advantages and disadvantages when comparing sample size and model variables. Selection of lag length in relatively small sample is more critical as choosing a longer lag length will consume considerable degree of freedom. Lütkepohl (2004) has suggested estimating model with different lag lengths and then apply tests of model specifications in order to eliminate risk of wrong use of lag length. Gujrati (2004) is of the view ‘There is no question that some trial and error is inevitable’. Computer software’s have made trial and error easier. They are helpful in choosing lag lengths which give more opportunities to pick correct and stable models. We tested model for 2, 3 and 4 lag lengths. Only VAR (2) passed post estimation stability and specification tests. Thus we used lag length 2 for our model. Lütkepohl (2005) suggested VAR (2) for the dataset where T=30 after applying different orders for VAR to different sample sizes. Keeping in view the size of the sample and previous literature chosen lag length is motivated. Majority of the studies mentioned in the literature review found that oil price impacts on economic growth vanished after 6-8 quarters. Time series included by us in this study is yearly based which covers 4-quarters in one lag.

Unit root tests have already revealed that our time series are non-stationary at levels for all countries except oil price variables which are readily generated through differencing process. Therefore, our VAR contains *lgdp lgcf* and *llpr* first differenced while *tg* is a trend variable which is used as an exogenous variable in the estimation of VAR system. Variables used in differenced form are reported with Δ as a prefix with their names in the estimation results.

4.3 Results and analysis

4.3.1 India

VAR results from India's time series data are given in Table 3. Results indicate that when the crude oil prices increases (op^{+}) the impact on economic growth is negative but it is insignificant. The negative impact is smaller in second year. The impact of crude oil price decrease is stronger than increase. When oil price decreases the first lag still shows negative impact but it is smaller than the impact created by oil price increase. The significant impact of crude oil price decrease on Indian economic growth is in second year. The results show that oil price decrease impacts on Indian economic growth is positively significant on second lag. It is probably because the real impacts of policy adjustments for oil price change show into local economy after some time. Gross capital formation shows a positive insignificant coefficient on first lag but there is significant positive impact from capital formation on the second lag. Labour participation rate's coefficients indicate that labour contributes positively to economic growth of India during first year and negatively next year. Impact of labour is insignificant for both lags. Trend variable technological growth has highly significant positive coefficient. This is in lines with economic theory's predictions. In Table 3 we have presented only results for the VAR when *lgdp* is dependant variable. Results for all recursive system of equations for all countries obtained from Stata are given in Appendix 3.

Table 3: Vector Auto Regressive results for – India (Dependant variable: $\Delta lgdp$)

Independent Variables		Coef.	Std. Err.	Z	P>z
$\Delta lgdp$	L1	-.2549371	.2302316	-1.11	0.268
	L2	-.1691143	.1979119	-0.85	0.393
$\Delta lgcf$	L1	.057362	.0554872	1.03	0.301
	L2	.1730879	.0590499	2.93	0.003
$\Delta llpr$	L1	1.424427	2.055242	0.69	0.488
	L2	-.6472104	2.780398	-0.23	0.816
op^{+}	L1	-.0492576	.0342686	-1.44	0.151
	L2	-.0119981	.0293575	-0.41	0.683
op^{-}	L1	-.0132773	.0245689	-0.54	0.589
	L2	.0678266	.0235849	2.88	0.004
Tg		.0026206	.0005663	4.63	0.000

R-Squared: 0.9128

Estimation results obtained through VAR are then used for Wald granger causality test and impulse response function. Wald granger test with H0: endogenous variable (Excluded) do not Granger cause the dependent variable (Equation) while others remaining constant.

In other words, system of VAR equations is testing if $\Delta lgdp$ is granger caused by $\Delta lgcf$, $\Delta llpr$ or changes in crude oil prices. The evidence of chi^2 and p-values in Table 4 show that we can reject the null hypothesis in gross capital formation case. Null hypothesis cannot be rejected for labour and crude oil price increase variables. Crude oil price decrease variable is significant so we can reject H0. Hence, on the basis of our Wald Granger causality test statistics we can conclude that oil price increase doesn't granger cause the economic growth of India but when price declines it granger cause the economic growth. We have presented only results from all other endogenous variables to GDP in Table 4 which are of prime interest. Wald Granger causality test for Pakistan and Bangladesh will be reported in same way. Complete results for all equations obtained from Stata are given in Appendix 4.

Table 4: Wald Granger Causality test Results - India

Equation	*Excluded*	chi2	Df	Prob > chi2
$\Delta lgdp$	$\Delta lgcf$	8.5957	2	0.014
$\Delta lgdp$	$\Delta llpr$	.53395	2	0.766
$\Delta lgdp$	op^{+}	2.336	2	0.311
$\Delta lgdp$	op^{-}	8.7658	2	0.012
ALL		20.79	8	0.008

Impulse responses table is obtained after VAR to see the magnitude of impact caused by crude oil price change on GDP growth. Table 5 shows the response from crude oil price changes to GDP per capita growth. The table shows that if crude oil price is increased by 10% it will reduce the GDP per capita growth by 0.49% in first year and 0.20% in second year. On the other hand if crude oil price is decreased by 10% it will still decrease the GDP growth by 0.13% in first year and will increase by 0.60% in next year. Graphs for impulse response functions for all countries are given in Appendix 5.

Table 5: Impulse Response Functions Table - India

	(1)	**(1)**	**(1)**	**(2)**	**(2)**	**(2)**
step	**Irf**	**Lower**	**Upper**	**irf**	**Lower**	**Upper**
0	0	0	0	0	0	0
1	-.049258	-.116423	.017908	-.013277	-.061431	.034877
2	-.020261	-.086026	.045504	.059715	.014848	.104582

95% lower and upper bounds reported

(1) Impulse = $op+$, and response = $\Delta lgdp$ (2) Impulse = $op-$, and response = $\Delta lgdp$

4.3.2 Pakistan

VAR results for Pakistan's data are shown in Table 6. Result for crude oil price increase is negative for first year and positive for second year. These impacts are insignificant for both lags. In case of oil price decrease the impact is positively insignificant for first lag and positively significant for the second lag. Gross capital formation's results are positive for both lags but significant only for the second lag. Labour participation rate is insignificantly positive in first year and negatively insignificant for second lag. Trend variable technological growth's impact is positively insignificant.

Table 6: Vector Auto Regressive estimation results –Pakistan (Dependant variable: $\Delta lgdp$)

Independent Variables		**Coef.**	**Std. Err.**	**Z**	**P>z**
$\Delta lgdp$	*L1*	.2634469	.1803152	1.46	0.144
	L2	-.0573117	.1814124	-0.32	0.752
$\Delta lgcf$	*L1*	.0233724	.0449561	0.52	0.603
	L2	.1214922	.046001	2.64	0.008
$\Delta llpr$	*L1*	.2948762	.3687324	0.80	0.424
	L2	-.2965451	.3553916	-0.83	0.404
op^{+}	*L1*	-.0379467	.0345418	-1.10	0.272
	L2	.0324209	.0325509	1.00	0.319
op^{-}	*L1*	.005959	.0218126	0.27	0.785
	L2	.0509522	.0247171	2.06	0.039
Tg		.0000383	.000408	0.09	0.925
R-Squared:	0.7129				

Wald Granger causality test results for the system of equation when $\Delta lgdp$ is dependant variable are presented in Table 7. These results show that we can't reject the null hypothesis for *lgcf*. It means in the VAR model *lgcf* granger causes *lgdp*. Other variables including crude oil price changes in both directions have insignificant impacts on the economic growth of Pakistan. Hence from Wald test we can conclude that crude oil price changes do not impact significantly on economic growth of Pakistan.

Table 7: Granger Causality Wald test Results - Pakistan

Equation	***Excluded***	**chi2**	**Df**	**Prob > chi2**
$\Delta lgdp$	$\Delta lgcf$	7.0418	2	0.030
$\Delta lgdp$	$\Delta llpr$	1.4992	2	0.473
$\Delta lgdp$	op^{+}	1.8149	2	0.404
$\Delta lgdp$	op^{-}	5.4097	2	0.067
ALL		11.232	8	0.189

Table 8 represents Impulse Response functions. Crude oil price change is impulse variable and GDP growth per capita is response variable. From impulse response table we can conclude that if crude oil price is increased by 10% it will reduce growth of GDP per capita of Pakistan by 0.38% during first year but will increase it by 0.17% in the next year. If oil price is decreased by 10% GDP growth will increase by 0.05% for the first lag and 0.45% for the second lag.

Table 8: Impulse Response Functions Table – Pakistan

	(1)	**(1)**	**(1)**	**(2)**	**(2)**	**(2)**
step	**Irf**	**Lower**	**Upper**	**irf**	**Lower**	**Upper**
0	0	0	0	0	0	0
1	-.037947	-.105648	.029754	.005959	-.036793	.048711
2	.016741	-.051523	.085004	.044472	.000766	.088179

95% lower and upper bounds reported

(1) Impulse = *op*+, and response = Δ*lgdp* (2) Impulse = *op*–, and response = Δ*lgdp*

4.3.3 Bangladesh

Table 9 shows VAR results for Bangladesh. VAR system of equation with Δ*lgdp* as dependant variable indicates that gross capital formation impacts the economic growth in first year negative and positive in second year. Impact is insignificant for both years. Labour has same tendency in the system. It is negative at first lag and positive on second lag. Both lags have insignificant results. Curd oil price change has no significant impact on economic growth of Bangladesh in our estimation results. It has negative impact when oil price increases for both lags. Impact is smaller for the first lag and comparatively larger for the second lag. Crude oil price decrease has negative impact for both years. The negative impacts are marginally smaller when oil price decreases as compared to price increase. Trend variable technological growth has significant positive impact.

Table 9: Vector Auto Regressive estimation results – Bangladesh

Independent Variables		**Coef.**	**Std. Err.**	**Z**	**P>z**
Δlgdp	*L1*	-.0384359	.1858899	-0.21	0.836
	L2	-.1079487	.1855203	-0.58	0.561
Δlgcf	*L1*	-.0397492	.0705189	-0.56	0.573
	L2	.1179102	.0732717	1.61	0.108
Δllpr	*L1*	-.33113	.5430667	-0.61	0.542
	L2	.466414	.5286389	0.88	0.378
op^+	*L1*	-.0019681	.0149785	-0.13	0.895
	L2	-.0221063	.0148025	-1.49	0.135
op^-	*L1*	-.0117877	.010341	-1.14	0.254
	L2	-.018588	.011173	-1.66	0.096
Tg		.0018706	.0004678	4.00	0.000

R-Squared: 0.9516

Wald Granger Causality test results for Bangladesh are presented in Table 10. Wald Granger causality test for both crude oil price variables have P>.05. Thus we can't reject the null hypothesis based on our results and can conclude that curd oil price change in either direction doesn't granger cause economic growth of Bangladesh.

Table 10: Wald Granger causality test - Bangladesh

Equation	***Excluded***	**chi2**	**Df**	**Prob > chi2**
Δlgdp	*Δlgcf*	2.9886	2	0.224
Δlgdp	*Δllpr*	.79887	2	0.671
Δlgdp	op^+	2.3623	2	0.307
Δlgdp	op^-	3.9781	2	0.137
ALL		7.7863	8	0.455

Impulse response function's results for Bangladesh are presented in Table 11. The magnitude of unit change in the price of crude oil has small impact on growth of GDP per capita in Bangladesh. If crude oil price is increased by 10% growth of GDP per capita is decreased by 0.02% on first lag and 0.25% second year. Similarly, if crude oil price is decreased by 10% GDP per capita growth is decreased 0.12% for first lag and 0.19% for the second lag. These empirical results for Bangladesh indicate that crude oil price is not a significant factor for country's economic growth.

Table 11: Impulse Response Functions Table – Bangladesh

step	(1) Irf	(1) Lower	(1) Upper	(2) irf	(2) Lower	(2) Upper
0	0	0	0	0	0	0
1	-.001968	-.031326	.027389	-.011788	-.032056	.00848
2	-.024519	-.052782	.003744	-.019113	-.039997	.001772

95% lower and upper bounds reported

(1) Impulse = *op+*, and response = $\Delta lgdp$ (2) Impulse = *op–*, and response = $\Delta lgdp$

4.4 Model's specification tests

4.4.1. Stability Condition Test

Lastly model's estimates are further tested for stability through eigenvalues stability condition. Method for eigenvalues in Stata (2009a) is mentioned as it forms a companion matrix

$$\boldsymbol{A} = \begin{pmatrix} \boldsymbol{A_1} & \boldsymbol{A_2} & \cdots & \boldsymbol{A_{p-1}} & \boldsymbol{A_p} \\ \mathbf{I} & \mathbf{0} & \cdots & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I} & \cdots & \mathbf{0} & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{I} & \mathbf{0} \end{pmatrix}$$

and obtains eigenvalues using matrix's eigenvalues. The modulus of the complex eigenvalue $r + ci$ is $\sqrt{r^2 + c^2}$. StataCorp (2009a cited Hamilton 1994 and Lütkepohl 2005) that a VAR is stable if the modulus of each eigenvalue of companion matrix is strictly less than 1. Eigenvalues modulus for each country gives results that all eigenvalues are inside the unit circle. Thus our VAR model fulfills the stability conditions. Eigenvalues stability test graphs and tables for each country obtained from Stata are reported in Appendix 6.

4.4.2. Lag Order Autocorrelation Test

VAR estimates are also tested for lag order autocorrelation. LM (Lagrange-multiplier) test for residual autocorrelation suggested by Johansen (1995) is applied. H0 of the test is no autocorrelation at lag orders. Method and formula for LM test statistic described by Stata (2009b) is given as:

$$\text{LMs}= (T - d - 0.5)\ln\left(\frac{|\hat{\Sigma}|}{\tilde{\Sigma}_s}\right)$$

Where T is number of observations in VAR, $\hat{\Sigma}$ is the maximum likelihood estimate of Σ, the variance-covariance matrix of the disturbances from the VAR and $\tilde{\Sigma}_s$ is the maximum likelihood estimate of Σ from the augmented VAR created for residuals of original VAR and d is the number of coefficients estimated in the augmented VAR.

LM residual test results for all three countries are presented in Table 10 collectively. The Chi^2 and P-values show that we can't reject the null hypothesis on both lags for all countries. Therefore, our VAR model has no lag order autocorrelation.

Table 12: Lagrange-multiplier (LM) test for residual autocorrelation after VAR

	India		Pakistan		Bangladesh	
Lags	**chi^2**	**Prob > chi^2**	**chi^2**	**Prob > chi^2**	**chi^2**	**Prob > chi^2**
1	33.3332	0.12295	26.5278	0.37988	34.8801	0.09040
2	22.1112	0.62931	20.6406	0.71247	24.6674	0.48113

5. Discussion and Conclusions

In this study we have analyzed impact of crude oil price change on economic growth of India, Pakistan and Bangladesh from 1981 to 2010. We based our model on aggregate production function with inclusion of oil price as a factor affecting economic growth. Other explanatory factors are capital, labour and technological growth. For estimation purpose we used VAR modelling technique proposed by Sims (1980).

Our analysis shows that crude oil price increase has negative impact on all three countries on first lag. This negative impact continues for next lag as well for India and Bangladesh but for Pakistan impact becomes positive. The important finding about crude oil price increase variable is that its impact is small and insignificant. In comparative analysis of three economies India faces more negative impact than other two. In contrast to Kumar (2009) impact on economic growth of India are small in our analysis. The reason behind this could be the fact that Kumar included industrial growth as a growth variable. Intuitively industrial growth is largely driven by energy consumption and crude oil is major source of energy for India. Thus its higher impact on industrial growth is expected.

Bangladesh is comparatively new and small economy. Crude oil price change in any direction has negative but insignificant role in the economic growth of Bangladesh.

Crude oil price increase variable has a negative impact on Pakistan's economic growth in first year and positive in second year. These results are insignificant. Oil price decrease has positive impact for both lags for Pakistan. This impact is significant only on second lag.

Wald Granger causality test shows that crude oil price increase doesn't Granger cause economic growth of any of these three countries. Decrease in crude oil price Granger causes economic growth of India but not Pakistan and Bangladesh.

From this study we can conclude that oil price decline impact is higher for the economic growth of these countries than its increase impact. The size of the impact for these developing countries is smaller than developed countries like US and other OECD countries.

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Appendix

Appendix 1: Detailed definitions of variables mentioned in World Bank's Mata data.

GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant U.S. dollars

"Gross capital formation (GCF) (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation. Data are in constant 2000 U.S. dollars"

"***Labor force participation rate (LPR)*** is the proportion of the population ages 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period"

Appendix 2: Summary Statistics Results from Stata.

India

Variable	Obs	Mean	Std. Dev.	Min	Max
gdp	30	425.0769	166.5363	237.6568	822.7632
gcf	30	1.18e+11	8.85e+10	3.40e+10	3.40e+11
lpr	29	59.26897	1.073747	57.6	60.5
op	30	44.50067	21.34112	16.44	95.25
tg	30	15.5	8.803408	1	30

Pakistan

Variable	Obs	Mean	Std. Dev.	Min	Max
gdp	30	496.031	89.00879	354.0502	668.5464
gcf	30	1.18e+11	8.85e+10	3.40e+10	3.40e+11
lpr	29	51.3069	1.242098	49.4	54.3
op	30	44.50067	21.34112	16.44	95.25
tg	30	15.5	8.803408	1	30

Bangladesh

Variable	Obs	Mean	Std. Dev.	Min	Max
gdp	30	347.0048	89.87894	255.3386	558.0624
gcf	30	9.25e+09	6.05e+09	2.63e+09	2.22e+10
lpr	29	72.71379	1.738169	70.6	75.6
op	30	44.50067	21.34112	16.44	95.25
tg	30	15.5	8.803408	1	30

Appendix 3: VAR results from Stata.

India

```
Vector autoregression

Sample:   1984 - 2009                             No. of obs      =        26
Log likelihood =   307.9928                       AIC             = -19.46099
FPE            =   3.23e-15                       HQIC            = -18.69461
Det(Sigma_ml)  =   3.54e-17                       SBIC            = -16.79963
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_lgdp	11	.01874	0.9128	272.1285	0.0000
D_lgcf	11	.088607	0.6754	54.09107	0.0000
D_lnlpr	11	.001644	0.7726	88.313	0.0000
opu	11	.122315	0.6896	57.77569	0.0000
opd	11	.218507	0.3473	13.83663	0.2422

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_lgdp						
lgdp						
LD.	-.2549371	.2302316	-1.11	0.268	-.7061828	.1963086
L2D.	-.1691143	.1979119	-0.85	0.393	-.5570145	.2187858
lgcf						
LD.	.057362	.0554872	1.03	0.301	-.0513909	.166115
L2D.	.1730879	.0590499	2.93	0.003	.0573523	.2888235
lnlpr						
LD.	1.424427	2.055242	0.69	0.488	-2.603773	5.452627
L2D.	-.6472104	2.780398	-0.23	0.816	-6.096691	4.80227
opu						
L1.	-.0492576	.0342686	-1.44	0.151	-.1164229	.0179077
L2.	-.0119981	.0293575	-0.41	0.683	-.0695377	.0455416
opd						
L1.	-.0132773	.0245689	-0.54	0.589	-.0614314	.0348768
L2.	.0678266	.0235849	2.88	0.004	.021601	.1140522
tg	.0026206	.0005663	4.63	0.000	.0015107	.0037304
D_lgcf						
lgdp						
LD.	-.4493316	1.088575	-0.41	0.680	-2.582899	1.684236
L2D.	.2278069	.9357614	0.24	0.808	-1.606252	2.061865
lgcf						
LD.	-.2315858	.2623531	-0.88	0.377	-.7457885	.2826168
L2D.	.3633189	.2791979	1.30	0.193	-.1838989	.9105367
lnlpr						
LD.	21.71223	9.717537	2.23	0.025	2.666205	40.75825
L2D.	-20.86371	13.1462	-1.59	0.113	-46.62979	4.902375
opu						
L1.	-.1815209	.162028	-1.12	0.263	-.4990899	.1360481
L2.	-.1577443	.1388073	-1.14	0.256	-.4298016	.114313
opd						
L1.	.0271188	.1161658	0.23	0.815	-.200562	.2547996
L2.	.2061068	.1115136	1.85	0.065	-.0124559	.4246695
tg	.0055113	.0026774	2.06	0.040	.0002636	.0107589
D_lnlpr						
lgdp						
LD.	.0111806	.0202018	0.55	0.580	-.0284143	.0507755
L2D.	-.0160843	.0173659	-0.93	0.354	-.0501209	.0179523
lgcf						
LD.	-.0006845	.0048688	-0.14	0.888	-.0102271	.0088581
L2D.	.0027747	.0051814	0.54	0.592	-.0073806	.01293
lnlpr						
LD.	.0947191	.1803387	0.53	0.599	-.2587383	.4481765
L2D.	.6831765	.2439681	2.80	0.005	.2050077	1.161345
opu						
L1.	.0020193	.0030069	0.67	0.502	-.0038742	.0079127
L2.	.0074565	.002576	2.89	0.004	.0024077	.0125054
opd						
L1.	-.0004076	.0021558	-0.19	0.850	-.0046329	.0038177
L2.	.0001923	.0020695	0.09	0.926	-.0038638	.0042484
tg	-.0000781	.0000497	-1.57	0.116	-.0001755	.0000193

opu						
lgdp						
LD.	1.464865	1.502688	0.97	0.330	-1.48035	4.41008
L2D.	-1.557494	1.291742	-1.21	0.228	-4.089262	.9742742
lgcf						
LD.	.2525383	.362157	0.70	0.486	-.4572764	.9623529
L2D.	.2898786	.3854099	0.75	0.452	-.4655109	1.045268
lnlpr						
LD.	-13.55394	13.41427	-1.01	0.312	-39.84542	12.73754
L2D.	2.979734	18.14726	0.16	0.870	-32.58823	38.5477
opu						
L1.	.162343	.2236664	0.73	0.468	-.276035	.600721
L2.	-.365338	.1916121	-1.91	0.057	-.7408909	.0102148
opd						
L1.	.1583025	.1603574	0.99	0.324	-.1559922	.4725972
L2.	.0205148	.1539354	0.13	0.894	-.2811931	.3222227
tg	.0035159	.0036959	0.95	0.341	-.003728	.0107598
opd						
lgdp						
LD.	-.6115548	2.684457	-0.23	0.820	-5.872994	4.649885
L2D.	2.598046	2.307615	1.13	0.260	-1.924797	7.120888
lgcf						
LD.	-.0171287	.6469704	-0.03	0.979	-1.285167	1.25091
L2D.	-.9286747	.6885102	-1.35	0.177	-2.27813	.4207806
lnlpr						
LD.	-27.00676	23.96373	-1.13	0.260	-73.97481	19.96129
L2D.	35.62147	32.41892	1.10	0.272	-27.91845	99.16138
opu						
L1.	.3982324	.3995657	1.00	0.319	-.384902	1.181367
L2.	-.0273993	.3423029	-0.08	0.936	-.6983006	.643502
opd						
L1.	.3520279	.2864683	1.23	0.219	-.2094396	.9134954
L2.	-.1649064	.2749959	-0.60	0.549	-.7038884	.3740756
tg	.0027291	.0066026	0.41	0.679	-.0102117	.0156699

Pakistan

Vector autoregression

Sample: 1984 - 2009		No. of obs	= 26
Log likelihood =	247.0749	AIC	= -14.77499
FPE =	3.50e-13	HQIC	= -14.00862
Det(Sigma_ml) =	3.83e-15	SBIC	= -12.11364

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_lgdp	11	.019811	0.7129	64.56144	0.0000
D_lgcf	11	.082944	0.7155	65.40115	0.0000
D_lnlpr	11	.009783	0.3621	14.76078	0.1937
opu	11	.108889	0.7540	79.70702	0.0000
opd	11	.227905	0.2900	10.61911	0.4757

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_lgdp						
lgdp						
LD.	.2634469	.1803152	1.46	0.144	-.0899644	.6168581
L2D.	-.0573117	.1814124	-0.32	0.752	-.4128735	.29825
lgcf						
LD.	.0233724	.0449561	0.52	0.603	-.06474	.1114848
L2D.	.1214922	.046001	2.64	0.008	.0313318	.2116526
lnlpr						
LD.	.2948762	.3687324	0.80	0.424	-.427826	1.017578
L2D.	-.2965451	.3553916	-0.83	0.404	-.9930998	.4000096
opu						
L1.	-.0379467	.0345418	-1.10	0.272	-.1056475	.029754
L2.	.0324209	.0325509	1.00	0.319	-.0313776	.0962195
opd						
L1.	.005959	.0218126	0.27	0.785	-.036793	.048711
L2.	.0509522	.0247171	2.06	0.039	.0025075	.0993969
tg	.0000383	.000408	0.09	0.925	-.0007613	.0008379
D_lgcf						
lgdp						
LD.	.3295387	.7549534	0.44	0.662	-1.150143	1.80922
L2D.	1.54352	.7595473	2.03	0.042	.054835	3.032206
lgcf						
LD.	-.4055196	.1882248	-2.15	0.031	-.7744334	-.0366058
L2D.	.0990794	.1925997	0.51	0.607	-.278409	.4765678
lnlpr						
LD.	2.463857	1.543829	1.60	0.111	-.561992	5.489706
L2D.	-1.695874	1.487973	-1.14	0.254	-4.612247	1.2205
opu						
L1.	-.2065816	.1446217	-1.43	0.153	-.4900349	.0768717
L2.	-.1383074	.1362858	-1.01	0.310	-.4054227	.1288079
opd						
L1.	.086453	.0913263	0.95	0.344	-.0925433	.2654492
L2.	.1477372	.1034871	1.43	0.153	-.0550938	.3505681
tg	.0047834	.0017082	2.80	0.005	.0014355	.0081314
D_lnlpr						
lgdp						
LD.	-.0227501	.0890459	-0.26	0.798	-.1972768	.1517765
L2D.	.0388667	.0895877	0.43	0.664	-.136722	.2144553
lgcf						
LD.	-.0063007	.0222009	-0.28	0.777	-.0498137	.0372122
L2D.	.0194893	.0227169	0.86	0.391	-.025035	.0640136
lnlpr						
LD.	-.1160333	.1820928	-0.64	0.524	-.4729286	.2408621
L2D.	.0218687	.1755046	0.12	0.901	-.3221141	.3658515
opu						
L1.	.0207961	.017058	1.22	0.223	-.0126369	.0542291
L2.	-.0200147	.0160748	-1.25	0.213	-.0515206	.0114912
opd						
L1.	-.0038466	.0107718	-0.36	0.721	-.024959	.0172658
L2.	-.0121181	.0122062	-0.99	0.321	-.0360418	.0118056
tg	.0001768	.0002015	0.88	0.380	-.0002181	.0005717

opu						
lgdp						
LD.	.7211246	.9911096	0.73	0.467	-1.221414	2.663664
L2D.	-2.251672	.9971405	-2.26	0.024	-4.206032	-.297313
lgcf						
LD.	.4545168	.2471032	1.84	0.066	-.0297966	.9388302
L2D.	.2609841	.2528466	1.03	0.302	-.234586	.7565543
lnlpr						
LD.	-.4493837	2.026753	-0.22	0.825	-4.421746	3.522978
L2D.	4.486686	1.953424	2.30	0.022	.6580446	8.315327
opu						
L1.	.2279678	.1898606	1.20	0.230	-.1441523	.6000878
L2.	-.460074	.1789173	-2.57	0.010	-.8107454	-.1094026
opd						
L1.	.2474822	.119894	2.06	0.039	.0124943	.4824701
L2.	.0280819	.1358588	0.21	0.836	-.2381964	.2943602
tg	.0044999	.0022425	2.01	0.045	.0001047	.0088951
opd						
lgdp						
LD.	-1.01786	2.074386	-0.49	0.624	-5.083581	3.047861
L2D.	2.351397	2.087008	1.13	0.260	-1.739064	6.441859
lgcf						
LD.	-.1308729	.5171853	-0.25	0.800	-1.144538	.8827918
L2D.	-.3630652	.5292062	-0.69	0.493	-1.40029	.6741598
lnlpr						
LD.	-1.03067	4.24198	-0.24	0.808	-9.344797	7.283457
L2D.	-3.259033	4.088504	-0.80	0.425	-11.27235	4.754288
opu						
L1.	.2791093	.397377	0.70	0.482	-.4997354	1.057954
L2.	-.0494147	.3744726	-0.13	0.895	-.7833676	.6845382
opd						
L1.	.0763346	.2509373	0.30	0.761	-.4154935	.5681627
L2.	-.0089951	.2843515	-0.03	0.975	-.5663137	.5483236
tg	.0045479	.0046935	0.97	0.333	-.0046512	.013747

Bangladesh

Vector autoregression

Sample: 1984 - 2009		No. of obs	= 26
Log likelihood =	328.0031	AIC	= -21.00024
FPE =	6.93e-16	HQIC	= -20.23386
Det(Sigma_ml) =	7.58e-18	SBIC	= -18.33888

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_lgdp	11	.009186	0.9516	511.0105	0.0000
D_lgcf	11	.025493	0.9382	394.8136	0.0000
D_lnlpr	11	.003276	0.7461	76.40029	0.0000
opu	11	.128045	0.6599	50.44545	0.0000
opd	11	.195954	0.4751	23.53434	0.0148

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_lgdp						
lgdp						
LD.	-.0384359	.1858899	-0.21	0.836	-.4027733	.3259016
L2D.	-.1079487	.1855203	-0.58	0.561	-.4715619	.2556644
lgcf						
LD.	-.0397492	.0705189	-0.56	0.573	-.1779636	.0984653
L2D.	.1179102	.0732717	1.61	0.108	-.0256997	.2615201
lnlpr						
LD.	-.33113	.5430667	-0.61	0.542	-1.395521	.7332612
L2D.	.466414	.5286389	0.88	0.378	-.5696992	1.502527
opu						
L1.	-.0019681	.0149785	-0.13	0.895	-.0313255	.0273893
L2.	-.0221063	.0148025	-1.49	0.135	-.0511186	.006906
opd						
L1.	-.0117877	.010341	-1.14	0.254	-.0320556	.0084802
L2.	-.018588	.011173	-1.66	0.096	-.0404867	.0033106
tg	.0018706	.0004678	4.00	0.000	.0009537	.0027874
D_lgcf						
lgdp						
LD.	-.5979067	.5158816	-1.16	0.246	-1.609016	.4132028
L2D.	-.5545999	.514856	-1.08	0.281	-1.563699	.4544994
lgcf						
LD.	.4055593	.195704	2.07	0.038	.0219865	.7891321
L2D.	.3639894	.2033437	1.79	0.073	-.034557	.7625357
lnlpr						
LD.	-3.66558	1.507119	-2.43	0.015	-6.619479	-.711681
L2D.	2.762075	1.467079	1.88	0.060	-.1133463	5.637497
opu						
L1.	-.0538911	.0415685	-1.30	0.195	-.1353638	.0275816
L2.	.0247232	.0410798	0.60	0.547	-.0557917	.1052382
opd						
L1.	.0391677	.0286982	1.36	0.172	-.0170798	.0954152
L2.	.0091323	.0310073	0.29	0.768	-.0516409	.0699054
tg	.0025184	.0012982	1.94	0.052	-.0000261	.0050628
D_lnlpr						
lgdp						
LD.	.0729547	.0662939	1.10	0.271	-.0569789	.2028884
L2D.	-.1177794	.0661621	-1.78	0.075	-.2474548	.0118959
lgcf						
LD.	.0015999	.0251491	0.06	0.949	-.0476915	.0508913
L2D.	-.0035674	.0261309	-0.14	0.891	-.054783	.0476482
lnlpr						
LD.	.9034152	.1936739	4.66	0.000	.5238213	1.283009
L2D.	-.1770306	.1885285	-0.94	0.348	-.5465396	.1924784
opu						
L1.	.0094709	.0053418	1.77	0.076	-.0009988	.0199407
L2.	.0012203	.005279	0.23	0.817	-.0091263	.011567
opd						
L1.	.0004878	.0036879	0.13	0.895	-.0067404	.0077159
L2.	-.0006372	.0039846	-0.16	0.873	-.0084469	.0071725
tg	-.0000196	.0001668	-0.12	0.907	-.0003466	.0003074

opu						
lgdp						
LD.	-2.742373	2.591182	-1.06	0.290	-7.820997	2.336251
L2D.	-2.298842	2.586031	-0.89	0.374	-7.367369	2.769685
lgcf						
LD.	.4254348	.9829866	0.43	0.665	-1.501184	2.352053
L2D.	-.482787	1.021359	-0.47	0.636	-2.484615	1.519041
lnlpr						
LD.	10.80288	7.569992	1.43	0.154	-4.034031	25.63979
L2D.	-8.515807	7.368878	-1.16	0.248	-22.95854	5.926928
opu						
L1.	.1547634	.208791	0.74	0.459	-.2544595	.5639862
L2.	-.510499	.2063366	-2.47	0.013	-.9149112	-.1060867
opd						
L1.	.1571644	.1441461	1.09	0.276	-.1253568	.4396856
L2.	.0243473	.1557442	0.16	0.876	-.2809057	.3296003
tg	.0161251	.0065207	2.47	0.013	.0033447	.0289055
opd						
lgdp						
LD.	2.855144	3.965431	0.72	0.472	-4.916958	10.62725
L2D.	6.642812	3.957548	1.68	0.093	-1.113839	14.39946
lgcf						
LD.	-1.565473	1.504319	-1.04	0.298	-4.513885	1.382939
L2D.	4.204626	1.563043	2.69	0.007	1.141117	7.268135
lnlpr						
LD.	-15.58134	11.58478	-1.34	0.179	-38.2871	7.124413
L2D.	18.09829	11.27701	1.60	0.109	-4.004239	40.20081
opu						
L1.	.1009149	.3195245	0.32	0.752	-.5253417	.7271715
L2.	-.0803006	.3157684	-0.25	0.799	-.6991953	.5385941
opd						
L1.	-.0890709	.2205949	-0.40	0.686	-.5214289	.3432871
L2.	-.0650977	.238344	-0.27	0.785	-.5322434	.402048
tg	-.0199846	.009979	-2.00	0.045	-.0395431	-.000426

Appendix 4: Wald Granger causality test results of all equations

India

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vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
D_lgdp	D.lgcf	8.5957	2	0.014
D_lgdp	D.lnlpr	.53395	2	0.766
D_lgdp	opu	2.336	2	0.311
D_lgdp	opd	8.7658	2	0.012
D_lgdp	ALL	20.79	8	0.008
D_lgcf	D.lgdp	.22524	2	0.893
D_lgcf	D.lnlpr	5.0834	2	0.079
D_lgcf	opu	2.7561	2	0.252
D_lgcf	opd	4.6028	2	0.100
D_lgcf	ALL	13.69	8	0.090
D_lnlpr	D.lgdp	1.1417	2	0.565
D_lnlpr	D.lgcf	.42075	2	0.810
D_lnlpr	opu	9.1786	2	0.010
D_lnlpr	opd	.03603	2	0.982
D_lnlpr	ALL	12.02	8	0.150
opu	D.lgdp	2.3524	2	0.308
opu	D.lgcf	.76806	2	0.681
opu	D.lnlpr	1.3312	2	0.514
opu	opd	1.3241	2	0.516
opu	ALL	10.426	8	0.236
opd	D.lgdp	1.3086	2	0.520
opd	D.lgcf	2.0814	2	0.353
opd	D.lnlpr	1.5467	2	0.461
opd	opu	.99336	2	0.609
opd	ALL	5.7136	8	0.679

Pakistan

Granger causality Wald tests

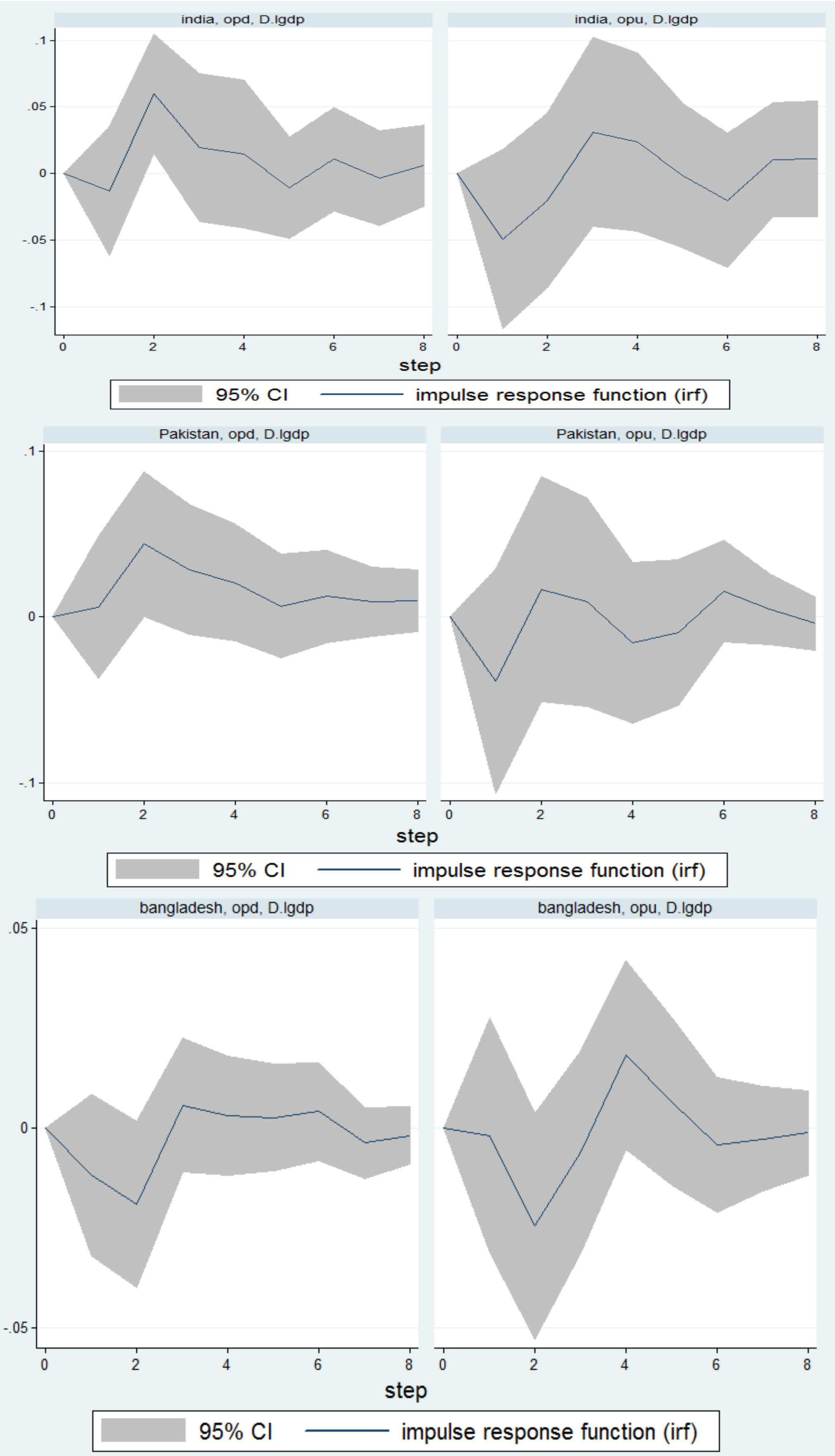
Equation	Excluded	chi2	df	Prob > chi2
D_lgdp	D.lgcf	7.0418	2	0.030
D_lgdp	D.lnlpr	1.4992	2	0.473
D_lgdp	opu	1.8149	2	0.404
D_lgdp	opd	5.4097	2	0.067
D_lgdp	ALL	11.232	8	0.189
D_lgcf	D.lgdp	5.6136	2	0.060
D_lgcf	D.lnlpr	4.2939	2	0.117
D_lgcf	opu	3.8638	2	0.145
D_lgcf	opd	4.4605	2	0.107
D_lgcf	ALL	19.294	8	0.013
D_lnlpr	D.lgdp	.20071	2	0.905
D_lnlpr	D.lgcf	.8738	2	0.646
D_lnlpr	opu	2.5032	2	0.286
D_lnlpr	opd	1.5633	2	0.458
D_lnlpr	ALL	7.9605	8	0.437
opu	D.lgdp	5.1028	2	0.078
opu	D.lgcf	4.1111	2	0.128
opu	D.lnlpr	5.5012	2	0.064
opu	opd	5.275	2	0.072
opu	ALL	19.961	8	0.010
opd	D.lgdp	1.2806	2	0.527
opd	D.lgcf	.50511	2	0.777
opd	D.lnlpr	.66004	2	0.719
opd	opu	.49367	2	0.781
opd	ALL	3.1522	8	0.924

Bangladesh

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
D_lgdp	D.lgcf	2.9886	2	0.224
D_lgdp	D.lnlpr	.79887	2	0.671
D_lgdp	opu	2.3623	2	0.307
D_lgdp	opd	3.9781	2	0.137
D_lgdp	ALL	7.7863	8	0.455
D_lgcf	D.lgdp	2.8231	2	0.244
D_lgcf	D.lnlpr	5.9196	2	0.052
D_lgcf	opu	1.848	2	0.397
D_lgcf	opd	1.9312	2	0.381
D_lgcf	ALL	14.472	8	0.070
D_lnlpr	D.lgdp	3.987	2	0.136
D_lnlpr	D.lgcf	.01971	2	0.990
D_lnlpr	opu	3.401	2	0.183
D_lnlpr	opd	.04411	2	0.978
D_lnlpr	ALL	12.669	8	0.124
opu	D.lgdp	2.1513	2	0.341
opu	D.lgcf	.25089	2	0.882
opu	D.lnlpr	2.0386	2	0.361
opu	opd	1.2057	2	0.547
opu	ALL	7.2385	8	0.511
opd	D.lgdp	3.6569	2	0.161
opd	D.lgcf	8.0947	2	0.017
opd	D.lnlpr	2.5913	2	0.274
opd	opu	.14325	2	0.931
opd	ALL	13.434	8	0.098

Appendix 5: Impulse Response Function Graphs



Appendix 6: Eigenvalues tables and graphs for all countries

India

Eigenvalue stability condition

Eigenvalue	Modulus
-.8559074	.855907
.8490158	.849016
.08882499 + .7732766*i*	.778361
.08882499 - .7732766*i*	.778361
.3647214 + .4939316*i*	.613995
.3647214 - .4939316*i*	.613995
-.5451044 + .2171762*i*	.586774
-.5451044 - .2171762*i*	.586774
.4687201	.46872
-.1561457	.156146

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

Pakistan

Eigenvalue stability condition

Eigenvalue	Modulus
-.2301803 + .7201855*i*	.756075
-.2301803 - .7201855*i*	.756075
.2806944 + .6988959*i*	.753157
.2806944 - .6988959*i*	.753157
.6972803	.69728
-.5514351 + .2186147*i*	.593189
-.5514351 - .2186147*i*	.593189
.4835304	.48353
-.06638615 + .2961401*i*	.30349
-.06638615 - .2961401*i*	.30349

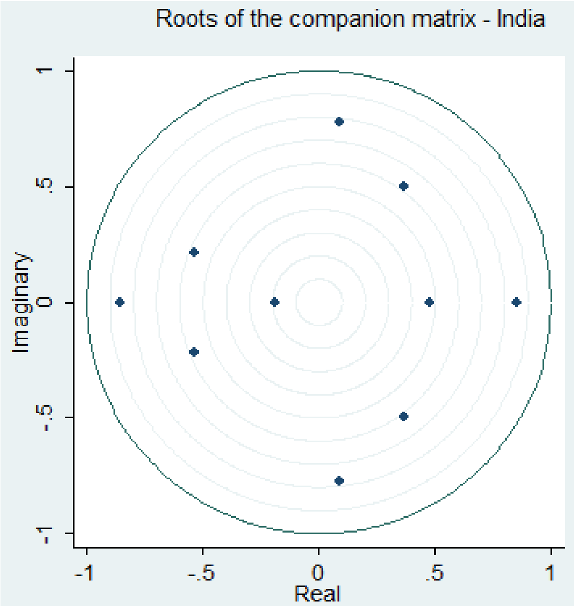
All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

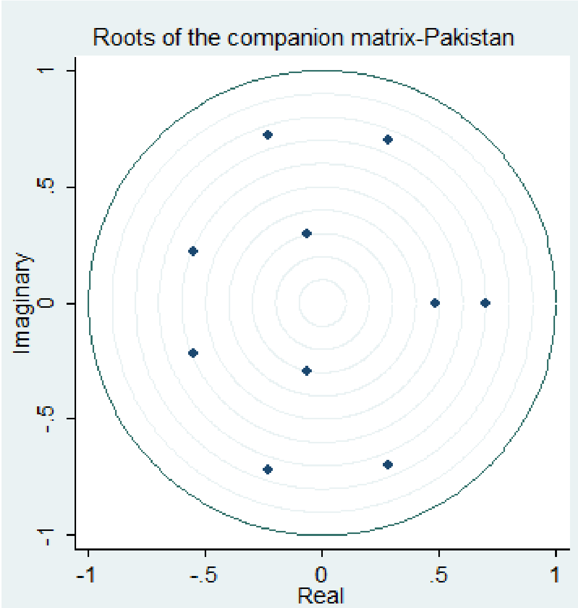
Bangladesh

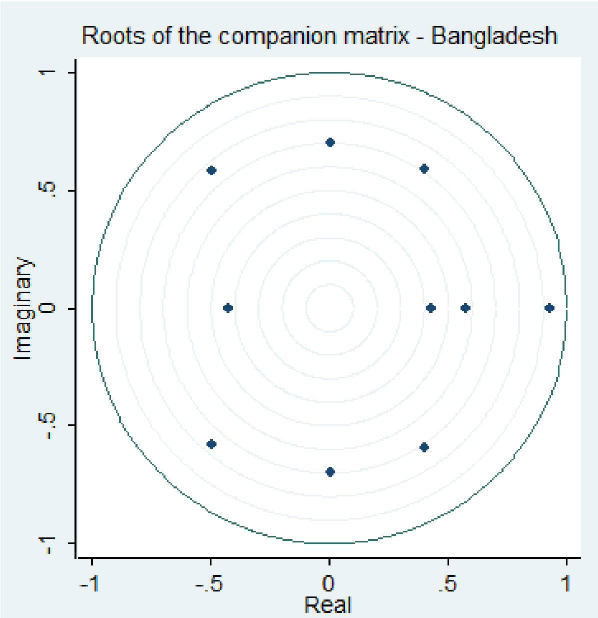
Eigenvalue stability condition

Eigenvalue	Modulus
.9259864	.925986
-.4919105 + .5826422*i*	.762527
-.4919105 - .5826422*i*	.762527
.3992011 + .5909809*i*	.713176
.3992011 - .5909809*i*	.713176
.00861265 + .6980929*i*	.698146
.00861265 - .6980929*i*	.698146
.5740022	.574002
.4304851	.430485
-.4260492	.426049

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.


Roots of the companion matrix - India
Imaginary
Real
-1
-.5
0
.5
1


Roots of the companion matrix-Pakistan
Imaginary
Real
-1
-.5
0
.5
1


Roots of the companion matrix - Bangladesh
Imaginary
Real
-1
-.5
0
.5
1