

## Inflation and economic growth in Bangladesh: An empirical analysis by using VAR model

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### Abstract

The main objective of this study is to examine the empirical relationship between inflation and economic growth in Bangladesh for the time period 1976 to 2011. In this study we use Vector Auto-regression (VAR) methodology to investigate the linkage between inflation and economic growth; trade openness and economic growth; and remittances and economic growth in Bangladesh. The major findings of the study shows that inflation and economic growth have a statistically significant negative relationship; remittances and economic growth have a statistically significant positive relationship, whereas a statistically negligible relationship find between trade openness and economic growth in Bangladesh. The findings of the study may be useful for monetary decision makers in Bangladesh to keep inflation rate at a reasonable rate which is consistent with economic growth in Bangladesh.

**Keywords:** Inflation, economic growth, vector auto-regression (VAR), granger causality test, impulse response function, variance decomposition, Bangladesh

### Introduction

One of the important macroeconomic variables in the economy is inflation. It has a substantial impact on economic growth and development of the country. Many researchers stated that moderate and stable inflation rate promotes economic growth of the country (for example: Ahmed and Mortaza, 2005). Barro (1995) stated that high inflation rate associated with high price levels of the economy that adversely affects general people's purchasing power and lowers the economic performance of the country. Most of the central banks of the world concern about keeping inflation rate lower but it should be positive. Even in the long run such an inflation targeting policy may slow down economic growth if fiscal targeting is not implemented at the same time. Bangladesh has been achieving substantial growth rate at 6% per annum on average for last ten years but inflation rate was 7% in 2005 and it became 11% in 2011 (World Bank, 2012). High inflation rate deteriorates the standard of living of the poor and unemployed people of the economy.

The theoretical background of this study based on the analysis of classical growth theory, monetarist view, new-classical growth theory and finally Keynesian view.

### Classical growth model

Prominent economists Adam Smith is the founder of classical growth model. He considered supply side driven growth model by using the following production function equation:

$$Y = f(L, K, T) \text{ ----- (i)}$$

Where Y is output, L is labor, K is capital and T is land inputs respectively. Equation (i) shows that output is not only depend on labor input but also related to capital and land. According to Gokal and Hanif (2004), the relationship between inflation and output growth is not mentioned in the classical growth model.

### Monetarist view

Milton Friedman (1992), the renowned monetary economist proclaimed that “Inflation is always and everywhere a monetary phenomenon.” The monetarist view regarding inflation- output relationship can be expressed through fundamental quantity theory of money. The quantity theory of money states that there is a one to one relationship between money supply and inflation. The relationship between money supply and inflation can be expressed by the following fundamental equation:

$$MV = PT \text{ ----- (ii)}$$

Where M is the Money supply of the economy, V is the velocity of money in circulation in the economy, P is the general price level and T is the total transactions level of the economy. Monetarists assume that in the long run T and V are determined by real variables and also T and V are unaffected by changes in nominal variables such as money supply. That means when T and V are constant, M has one to one relationship with P. That is, P changes proportionately with the change in M. Equation (ii) implies that increase in M remaining V constant, the right side of the equation (PT), the nominal value of output must be increase. Since the real value of output T is fixed, P increases proportionately implying that there is a one to one relationship between money supply growth and inflation.

### New- classical theory

Solow growth model is considered one of the important models in new classical growth theory. Solow (1956) states that labor and capital inputs provide diminishing returns to scale whereas combinations of labor and capital factors of production ensure constant returns to scale (CRS). Todaro (2000) stated that technological advancement replaces as capital investment which is considered as an important factor for long run economic growth. However, the level of technological advances was assumed exogenous variable including inflation by the growth theorists. Mundell (1963) developed a growth model relating to inflation and output growth. Mundell’s model shows that an increase in inflation or inflation expectations directly decreases in people’s wealth. Decrease in wealth leads to fall in real money balances. When people anticipation in wealth increase, people save more money by switching money to assets which leads to increasing their prices, thus driving down economy’s real interest rate. More savings leads to more capital accumulation and more capital accumulation promotes economic growth. Tobin theory (1965) stated that either money holding or acquiring capital; people substitute current consumption into future consumption. Tobin theory suggests that inflation causes individual substitute money into interest earning assets; leads to better capital accumulation and better capital accumulation stimulates economic growth.

### **Keynesian view**

Keynes (1936) developed simple Aggregate Demand (AD) and Aggregate Supply (AS) curves model to show the relationship between inflation and economic growth. This simple model shows that in the short run, the AS curve is upward slopping. The upward slopping AS curve shows how the changes in AD affect both prices and output (Dornbusch *et al.*, 1996). This model also suggests that people's expectations; labor force; factor prices; fiscal and/ or monetary policy drives both inflation and output in the short run (Gokal and Hanif, 2004). Keynes (1936) stated that output is determined by the aggregate demand, which also determines by employment and prices. According to Keynes, at full employment level of the economy; the excessive demand for goods and services raises the general price level which leads to inflation.

The findings of researcher's between inflation and economic growth relationship are mixed. Some studies found a positive relationship between inflation and economic growth (Abidemi and Maliq, 2010; Malik and Chowdhury, 2001). Some studies found a negative relationship between inflation and economic growth (Barro, 1995; Faria and Carneiro, 2001; Malla, 1997; Saaed, 2007). Some studies found a threshold level inflation, below that level of inflation are good for economy and above that level of inflation is bad for economy (Hussain, 2011; Khan and Senhadji, 2001; Mubarak, 2005).

Although a huge number of studies have conducted in the field of economics to investigate the exact relationship between inflation and economic growth, but a very few empirical studies have conducted to examine the relationship between inflation and economic growth in the context of Bangladesh economy. Therefore, the main aim of this study is to empirically re examine the relationship between inflation and economic growth in Bangladesh by using VAR model. However, this study has some policy implications in the economy of Bangladesh because it helps the policy maker to predict the standard level of inflation rate which is consistent with economic growth in Bangladesh.

### **Literature review**

The link between inflation and economic growth in the field of economics is highly debatable issue. Economists have shown different opinions regarding the linkage between inflation and economic growth. Therefore, the findings of researchers regarding the relationship between inflation and economic growth are mixed.

Mallik and Chowdhury (2001) conducted a study to examine the short run and long run relationship between CPI inflation and GDP growth of four South Asian countries (Bangladesh, India, Pakistan and Srilanka). They employed Error Correction Model (ECM) to examine the link between CPI inflation and GDP growth. They found a significant positive link between CPI inflation and economic growth. Abidemi and Maliq (2010) examined the linkage between inflation and determinants of inflation such as growth rate of real output, money supply, import, exchange rate, interest rate and fiscal deficit in the Nigerian economy from 1970 to 2007. They found that both inflation and interest rate have a positive impact on economic growth in Nigerian economy.

Saaed (2007) examined the link between inflation and economic growth in Kuwait by using time series data ranges from 1985 to 2005. He used the Engle- Granger causality test and ECM to show the short run and long run relationships between inflation and economic growth in Kuwait. He found a short run and long run strong negative relationship between CPI inflation and real GDP growth in Kuwait economy. Barro (1995), by using panel data of 100 countries, found a significant negative relationship between inflation and economic growth. Faria and Carneiro's

(2001), by using the time series data in Brazil, found short run and long run negative relationship between inflation and economic growth in Brazil.

Malla (1997) conducted separate empirical studies on some Asian countries and high economic advancement countries like OECD (Organization for Economic Cooperation and Development) countries. He stated that there is a significant negative relationship between inflation and economic growth in case of OECD countries, but an insignificant relationship in the case of Asian countries. Iqbal and Sattar (2012) conducted a study to find out the relationship between inflation and economic growth in Pakistan economy. They found statistically significant negative relationship between inflation and economic growth in Pakistan. Ahmed and Mortaza (2005) empirically observed the relationship between inflation and economic growth in the context of Bangladesh economy by using annual data on real GDP and CPI inflation from 1980 to 2005. They found statistically significant long run negative relationship between inflation and economic growth in Bangladesh.

Johnson (1967) conducted a study to examine the relationship between inflation and economic growth of 30 high inflation countries by using panel data. The empirical finding of the Johnson's study has shown that there is no conclusive empirical evidence regarding the relationship between inflation and economic growth of 30 high inflation countries. Khan and Senhadji (2001) using panel data from 140 samples of both developing and industrially developed countries examined the linkage between inflation and real GDP growth. They noted different threshold level of inflation for developing countries (7% to 11%) and industrially developed countries (1% to 3%). They also stated that beyond that threshold level of inflation, inflation adversely affects economic growth.

From the above analysis we see that the empirical findings regarding the relationship between inflation and economic growth are mixed. Therefore, we attempt to reinvestigate the empirical relationship between inflation and economic growth in the context of Bangladesh economy by using VAR model.

### **Relationship between inflation and economic growth in Bangladesh**

Ahmed and Mortaza (2005) empirically observed the relationship between inflation and economic growth in Bangladesh economy by using annual data on real GDP and CPI from 1980 to 2005. The empirical finding of Shamim and Mortaza's study has shown the existence of statistically significant long run negative relationship between inflation and economic growth in Bangladesh. They also stated a threshold level of inflation (i.e. 6 %) for the Bangladeshi economy. They mentioned that above that level of inflation adversely affects the economic growth in Bangladesh. The present study based on the study of Ahmed and Mortaza (2005). In this study we use GDP growth and inflation just like Ahmed and Mortaza (2005) study but it is different from Ahmed and Mortaza study because we add two more macroeconomic variables such as trade openness and remittances. The main objective of addition two more macroeconomic variables are observing; whether the result found by Ahmed and Mortaza (2005) changes if more macroeconomic variables are added. In addition, they used the Eangle-Granger two stage co-integration procedures but in this study we use VAR model to reexamine the relationship between inflation and economic growth in Bangladesh.

The empirical relationship between inflation and GDP growth in Bangladesh can be shown in figure 1. From the figure 1, we see that in the early stage of eighty both inflation and GDP growth rate was very low, after that they fluctuate over the time period. This graphical presentation shows that in the eighty there existence of negative relationship between inflation and economic growth in Bangladesh. In 1990, both have upward trend showing a positive association between them.

During the nineties and last decade, growth rate becomes relatively consistent but inflation fluctuates rapidly over the time being. Therefore, by using the graphical analysis, we do not observe any exact relationship between inflation and economic growth in Bangladesh. As result, we intend to this study to find out the precise relationship between these two.

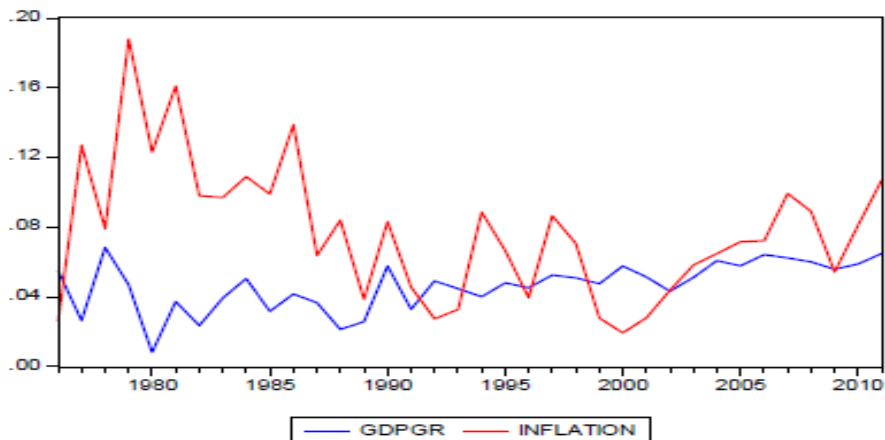


Figure 1: Inflation and GDP growth in Bangladesh

**Relationship between remittances growth and economic growth**

The empirical relationship between GDP growth and remittances growth in Bangladesh can be shown in figure 2. By observing the figure 2, we see that the growth rate of remittances fluctuates over the time period. During the late 1970s, the growth rate of remittances was higher because of higher growth rate in West Asian countries. But in 1980s, there was a negative remittances growth rate because of Gulf war in 1988 to 1991. Since 1990, the growth rate of GDP fluctuate over time period and remains over 5%. Therefore, by observing the figure 2, we see that there is a relationship between remittances growth and GDP growth in Bangladesh.

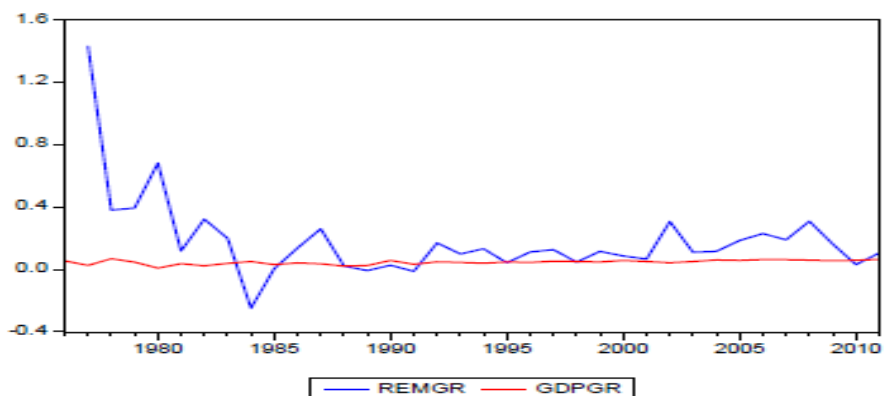
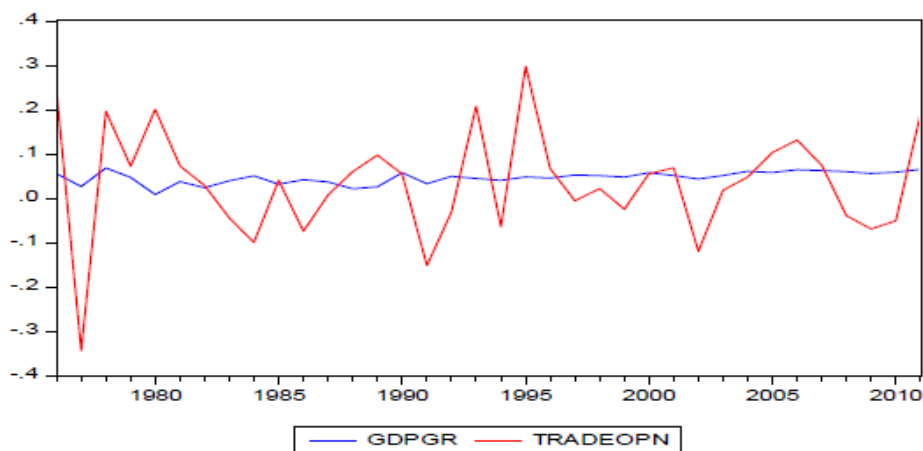


Figure 2: GDP growth and remittance growth in Bangladesh

**Relationship between GDP growth and trade openness**

The empirical relationship between GDP growth and trade openness in Bangladesh can be shown in figure 3. By observing the figure 3, we see that trade openness fluctuate over the time period where as GDP growth rate fluctuate but still a deterministic trend. From the figure 3, we could not

find any exact relationship between GDP growth and trade openness in Bangladesh. Therefore, in order to find out the exact relationship between two, we include trade openness in our model as an explanatory variable.



**Figure 3: GDP growth and trade openness in Bangladesh from 1976 to 2011**

**Data and rationality of selection of four macroeconomic variables**

This study based on the four macroeconomics variables such as GDP Growth (gdpgr), Inflation rate (inflation), Trade openness (tradeopn) and Remittances Growth (remgr). The GDP growth rate calculated from the first difference of logarithm of real GDP in US\$ with base year 2000. The remittances growth rate calculated from first difference of logarithm of remittances in US\$. Similarly, the trade openness calculated export plus import divided by GDP in US\$. Finally, from the Consumer Price Index (CPI) with base year 1995-1996, we get the inflation rate. In this study, we use only two sources of secondary data (annual data) such as World Bank data bank and Bangladesh Bureau of Statistics (BBS). The rationality of selection of four variables can be explained as follows:

**Trade openness**

In national income account, trade is one of the most important components. According to Edwards (1993), trade openness is synonym of free trade because under trade openness almost all bars in trading systems are abolished. Economists often argued that there is a positive association between exports and economic growth. Some researchers found positive association between export growth and economic growth (for example: Haydory and Salah, 2009). For this reason, we include trade openness in our study to examine the exact relationship between trade openness and economic growth in Bangladesh.

**Remittances**

Rao and Hassan (2009) examined the effects of workers’ remittances on economic growth. By using Solow growth model, they found that workers’ remittances have a positive but marginal effect on economic growth. Ahmed *et al.* (2011) studied the relationship between workers’ remittances inflow and economic growth in Pakistan. They found that remittances have a both short run and long run significant positive impacts on economic growth in Pakistan. Adams (1991) studied the impact of remittances on poverty reduction in Egypt. He stated that remittances have a small impact of poverty reduction in Egypt. He also stated that the overall impact of remittance on income distribution in Egypt was negative. Spatafora (2005) conducted a study based on sample

of 101 countries from 1970 to 2003. By using a standard cross-country growth regression framework, he found that per capita output growth and remittances have no significant relationship. Therefore, we include remittances growth in our study to check the precise relationship between remittances and economic growth in Bangladesh.

**Estimation techniques**

In this study, firstly we check whether the data series are stationary or non-stationary since we use annual time series data. For this purpose, we will use Augmented Dickey Fuller (ADF) test and KPSS test. By using ADF and KPSS tests we can be able to know whether time series data are stationary or not. Then, we will use Granger casualties in the VAR model to examine the casualties between the variables. Then, we will also use impulse response function and variance decomposition under VAR methodology to examine the shock of the variables. Finally, to justify the robustness of the VAR model we will use stationary of VAR model, autocorrelation test for residuals, the normality and homoscedasticity of residual errors and functional form tests of the model.

**Stationary of data**

In order to check the stationarity of the four variables we used ADF tests. The null hypothesis of ADF test can be formulated as follows (e.g.):

$H_0$ : Inflation has a unit root.

$H_A$ : Inflation has no unit root

If we reject the null hypothesis  $H_0$  at 1% or 5% or 10% level of significance, we can say that the variable has no unit root i.e. the variable is stationary at 1% or 5% or 10% level of significance. But if we fail to reject the null hypothesis  $H_0$ , we can say that the variable has a unit root. When the variable has a unit root, we can transform the nonstationary variables into stationary variable by taking first difference of the variables. The summary results of ADF test of four variables can be shown in Table 1. The results show that GDP growth (gdpg), remittances growth (remgr), trade openness (tradeopn) and inflation rate (inflation) have no unit root at level at 1% or 5% or 10% level of significance.

**Table 1: ADF test for unit root test of four variables**

Variables	P -value	Order of Integration/ stationary
Gdpg	0.000	I(0)
Inflation	0.005	I(0)
Tradeopn	0.000	I(0)
Remgr	0.000	I(0)

The summary results of KPSS tests (stationary test) of four variables can be shown in Table 2. The results show that GDP growth (gdpg), inflation rate (inflation), trade openness (tradeopn), and remittances growth (remgr) are stationary at level at 1% or 5% or 10% level of significance.

**Table 2: KPSS test for stationary of four variables**

Variables	LM-Stat	Order of Integration/ stationary
Gdpg	0.129	I(0)
Inflation	0.330	I(0)
Tradeopn	0.197	I(0)
Remgr	0.296	I(0)

**VAR lag selection**

One of the important tasks in VAR model is VAR lag selection because Johansen cointegration tests are sensitive to the lags used.

**Table 3: Result of VAR lag selection criteria**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	65.841	NA	2.17e-07	-3.989	-3.804*	-3.929
1	86.955	35.416*	1.58e-07*	-4.319*	-3.394	-4.018*
2	94.070	10.099	2.97e-07	-3.746	-2.081	-3.203
3	108.593	16.865	3.80e-07	-3.651	-1.245	-2.867
4	130.458	19.748	3.59e-07	-4.029	-0.884	-3.004

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

From the Table 3, we see the result of five lag selection criteria such as sequential modified LR test statistic (each test at 5% level), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn information (HQ). According to theory the lag selection of VAR model based on the minimal value of the test such as Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn information (HQ). The reason behind theory of lag selection is to minimize the prediction error of the estimated model. Therefore, based on the theory and results of different test we select one lag for estimating the VAR model in present study because our sample size is not large.

**Cointegration test**

In order to show the long run relationship among the four variables, we have to use the Johnson multivariate cointegration test. By using the Trace test under congregation, we find that there is a full rank i.e. n=4. Since n=4 and our number of variables 4, we can run VAR model at the level forms. Therefore, we develop VAR model considering all the variables are stationary at levels form.

**Table 4: Result of unrestricted cointegration rank test (Trace)**

Hypothesized	Trace		0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.565	59.373	47.856	0.002
At most 1 *	0.373	31.858	29.797	0.028
At most 2 *	0.240	16.433	15.494	0.036
At most 3 *	0.199	7.342	3.841	0.006

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level \* denotes rejection of the hypothesis at the 0.05 level \*\*MacKinnon-Haug-Michelis (1999) p-values

**Methodology**

**Specification of VAR model**

The VAR model can be specified as follows:

$$Y_t = A(L)Y_{t-1} + \varepsilon_t \text{ ----- (iii)}$$

Where  $Y_t$  is the vector of endogenous variables and  $\varepsilon_t$  white noise which is iid (independently and identically distributed).



In order to reexamine the relationship between economic growth and inflation in Bangladesh, we can use recursive VAR model. The specification of the VAR model can be expressed the following dynamic structural model.

$$A(L)Y_t = v_t \quad \text{----- (iv)}$$

where  $A(L)$  is  $n \times n$  matrix polynomial in the lag operator,  $Y_t$  is  $n \times 1$  vector of endogenous variables,  $v_t$  is a  $n \times 1$  vector of structural disturbances term with  $E(v_t) = 0$  and  $\text{var}(v_t) = \psi$  where  $\psi$  represents diagonal matrix representing structural disturbances. In this case we assume that structural disturbances are mutually uncorrelated to each other.

The reduced form of VAR equation (iii) can be expressed as follows:

$$Y_t = C(L)Y_t + u_t \quad \text{----- (v)}$$

Where  $C(L)$  is the matrix polynomial in the lag operator of VAR model and  $u$  is vector of VAR residual with the property that mean is zero i.e.  $E(u_t) = 0$  and variance is constant i.e.  $\text{var}(u_t) = \Sigma$ . The error terms of the structural model and reduced form model can be expressed by the following equations:

$$u_t = H^{-1} v_t \quad \text{----- (vi)}$$

$$\Sigma = H^{-1} \psi H^{-1} \quad \text{----- (vii)}$$

Where  $H$  is the contemporaneous coefficient matrix.

The endogenous variables in our model can be expressed as follows:

$$Y_t = [gdpg_{t-i} \text{ inflation}_{t-i} \text{ tradeop}_{t-i} \text{ remgr}_{t-i}] \text{----- (viii)}$$

Since we use recursive VAR model, the ordering of recursive VAR model can be shown as follows: (1) GDP growth, (2) inflation, (3) trade openness and (4) remittance growth. The recursive VAR model consists of four endogenous VAR equations. The first equation of recursive VAR model shows that GDP growth is the dependent variable and the lags of all four variables are the explanatory variables. The second equation of recursive VAR model states that inflation is the dependent variable and the lags of all four variables plus the current value of the GDP growth rate are the explanatory variables. The third equation of recursive VAR model shows that trade openness is the dependent variable and the lags of all four variables plus the current value of the GDP growth and the current value of the inflation are the explanatory variables. The fourth equation of recursive VAR model shows that remittance growth rate is the dependent variable and lags of all four variables plus the current value of the GDP growth, the current value of the inflation and current value of trade openness are the explanatory variables. According to Stock and Watson (2001), the estimated recursive VAR model result depends on the ordering of the variables. They stated that changing the order of the variables, changes the VAR equations, coefficients and residuals also. In the present study, changing the order of the variables changes the result of VAR model insignificantly. Therefore, in the present study we order the recursive VAR model as follows: firstly GDP growth is the dependent variable, and then the main explanatory variable is inflation, then trade openness and lastly remittance growth.

### Identification scheme of VAR model

In the present study, in order to estimate recursive VAR model we use Cholesky approach. We use this approach because it is a unique case of exactly identified of VAR model.

The reduced form of recursive VAR covariance matrix can be expressed as follows:

$$\begin{bmatrix} V_{gdpgr} \\ V_{inflation} \\ V_{tradeopn} \\ V_{remgr} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ a_{11} & 1 & 0 & 0 \\ a_{21} & a_{22} & 1 & 0 \\ a_{31} & a_{32} & a_{33} & 1 \end{bmatrix} \begin{bmatrix} u_{gdpgr} \\ u_{inflation} \\ u_{tradeopn} \\ u_{remgr} \end{bmatrix} \dots\dots\dots (ix)$$

In equation (ix) of recursive VAR model, we assume that first two variables such as GDP growth and inflation rate are exogenous to all other variables contemporaneously. We also assume that inflation does not affect GDP growth contemporaneously while GDP growth will affect inflation contemporaneously. We assume that GDP growth, inflation and remittances growth have an impact on trade openness instantly. We also assume that all the three variables have an impact on remittances growth. Finally, we assume that inflation has no instantaneous impact on GDP growth, then trade openness has no instantaneous impact on inflation and remittances growth has no instantaneous impact on trade openness.

**Estimation of recursive VAR model**

The estimation of recursive VAR model based on the results of VAR Granger-Causality tests, impulse response functions and forecast error variance decompositions. In this study, the recursive VAR model results can be explained as follows:

**VAR granger causality test**

We used VAR model to test the Granger causality among the four variables under consideration. For four variables GDP growth (gdpgr), inflation rate (inflation), trade openness (tradeopn) and remittances growth (remgr), the VAR Granger causality summary statistics can be shown in Table 5. From the table 5, we see that remittances growth and inflation are causes of GDP growth in Bangladesh (since both coefficient are at 5% (p-value 0.0119) and 1 % (p-value 0.0003) level of significance respectively). We see that GDP growth and inflation are causes of remittances growth in Bangladesh (since both variables coefficients are at 5% (p-value 0.0274) and 1 % (p-value 0.0069) level of significance respectively). We also see that trade openness does not cause both GDP growth and remittance growth in Bangladesh (since coefficient of trade openness is insignificant in case of GDP growth and remittances growth). In case of trade openness, GDP growth, remittance growth and inflation don't have any significant impact on trade openness (since coefficients of GDP growth, inflation and remittances growth are insignificant respectively). Trade openness has a significant impact on inflation in Bangladesh (since coefficient of trade openness is at 1% (p -value 0.0099) level of significance).

**Table 5: Granger- causality tests of VAR model**

Regressor/explanatory variable	Dependent Variable			
	gdpgr	inflation	tradeopn	remgr
Gdpgr	0.000	0.906	0.791	0.027**
Inflation	0.000***	0.000	0.623	0.006***
Tradeopn	0.142	0.009***	0.000	0.163
Remgr	0.011**	0.124	0.192	0.000

Superscripts\*\*\* and \*\* indicate rejection of null hypothesis at 1% and 5% level of significance

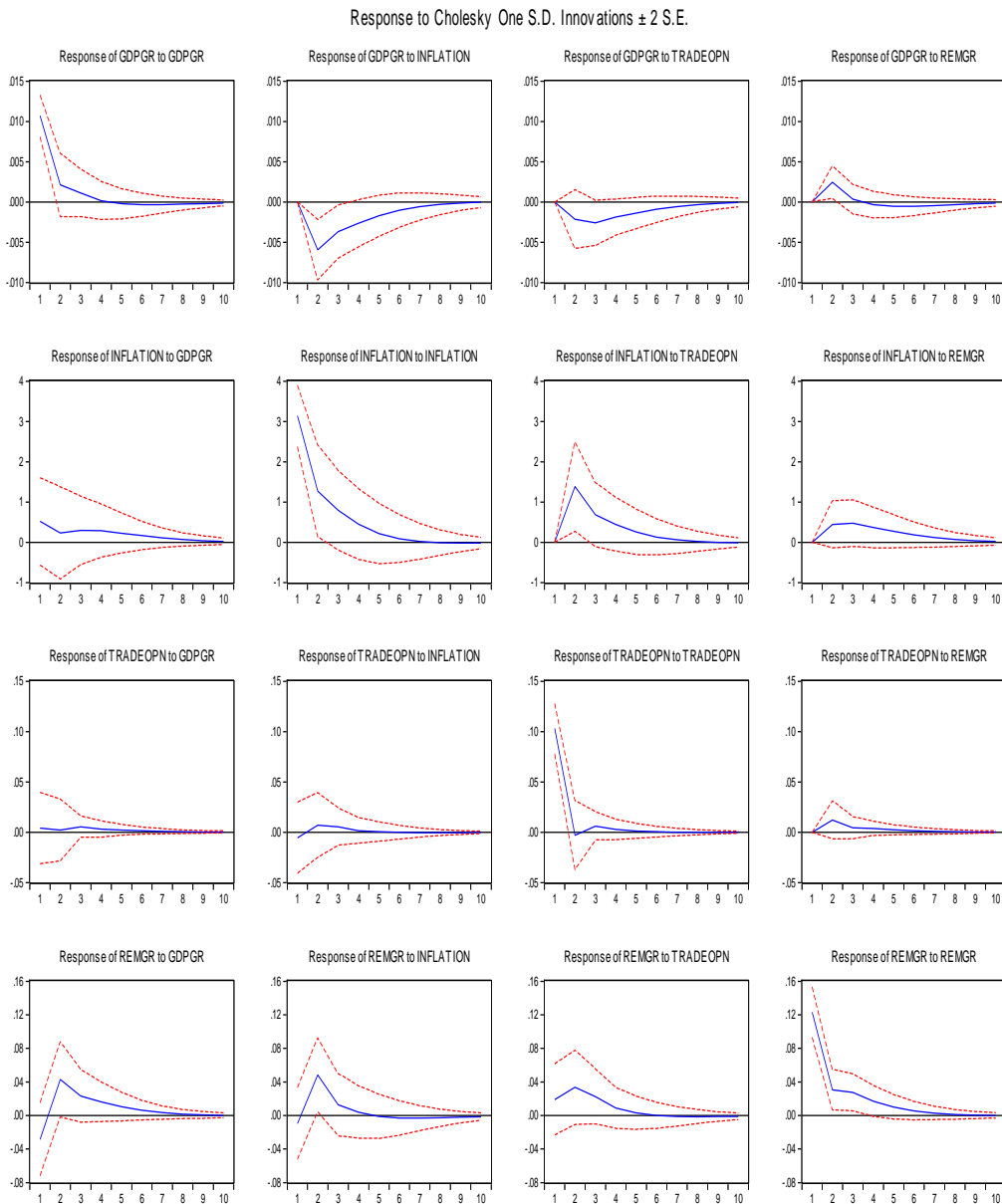
**Impulse response function of recursive VAR model**

The impulse responses of recursive VAR model ordering GDPGR, INFLATION, TRADEOPN and REMGR can be shown in figure 4. The first column shows unexpected shock of economic

growth slowly fades away over time horizons 4. The unexpected shock on economic growth causes inflation reduces insignificantly in second period and slowly fades away in time horizon 9. Similarly, the unexpected shock in economic growth causes reduces remittances growth significantly in first period. After that remittances growth increases up to the time horizon 2 and it become insignificant in time horizon 8. We also see that unexpected shock on GDP growth has a negligible and insignificant impact on trade openness. The second column shows that an unexpected shock in inflation significantly reduces the GDP growth rate in period up to time horizon 2. After that GDP growth increases slowly and its impact fades away in time horizon 9. The unexpected shock in inflation leads to significantly increase in remittances growth up to time horizon 2. After that, it decreases slowly and fades away in time horizon 9. We also see that unexpected shock in inflation has no significant impact on trade openness even in time horizon 1. The third column shows that unexpected increase in trade openness reduces GDP growth up to time horizon 2 and then the impact of negative shock fades away in time horizon 8. The unexpected shock in trade openness leads to increase in remittances growth in time horizon 1. After the period 1, the impact of trade openness on remittances decreases and fades away in time horizon 5. We also see that unexpected trade openness shock leads to decrease in inflation in time horizon 1. After period 1, the unexpected shock in trade openness reduces inflation slowly and fades away in time horizon 6. The fourth column shows that unexpected shock in remittances growth leads to increase in GDP growth rate in time horizon 1. After time period 1, the unexpected shock in remittances growth leads to decreases in GDP growth and become insignificant in time horizon 4. We also see that unexpected shock in remittances growth has a negligible and insignificant impact on trade openness. Finally, we see that unexpected shock of remittances growth leads to increase in inflation rate up to time horizon 2. After time period 2, the unexpected shock in remittances growth leads to decreases in inflation and inflation fades away slowly in time horizon 8.

### **Variance decomposition analysis**

In order to analyze the dynamic behavior of the VAR model, we need consider the variance decomposition analysis. The variance decomposition of the recursive VAR orders as GDPGR, INFLATION, TRADEOPN and REMGR can be shown in Table 6.



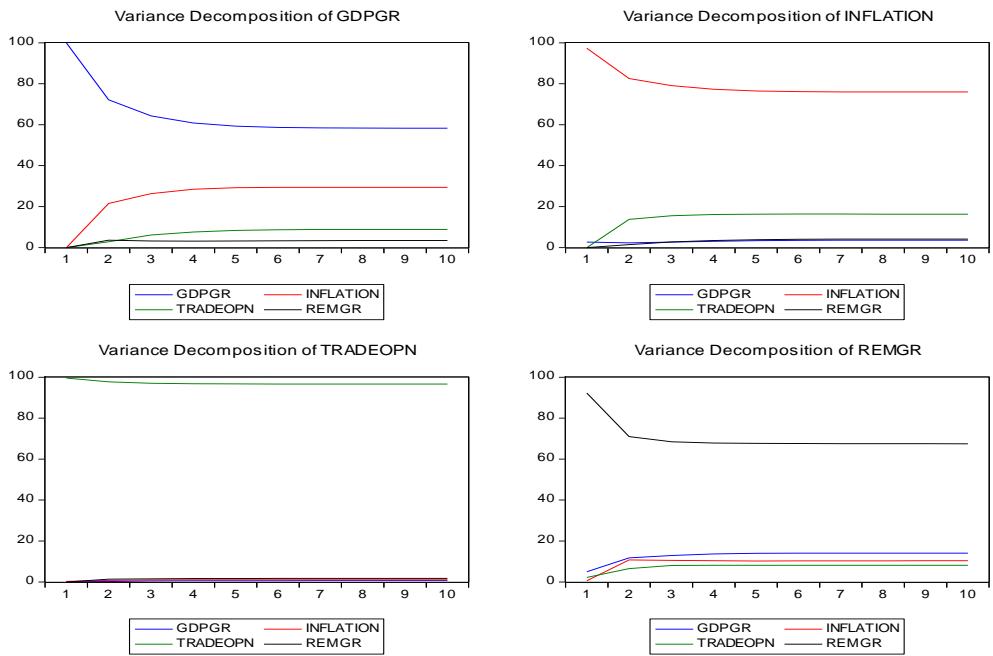
**Figure 4: Impulse responses on GDP growth- trade openness- inflation rate – remittance growth in recursive VAR**

**Table 6: Variance decompositions of recursive VAR ordered as GDPGR, INFLATION, TRADEOPN and REMGR**

Variables	Forecast Time Horizon	Forecast Standard Error	Variance decomposition in percentage points			
			GDPGR	INFLATION	TRADEOPN	REMGR
GDPGR	1	0.011	100.000	0.000	0.000	0.000
	3	0.013	64.327	26.331	6.129	3.2105
	9	0.014	58.320	29.397	8.847	3.434
INFLATION	1	3.182	2.644	97.355	0.000	0.000
	3	3.913	2.655	79.097	15.528	2.718
	9	4.034	3.585	75.969	16.324	4.120
TRADEOPN	1	0.103	0.155	0.294	99.550	0.000
	3	0.104	0.463	0.994	97.021	1.520
	9	0.105	0.619	1.020	96.648	1.711
REMGR	1	0.128	4.950	0.560	2.216	92.272
	3	0.157	12.937	10.537	8.071	68.452
	9	0.160	14.070	10.323	8.117	67.489

From the table 6, we see that unexpected shock in GDP growth has a larger impact on inflation compare to other variables. The result also show that in the long run, the variation of GDP growth also depends on the shocks of other variables such as inflation, remittance growth and trade openness. In the third period 36 % of the total change on the variance is due to remittance growth, trade openness and inflation variables. This percentage increases over the time period and in the ninth time horizon it became 42%. In the case of inflation, we see that in the third period 21% of the total change on the variance is due to variables of GDP growth, trade openness and remittances growth. This percentages increase slowly over the time period and even in the ninth horizon it became only 25% of the total change on the variance is due to rest of the variables. In case of trade openness, the total change on the variance is due to rest of the variable is minimal even in the ninth time horizon, only 4% of total change is due to rest of the variables. In case of remittances growth, the impact on variance decomposition from the other variables is increasing overtime and in the ninth time horizon, 14%, 10% and 8% of the variation of remittances growth is due to GDP growth rate, inflation and trade openness respectively.

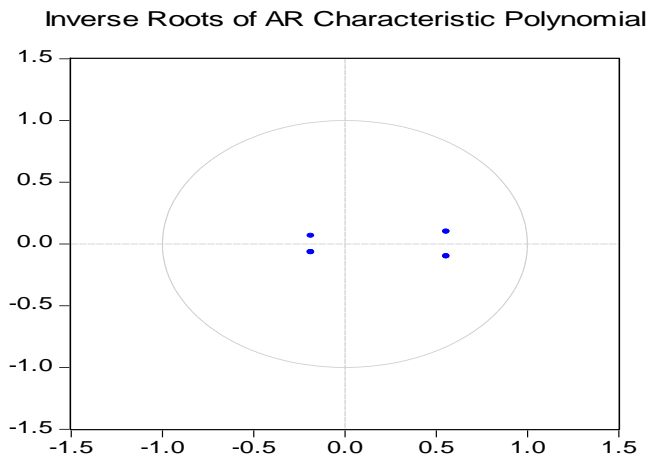
The variance decomposition of recursive VAR ordered as *gdpg*, *inflation*, *tradeopn* and *remgr* are shown in figure 5. According to figure 5, we see that the variance of GDP growth rate due to shock of GDP growth rate is decreasing and the shock of inflation is increasing. From figure 5, we observe that the variance of inflation rate due to shock of inflation rate is decreasing; then it becomes stable after time horizon 5. The shock of other variables remains more or less stable. From figure 5, we also observe that the variance of trade openness due to shock of trade openness is decreasing; then it becomes stable after time horizon 2. The shocks of other variables are minimal. Finally, we observe that the variance of remittances growth due to shock of remittances is decreasing; then it becomes stable after time horizon 3. The shocks of other variables are also remaining more or less stable after time horizon 4. Since all the variables in VAR are stationary, the shocks become stable after some period of time.



**Figure 5: Variance decomposition of GDP growth- Inflation -trade openness- remittance growth in recursive VAR**

**Stationary of VAR model**

We can test the stationarity of VAR model by using the inverse roots of AR characteristics polynomial. Figure 6 shows the inverse roots of AR characteristics polynomial. From the figure 6, we see that all the roots of four variables are within circle point. Since all the roots of four variables are within circle point which indicate that VAR model is stable one. The results of inverse roots of AR characteristics polynomial seems to be logical because all the variables in VAR model are stationary.



**Figure 6: Inverse roots of AR characteristics polynomial**

**Diagnostic tests of VAR model**

In this study we used several diagnostic tests to justify the robustness of the model. The main diagnostic tests includes VAR residuals Portmanteau Tests for Autocorrelation ( $H_0$ : no residual autocorrelation up to lag h), VAR Residual Serial Autocorrelation LM tests ( $H_0$ : no serial autocorrelation at lag order h), VAR Residual Heteroskedasticity ( $H_0$ : No cross terms) and VAR Residual Normality Tests ( $H_0$ : residual are multivariate normal). The results of different diagnostic tests are shown in table 7. From the table 7, we see that there is no autocorrelation at lag order; residuals are homoscedastic and multivariate normally distributed since we fail to reject the null hypothesis. The robustness tests show that the estimated VAR model is statistically sound and fitted well.

**Table 7: Diagnostic tests of the VAR model**

Test	Chi-square value of the tests	p-value	Decision
LM test for autocorrelation	18.408	0.300	Fail to Reject null hypothesis
Residual Heteroskedasticity tests	84.380	0.347	Fail to Reject null hypothesis
Jarque-Bera Normality tests	2.540	0.280	Fail to Reject null hypothesis

**Conclusion and policy implication**

This present study investigates the empirical relationship between inflation and economic growth in Bangladesh from 1976 to 2011 by using the VAR model. We used several econometrics techniques such as unit root test, stationarity test, co-integration test, VAR model, VAR Granger causality test, impulse response functions and variance decomposition of error term, VAR stationarity test and diagnostic test of VAR model. The empirical findings show that there is a statistically significant negative relationship between inflation and economic growth in Bangladesh. The result of the present study shows that worker’s remittances and economic growth in Bangladesh have a significant positive association. The empirical findings of the present study also show that the effect of trade openness on economic growth is negligible and statistically insignificant. Since inflation and economic growth is inversely related in Bangladesh, forecasting accurate inflation is necessary for economic growth in Bangladesh. Based on the major findings of the study, the policy implications are as follows.

- One of the important goals of the Central Bank is price stability. In order to maintain low and stable inflation, central bank should collaboration with the government in formulating monetary policy which should be consistent with the fiscal policy.
- In order to utilize workers’ remittances in productive sector, government should need to take effective policy scheme that encourages the workers’ sending remittances in formal channel.

The empirical findings of the study are very much useful for monetary decision makers to keep the inflation rate as a reasonable rate which is consistent with economic growth in Bangladesh. The above policy suggestions can be applicable for similar type of developing countries where remittances have a positive impact on economic growth and inflation also has a negative impact on the economic growth.

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