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Research Article

The World Uncertainty Index And The Macroeconomic Indicators; A Case For India

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ABSTRACT

In this study, we have empirically investigated the dynamic interplay among the World Uncertainty Index (WUI), growth rate, inflation rate, and interest rate using a Vector Autoregressive Model (VAR) with a lag order of 4, analyzing quarterly data spanning from 1996Q3 to 2021Q1. Our investigation employs various analytical techniques including the Augmented Dickey Fuller (ADF) test, Impulse Response Function (IRF), Granger causality, and Ordinary Least Squares (OLS) based CUSUM test for assessing model stability. Our empirical findings reveal a noteworthy positive correlation between the WUI and growth rate, suggesting that heightened global uncertainty tends to coincide with increased economic growth. Conversely, we observe a negative impact of interest rates on growth rate, indicating that higher interest rates may dampen economic expansion.

Keywords: World Uncertainty Index (WUI), VAR, IRF, Granger causality

1. Introduction:

In the fiscal year 2023-24, the real GDP is projected to reach ₹172.90 lakh crore, from ₹160.71 lakh crore in 2022-23. The GDP growth rate for 2023-24 was anticipated to be 7.6 percent, an increase from the 7.0 percent growth rate recorded in 2022-23. (MOSPI[1]). As against the actual growth rate of 6.33 percent in 2023 against7.24 percent in 2022. Nonetheless the national income of a country is affected by various factors such as labour force, capital stock, Technology and innovation, productivity and many more. Uncertainty which is defined as the people's inability to forecast the likelihood of events happening in the future Knight (1921). The uncertainty prevailing in the economy creates friction in the peace of economic growth which is supported by a numerous theoretical and empirical findings. India has experienced substantial policy shifts and reforms in different sectors, encompassing taxation, regulation, and trade. While some of these reforms are aimed at boosting long-term economic efficiency and growth, they may initially create uncertainty as businesses and individuals adapt to new regulations and practices. In recent years, various occurrences, such as the global financial crisis, political divisions, trade disputes, and the pandemic, have sparked worries about increasing economic uncertainty in India along with the entire world. The effect of uncertainty on growth can be traced to Friedman(1977), who pointed out the possible negative impact of inflation uncertainty on economic growth rate in the economy, on the contrary Dotsey and Sarte (2000) highlighted the possibility of the positive effect of uncertainty associated with the rate of inflation on growth rate. Similarly, uncertainty associated with the output growth rate might also affect the growth rate itself, for example Pindyck (1991) found a negative effect of uncertainty associated with output growth rate on the output growth rate itself while Mirman (1971), Black (1987), Blackburn (1999) argued for a positive effect of output uncertainty on the growth rate. More uncertainty on income may pave the way for higher savings for precautionary reasons (Sandmo, 1970), and thus higher investment and growth rate, on the opposite to that a high level of uncertainty associated with the major macroeconomic variable might delay the investment and therefore lower growth rate.

[1] https://www.mospi.gov.in/sites/default/files/press_release/PressNoteSAE2023-24.pdf

Now the one essential question arises of how to quantify the uncertainty associate with the economic variable. Initially variance of a variable was used as a proxy for uncertainty associated with a particular variable however there are no perfect measure of uncertainty, and a range of proxies like the volatility of the stock market or GDP has been used (Bloom, 2014), as a measure of uncertainty and recently conditional variance from GARCH model are being used as a proxy for uncertainty. Baker, Bloom, and Davis (2016) developed an index of EPU based on newspaper coverage, based on the frequency of words such as uncertain, uncertainty, economic, or economy, as well as policy in newspaper articles. The EPU was used as a proxy for economic uncertainty in many recent papers Bhagat *et al.* (2016), Gu *et al.* (2021), Nguyen et al. (2020) etc.
Recently Ahir, Bloom and Furceri, D. (2022) created World Uncertainty Index (WUI) as an improvement over EPU index. The WUI differs from the EPU along three key dimensions: source, frequency and country coverage. WUI covers a wider number of countries than EPU, WUI covers more time periods than EPU, Unlike the source of construction of Economic Policy Uncertainty (EPU) differs across countries the World Uncertainty Index (WUI) is constructed based on a single, consistent and standardized source (Economic Intelligent Unit) which make it comparable across countries. Ahir at el (2022).
In this paper we have investigated the effect of uncertainty on the major macroeconomic variables such as inflation rate, output growth rate and interest rate in India. The current paper contributes to the literature by taking world Uncertainty index as a proxy for overall economic uncertainty

2. Literature review:

Nilavongse *et al.* (2020) utilized a structural vector auto-regression (VAR) model to identify a negative correlation between EPU shocks and industrial production in the USA. Several researchers, including Cizomesija *et al.* (2017) and *Skrabic et al.* (2018), have explored Granger causality between EPU and economic activity, revealing heterogeneous findings across different countries. Another area of study has focused on examining the spill over effects of uncertainty. Colombo (2013) demonstrated that a one standard deviation shock to US EPU leads to decreases in European industrial production and prices. Similarly**,** Lee (2018) found that EPU in Korea is significantly impacted by US uncertainty. Conversely**,** Goodell et al. (2020) analyzed various types of uncertainty, concluding that election uncertainty influences both EPU and financial uncertainty.Additionally, EPU has been identified as a significant driver of house price volatility Wang et al.(2020) and Bitcoin returns Demir et al. (2018). Concurrently, efforts have emerged to enhance the leading indicator qualities of the EPU index**.** Baker et al. (2016) conducted a comprehensive audit study, revealing high correlation between human- and computer-generated EPU indices. Subsequent studies, such as Tobback *et al.* (2016)**,** have optimized the EPU index using advanced machine learning techniques, resulting in improved forecasting power and correlation with established indices**.** Azqueta-Gavaldon (2017) introduced an unsupervised machine learning algorithm for constructing the EPU index, utilizing the Latent Dirichlet Allocation (LDA) model. This approach yielded highly correlated results with the original categorical EPU indices. Overall, these studies collectively highlight the significant contributions of the EPU index to understanding economic uncertainty dynamics and its potential as a leading indicator in economic analysis. Xie (2020) introduced a novel approach, the Wasserstein Index Generation model (WIG), for constructing sentiment indices. Unlike Baker et al. (2016), WIG operates as an unsupervised machine learning method, eliminating the need for human classification of newspaper articles. Xie (2020) demonstrated that the EPU index constructed using WIG exhibits a significant correlation with the Baker et al. (2016) EPU index and outperforms the LDA approach.Saltzman and Yung (2018) augmented their uncertainty index construction by incorporating data from the Federal Reserve Beige Books. They utilized a natural language processing model to account for both positive and negative connotations of uncertainty. Through principal component analysis on 13 uncertainty fields, they identified two specific types: Politics and Government Uncertainty, and Business and Economics Uncertainty. Within a vector auto-regressive (VAR) framework, Saltzman and Yung (2018) established a significant relationship between uncertainty and several US macroeconomic variables. Moreover, they found a moderate correlation between their uncertainty measure and the original EPU index. Another method proposed by Castelnuovo and Tran (2016) involves measuring uncertainty through online searches by internet users. By selecting keywords based on the most commonly used uncertainty terms from the Federal Reserve's Beige Book for the US and the Reserve Bank's Monetary Policy Statement for Australia, they developed a Google Trends uncertainty index. Their findings indicated a moderate correlation between the Google Trends uncertainty index and the original EPU index for both the US and Australia.

3. Methodology:

3.1. The model:

Given the time series properties of the data and the theoretical dynamic interaction of each variable a four a vector autoregressive (VAR) model with four variables is undertaken. Following (Tsay, 2014) , a typical VAR model with T observation and four variables can be represented as follows

$$X_t=V+A_1X_{t-1}+A_2X_{t-2}+A_3X_{t-3}+A_4X_{t-4}+\ldots\ldots\ldots\ldots+A_pX_{t-p}+e_t \,, \qquad t=p+1,\ldots\ldots\ldots\ldots,T, \quad \textbf{....}\ (1)$$

Where,
X_t is a 4 ×1 vector of variables at time period t,
is transpose (V_1,V_2,V_3,V_4) is a fixed 4 ×1 vector of intercept term,
e_t is a transpose(e_1,e_2,e_3,e_4) is a 4 ×1 vector white noise with covariance matrix$\sum u$,
A_i are 4 ×4 coefficient matrix, $i \in 1,2,3,4....,p$
Covariance matrix$\sum e$ is assumed to be nonsingular
We have T-p data points for effective estimation
To facilitate the estimation, we modify the equation as follows

$$Y_t{}' = X_t' \beta + e_t' \quad \text{.......................} \quad (2)$$

Where Xt= $(1, Y_{t-1}', \; Y_{t-2}', \; Y_t', \; Y_t', \ldots\ldots\ldots\ldots.. \; Y_{t-p}')'$ is a (4×p+1) dimensional vector and β = $[A_0,A_1,A_2,A_3,A_4,..........A_p]$ is a 4×(4×p+1) matrix, With the new format we can write the data as

$$\boldsymbol{y} = \boldsymbol{x}\,\beta + \boldsymbol{e} \quad \text{................................}(3)$$

Where, **y** is a (T-p) × 4 matrix with i^th^ row being $\boldsymbol{y}_{p+i}'$,**x** is a (T-p) × (4×p+1) design matrix with i^th^ row being $\boldsymbol{x}_{p+i}'$ and **e** is a (T-p) ×4 matrix with i^th^ row being $\boldsymbol{e}_{p+i}'$
Under the assumption that e_i has zero mean and positive-definite covariance matrix Σe and that e_i and e_j are uncorrelated if i ≠ j. The ordinary least-squares estimate of β is then

$$\hat{\beta} = (\boldsymbol{x}'\boldsymbol{x})^{-1}\boldsymbol{x}'\boldsymbol{y}$$
$$= \left[\sum_{t=p+1}^{T} \boldsymbol{x}_t\boldsymbol{x}_t'\right]^{-1} \times \sum_{t=p+1}^{T} \boldsymbol{x}_t\boldsymbol{y}_t'$$

To determine the optimal lag order of the VAR model we calculated four information criteria namely The Akaike information criterion (AIC), the Hannan–Quinn information criterion (HQ), Schwarz information criterion (SC) and The Final Prediction Error (FPE).

AIC(n)=ln (det ($\sum e\,(n)$)) + $2nK^2/T$
HQ(n)= ln (det ($\sum e\,(n)$)) + $2\ln(\ln(T))nK^2/T$
SC(n)= ln (det ($\sum e\,(n)$)) + $\ln(T)nK^2/T$
FPE=$((T+n^*) /(T-n^*))^K$ det ($\sum e\,(n)$)
With $\sum e\,(n)=T^{-1}\sum_{t=1}^{T} \boldsymbol{e}_t\boldsymbol{e}_t'$ and n^* is the total number of parameters in each equation and n is the assign lag order.

3.2 Variables:

IIP: Growth rate of Index of Industrial Production (IIP) is used as a proxy for output growth rate. The Index of Industrial Production (IIP) growth rate is often considered a better proxy for output growth in India for several reasons. The IIP covers a broad spectrum of industrial activities, including manufacturing, mining, and electricity generation, providing a comprehensive snapshot of industrial performance. (Ministry of statistics and programmee implementation). Secondly, the IIP is based on actual production data collected from a large sample of industrial units, making it more reliable and accurate compared to other proxies. Finally, the IIP is widely recognized and used by policymakers, analysts, and researchers as a key proxy for growth such as Nain et. al. (2020), Hye et al. (2015), Raghutla et al. (2021), Sarmah et al. (2021) etc.
CPI: Consumer Price Index (CPI) tracks the fluctuations in prices of a selection of goods and services that households commonly purchase. This usually comprises essentials item like food, housing, transportation, and healthcare, reflecting what most individuals require. Consequently, the growth in CPI offers a closer depiction of the inflation felt by the economic agents. Inflation rate is included in our model due to its dynamic relationship with the growth rate which has both theoretical and empirical significance[2].
Interest rate : Interest rate also included in our model due a strong theoretical and empirical establishment on the dynamics among inflation rate, growth rate and interest rate[3] .The weighted average call rate (WACR) – which represents the unsecured segment of the overnight money market and is best reflective of systemic liquidity mismatches at the margin – was explicitly chosen as the operating target of monetary policy in India (Operating Procedure of Monetary Policy, 2021) , WACR is used as a proxy for interest rate

[2] See Barro (1996), Fischer(1983), Dua *at el.* (2021)
[3] Alvarez *et al.(*2001), Hevert *et al.* (1998), Bhat (2016).

World Uncertainty Index (WUI): World Uncertainty Index (WUI) is used as a proxy for uncertainty prevailing in the economy; The proxy has several advantages over some conventional proxies such as conditional variance from GARCH model of GDP, Economic Policy Uncertainty (EPU) etc. for several seasons.

3.3 Data:

The data for the current study is primarily secondary data on Consumer Price Index (CPI), Index of Industrial Production(IIP), Weighted Average Call Money rate(WCMR) and World Uncertainty index(WUI).CPI and IIP are collected from IMF financial statistics, WACMR is collected from Reserve Bank of India(RBI) database on Indian economy and WUI is collected from Federal Reserve Economic Data(FRED).The monthly data on WCMR is transformed to quarterly data, Inflation rate and growth rate is calculated by the following formulae. The time period for our empirical study is chosen from 1998Q2 to 2016Q2, Which is justified by the fact that Reserve Bank of India (RBI) followed '*Monetary Targeting*' from 1985 to 1998 and '*Multiple Indicator Approach'* from April 1998 to August and finally '*flexible inflation targeting (FIT)*' formally adopted with the amendment of the RBI Act in May 2016 (Das, 2020). Since uncertainty associated with different monetary policy regime likely to vary much, therefore a single monetary policy regime is chosen. WACMR is used as a proxy for interest rate (r), while Inflation rate and Growth rate are obtained by the following formulae.

$$Inflation\ rate = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \times 100$$

$$Growth\ rate = \frac{IIP_t - IIP_{t-1}}{IIP_{t-1}} \times 100$$

After preparing the date on inflation rate and growth rate we performed the Friedman Rank test[4] (1937) and Kruskall Wallis test[5] (1952) to assess the seasonality on each series. We found that inflation rate series and growth rate series have seasonal effect[6], therefore we decomposed inflation and growth rate series into seasonal, trend and irregular components using moving averages with a classical additive method and finally extracted seasonal adjusted inflation rate (P) and growth rate(Y).

3.4 Descriptive Statistics:

The descriptive statistics are provided by table (1). The reported average growth rate (Y), Inflation rate(P), Interest rate(r) and world Uncertainty Index(z) in the sample period are 1.02 %, 1.76%, 6.83% and 0.08 with standard deviation of 3.65%, 1.2893320%, 2.20% and 0.091 respectively. The value of kurtosis is greater than 3.0(the normal value for normal distribution) for all series except growth rate(Y), which implies that they are leptokurtic. Negative values for the skewness in the Growth rate(Y) series indicate leftward skewed while positive values for the rest of the series indicated a rightward skewed. While looking at the p-values (Values are in the parenthesis) of the Jarque-Bera statistics, the null hypothesis of a normal distribution is rejected of all the series except Growth rate(Y) at a 1 percent level of significance. This implies a deviation from normality.
The time series properties of each series are reported in table (2). To check whether series are stationary or not, the conventional Augmented Dickey-Fuller (ADF) test is performed with the optimal lag of each respective series. The optimal lag order is selected by using Schwarz Information Criterion (SIC). All the series are stationary or integrated with order zero with some drift since the test statistics exceeds the critical value in absolute term for all the series at 5% level of significance. In the table 1% and 10% significance level critical values are also reported for all the series. Further Interest rate(r) and WUI (z) have arch effect at 5% level of significance while Growth rate(Y) and Inflation rate (P) do not have arch effect confirmed by p-value of ARCH-LM statistics (up to lag 12).

Table.1

Statistics\Variable	*Growth rate(Y)*	*Inflation rate(P)*	*Interest rate(r)*	*WUI(z)*
Mean	1.0221656	1.7616380	6.8356164	0.083426774
Median	1.0838806	1.7929627	7.000	0.057247501
Variance	13.3649746	1.6623771	4.8614916	0.008344597
SD	3.6558138	1.2893320	2.2048791	0.091348767
COV	3.5765377	0.7318939	0.3225575	1.094957443
Range	19.5884657	7.8218770	13.0000000	0.354840606

[4] Friedman, M. (1937). The Use of Ranks to Avoid the Assumption of Normality Implicit in the Analysis of Variance. Journal of the American Statistical Association 32 (200), 675-701.
[5] Kruskal, W. H. and W. A. Wallis (1952). Use of Ranks in One-Criterion Variance Analysis. Journal of the American Statistical Association 47 (260), 583-621.
[6] Inflation rate series: Friedman rank Test statistic: 37.27 P-value: 000 and Kruskall Wallis Test statistic: 44.91,p-value:000 ;
Growth rate series: Friedman rank Test statistic: 40.07 P-value: 000 and Kruskall Wallis Test statistic: 39.53 ,p-value:000

Minimum	-10.9369605	-2.4270187	3.0000	0.00
Maximum	8.6515052	5.3948583	16.000	0.354840606
Skewness	-0.286585	0.2930813	0.7422928	0.8820101
Kurtosis	3.594193	4.663505	5.546711	2.977509
J.B. Statistic (p-value)	2.0732 0.354	9.4621 (0.008)	26.431 (0.000)	9.4665 (0.008)
ARCH -LM statistics	5.8524 (0.9233)	18.401 (0.104)	39.08 (0.000)	23.547 (0.023)

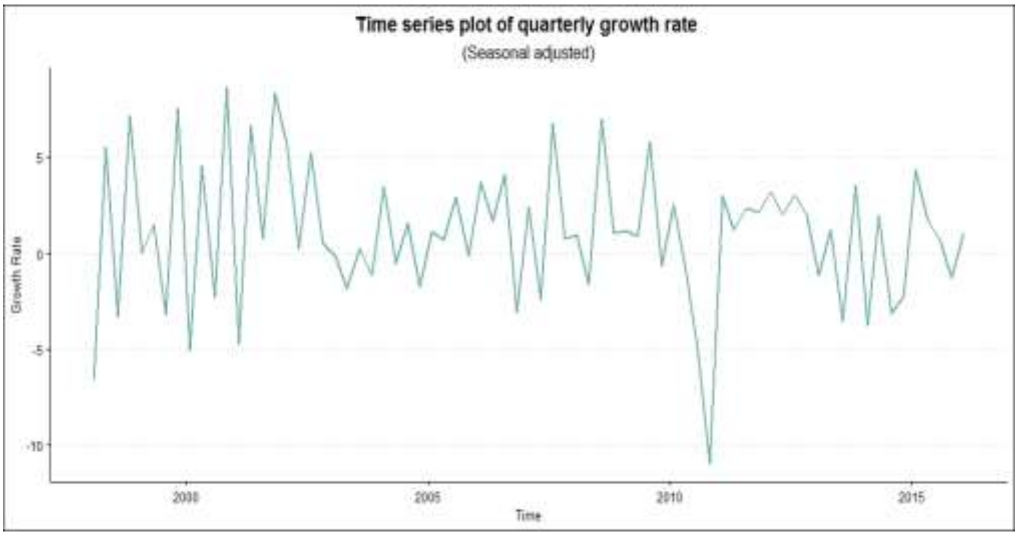
Note: SD- Standard Deviation, COV-Coefficient of variation

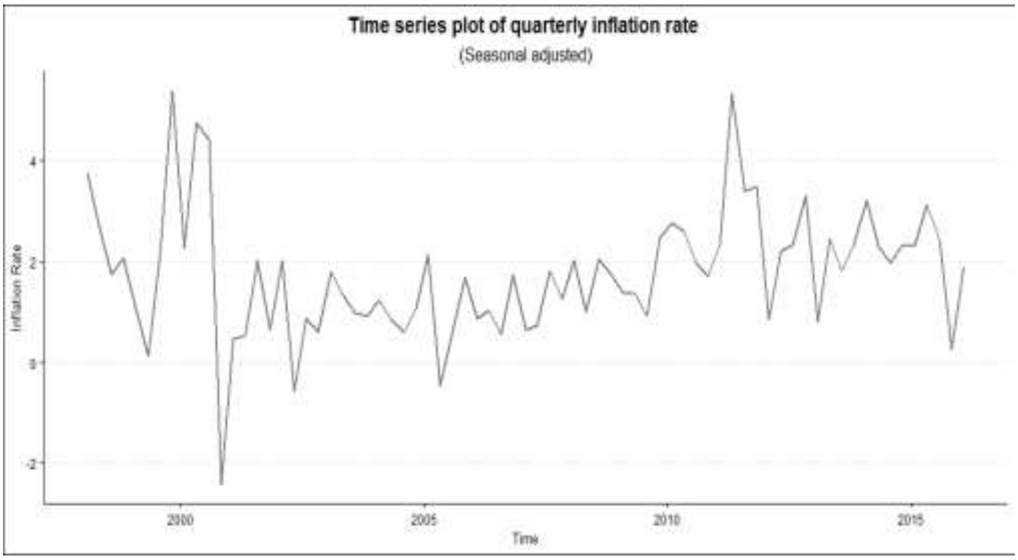
Table.2

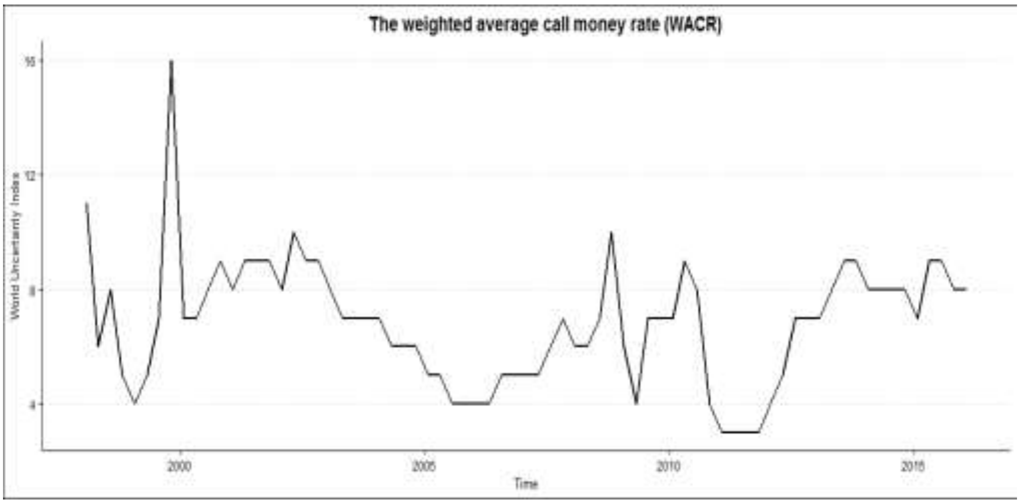
Variable	***Test***	***Lag (SC)***	***Test statistics***	***Critical value***			***Decision***
				1%	5%	10%	
Growth(Y)	*ADF with drift*	2	-5.0116	-3.51	-2.89	-2.58	I(0)
Inflation(P)	*ADF with drift*	1	-4.6851	-3.51	-2.89	-2.58	I(0)
Interest(r)	*ADF with drift*	1	-3.4683	-3.5	-2.89	-2.58	I(0)
WUI(z)	*ADF with drift*	1	-4.3666	-3.51	-2.89	-2.58	I(0)

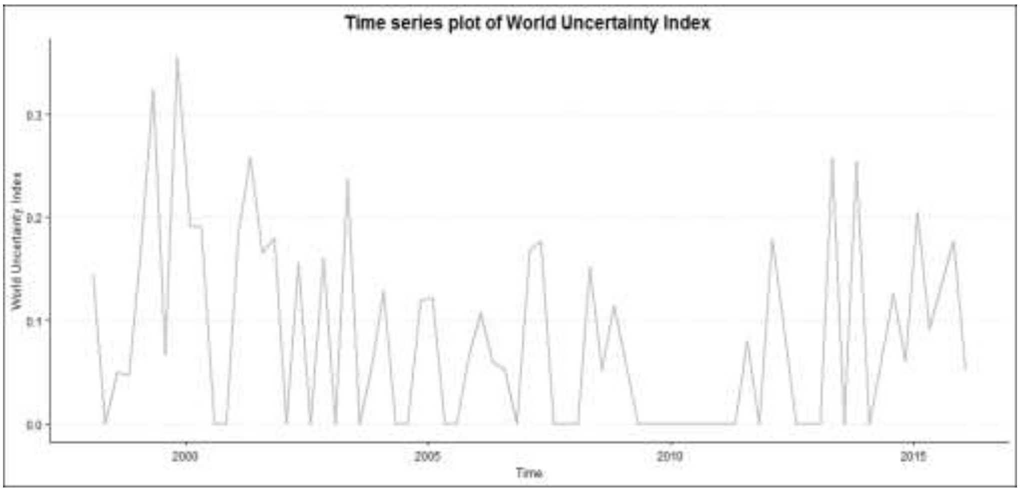
Note: I(0) integrated of order zero

Time series plot o Growth rate(Y), Inflation rate(P), Interest rate(r) and World Uncertainty Index(z) are plotted in figure.1, figure.2, figure.3 and figure.4 respectively.
Figure.1 to Figure. 4









Note: from top to bottom figure.1, figure.2, figure.3 and, figure.4

4. Empirical Results:

4.1 The VAR results:

Since all the series are integrated of order zero in other words all the series are stationary at level therefore a VAR model is employed. We identified the order of the VAR model using the Akaike Information Criterion (AIC), Schwarz Information Criteria (SC), and Hannan-Quinn Information Criteria (HQ). Out of which AIC suggest a VAR model of order 10 while HQ and SC suggest a VAR model of order one and FPE suggest a VAR mode of order 4. Taking excessive lags suggested by AIC reduces the degrees of freedom of the estimated parameters while taking too few lags suggested by SC and HQ will provide a model with auto-correlated residuals, therefore the lag order of 4 i.e. VAR (4) suggested by FPE is chosen as the optimal model. The optimal lag length criteria were presented in Table.3.

Table.3

Number of lag\ Criteria	Akaike Information Criteria (AIC)	Schwarz Information Criteria (SC)	Hannan-Quinn Information Criteria (HQ)	Final prediction error (FPE)
1	-1.992586	-1.312225*	-1.724997*	0.136525
2	-2.1340267	-0.9093783	-1.6523665	0.1192950
4	-2.40597157	-0.09274678	-1.49616895	0.09525852*
10	-2.6178376	2.9611163	-0.4236077	0.1997292*

Note: Asterisk (*) denotes lag order selected by the criterion.

The short-run dynamics among growth rate (Y), Inflation rate(Y), Interest rate(r) and World uncertainty index (Z) is estimated by VAR (4) model by OLS per equation which is represented by Table.4.
It is observed that the inflation rate has statistically significant positive effect on growth rate at lag four at 5% level of significance, at lag three inflation have negative effect on growth rate however at 10% level of significance. and it is insignificant alt 5% level of significance. Interest rate(r) at lag one has a negative effect on growth rate which is statistically significant even 1% level of significance. World uncertainty index(z) at lag two have positive effect of growth rate at 1% level of significance. Inflation rate(P) is negatively affected by

growth rate (Y) at lag two, moreover inflation rate (P) is negatively affected by the interest rate(r) at lag four with 1% level of significance. It is observed that no variable has a statistically significant effect of the world uncertainty index(Z). The AR coefficient of interest rate(r) at lag one has significant effect on current interest rate at 1% level of significance, Moreover the result suggest that interest rate (r) is positively affected by the World uncertainty index(Z) at lag two. Similarly following an increase in growth rate(R) of one percent, increases the interest rate by about 0.17% at a lag of four quarter with one percent level of significance. The adjusted R square of growth rate(Y)

Table.4

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Dependent variable:				
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y				
	(Y_t)	**(P_t)**	**(Z_t)**	**(r_t)**

Y_{t-1}	-0.062	-0.035	-0.0005	0.049
	(0.131)	(0.054)	(0.004)	(0.071)
P_{t-1}	-0.085	0.136	-0.006	-0.047
	(0.308)	(0.127)	(0.011)	(0.166)
Z_{t-1}	1.643	1.175	0.011	-0.970
	(4.113)	(1.694)	(0.141)	(2.217)
r_{t-1}	-0.726***	0.022	0.008	0.506***
	(0.244)	(0.101)	(0.008)	(0.132)
Y_{t-2}	0.249*	-0.110**	0.001	0.042
	(0.125)	(0.051)	(0.004)	(0.067)
P_{t-2}	-0.128	0.009	-0.010	-0.165
	(0.316)	(0.130)	(0.011)	(0.171)
Z_{t-2}	12.594***	2.098	0.250*	8.810***
	(4.108)	(1.692)	(0.141)	(2.215)
r_{t-2}	0.061	0.054	0.006	-0.052
	(0.285)	(0.117)	(0.010)	(0.154)
Y_{t-1}	-0.119	-0.097*	-0.001	0.082
	(0.126)	(0.052)	(0.004)	(0.068)
P_{t-3}	-0.586*	0.001	0.008	0.203
	(0.311)	(0.128)	(0.011)	(0.168)
Z_{t-3}	7.780	-0.238	-0.058	1.613
	(4.761)	(1.961)	(0.163)	(2.566)
r_{t-3}	-0.062	0.107	-0.007	0.029
	(0.255)	(0.105)	(0.009)	(0.137)
Y_{t-4}	0.157	-0.083*	-0.0002	0.179***
	(0.118)	(0.049)	(0.004)	(0.064)

P_{t-4}	0.621**	0.063	0.010	0.242
	(0.304)	(0.125)	(0.010)	(0.164)
Z_{t-4}	0.094	-1.041	-0.056	-2.688
	(4.768)	(1.964)	(0.163)	(2.570)
r_{t-4}	0.129	-0.271***	-0.002	0.084
	(0.216)	(0.089)	(0.007)	(0.116)
const	3.334*	2.144***	0.035	1.615*
	(1.783)	(0.734)	(0.061)	(0.961)
Observations	69	69	69	69
R2	0.491	0.376	0.157	0.626
Adjusted R2	0.334	0.184	-0.102	0.510
Residual Std. Error (df = 52)	2.847	1.173	0.098	1.535
F Statistic (df = 16; 52)	3.130***	1.957**	0.605	5.429***

Note: *p<0.1; **p<0.05; ***p<0.01

equation is about 33%, inflation rate (P) has a low adjusted R square, and interest rate(r) equation has a moderate adjusted R square of about 51 percent.

4.2. Granger Causality:

To examine for the forecasting relationship among growth rate (Y), Inflation rate(Y), Interest rate(r) and World uncertainty index (Z), Granger's Causality Test (Granger, 1969, 1981) is used, which is introduced by Granger (1969), and was popularized by Sims (1972). Schwarz Criterion (SC) has been applied to determine the optimum lag length. The Granger-causality test is used, since it is very sensitive to lags used in estimation procedure, The co-integration test ignores the effect of the past values of one variable on the current value of the other variable. The Granger causality test was hence used to examine such possible instances. Results are reported in table 5.

Table.5
Granger Causality Test (Multivariate)
F test and Wald χ^2 test based on VAR (4) model:

Effect Variable		Cause variable	F	df1	df2	p		Chisq	df	p	
Growth rate(Y)	<=	Inflation rate(P)	1.66	4	52	.174		6.63	4	.157	
Growth rate(Y)	<=	WUI(Z)	3.23	4	52	.019	*	12.92	4	.012	*
Growth rate(Y)	<=	Interest rate(r)	2.91	4	52	.030	*	11.64	4	.020	*
Growth rate(Y)	<=	ALL	2.23	12	52	.023	*	26.77	12	.008	*
Inflation rate(P)	<=	Growth rate(Y)	2.76	4	52	.037	*	11.04	4	.026	*
Inflation rate(P)	<=	WUI(Z)	0.58	4	52	.678		2.32	4	.676	
Inflation rate(P)	<=	Interest rate(r)	2.40	4	52	.062	.	9.60	4	.048	*
Inflation rate(P)	<=	ALL	2.07	12	52	.036	*	24.87	12	.015	*
WUI(Z)	<=	Growth rate(Y)	0.06	4	52	.994		0.22	4	.994	
WUI(Z)	<=	Inflation rate(P)	0.66	4	52	.625		2.62	4	.622	
WUI(Z)	<=	Interest rate(r)	0.71	4	52	.590		2.83	4	.587	
WUI(Z)	<=	ALL	0.43	12	52	.945		5.14	12	.953	
Interest rate(r)	<=	growth rate(Y)	2.54	4	52	.051		10.15	4	.038	*
Interest rate(r)	<=	Inflation rate(P)	1.29	4	52	.286		5.16	4	.271	

Interest rate(r) <= WUI(Z)	4.17	4	52	.005 **	16.68	4	.002 *
Interest rate(r) <= ALL	2.92	12	52	.004 **	35.05	12	.001**

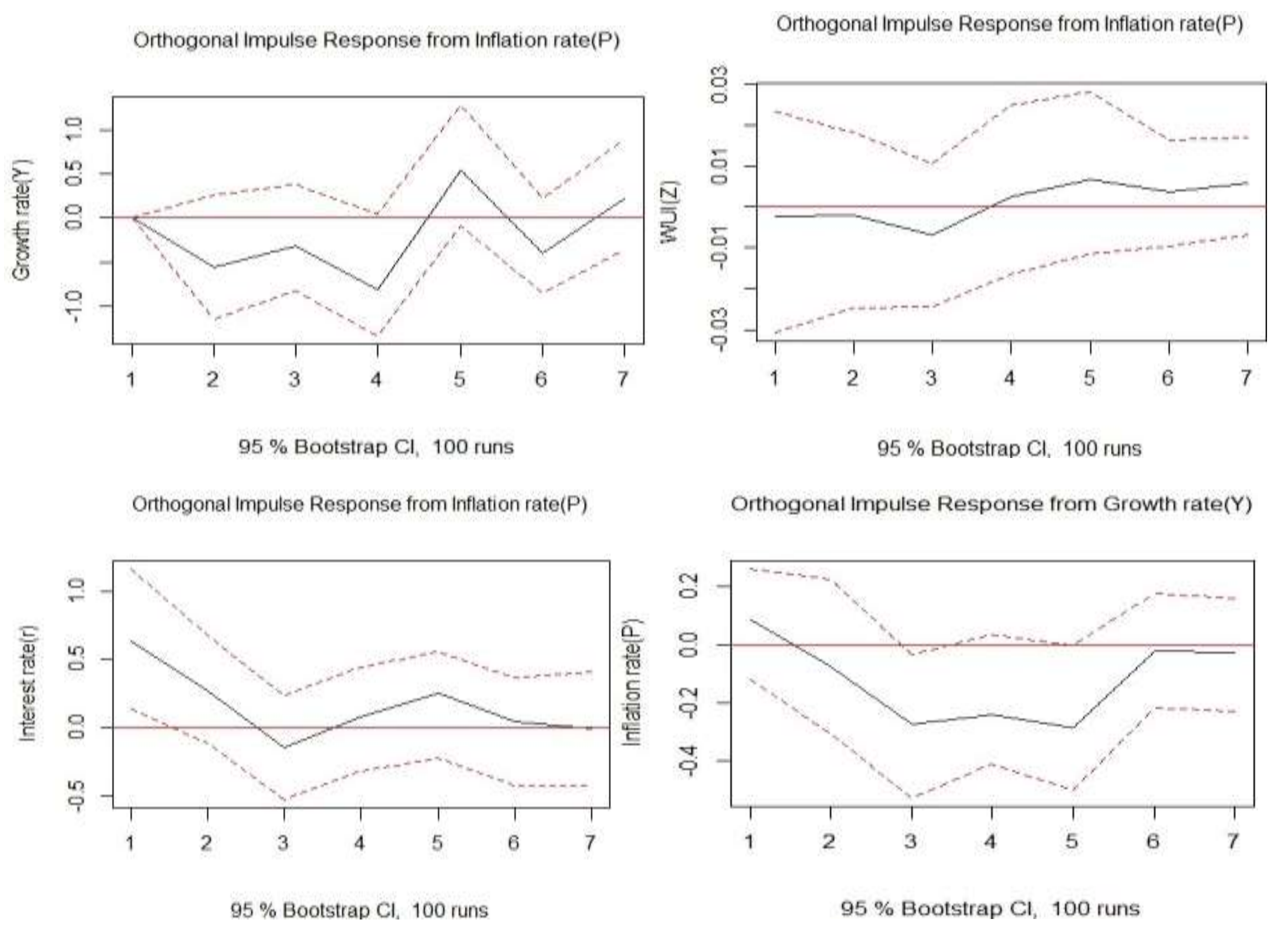
Note: Asterisk (*) denotes *$p<0.05$; **$p<0.01$*
Null hypothesis; H_0: Inflation rate (Cause variable) do not Granger-cause Growth rate(Effect variable)

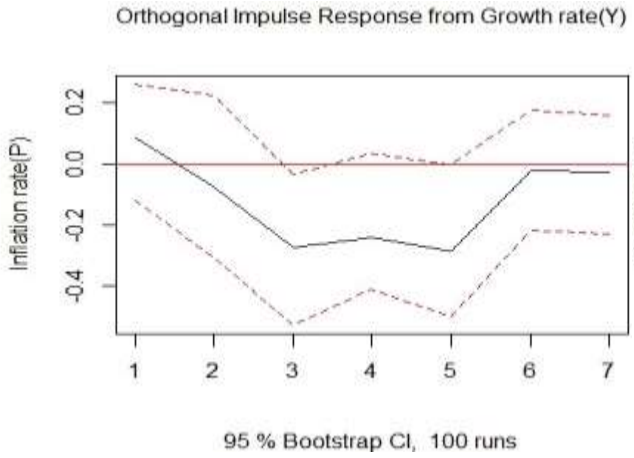
From the results it is inevitably proven that the World Uncertainty Index WUI (Z) granger causes Growth rate(Y) at percent level of significance which I confirmed by both the F test and Wald Chi-square test, similarly interest rate(r) is found to be Granger causes growth rate(Y),moreover it is found that Inflation rate(P),Interest rate(r) and WUI(Z) simultaneously Granger cause growth rate(Y).Likewise growth rate(Y) and interest rate(r) Granger causes Inflation rate(P),and Inflation rate is simultaneously Granger causes by growth rate(Y),WUI(z),and Interest rate(r).However it is found that no variable granger causes World Uncertainty Index WUI (Z).One of the important findings is that Interest rate(r) and is Granger causes by World uncertainty Index(Z) and Growth rate(Y) individually and together World uncertainty Index (Z),Inflation rate(P) and Growth rate(Y) Granger causes interest rate(r).

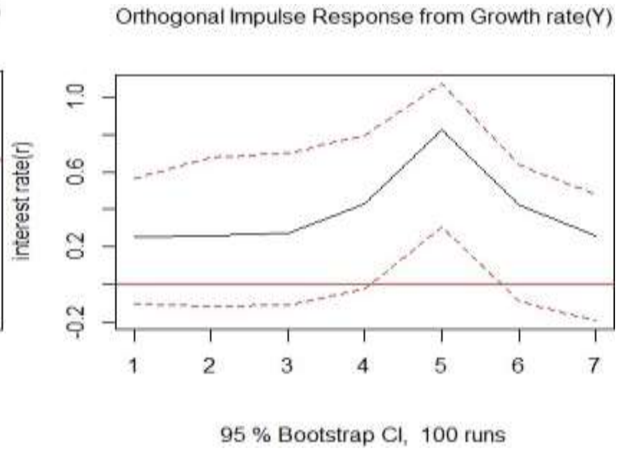
4.3. Impulse Response Functions (IRF):

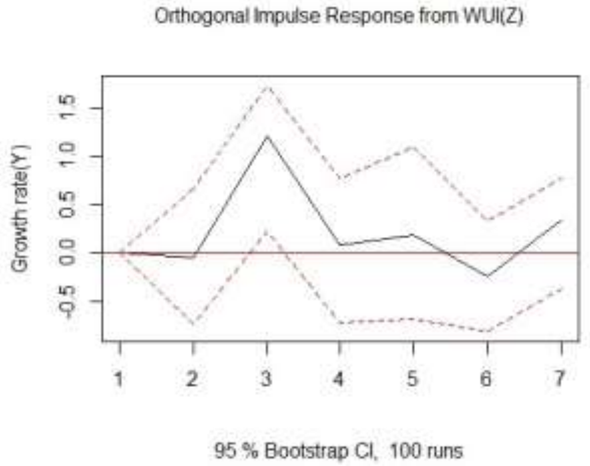
The impulse response functions of the dynamics among growth rate (Y), Inflation rate(Y), Interest rate(r) and World uncertainty index (Z) are presented in figure. 5(a) to figure.5(l). Impulse response functions describe the responses from a one standard deviation shock to a specific variable by the other variables over certain time period. In this paper we estimated the effect during seven quarters. Figure-5(c) reveals the effect of inflation rate(P) shock on Interest rate(r), it is observed that inflation rate(P) has a positive impact on interest rate(r) on current period but as time pass this shock gradually dies within two quarter period. While figure-5(e) reveals the effect of Growth rate(Y) shock on interest rate(r). It is observed that in growth rate(Y) do not have any impact on interest rate(r) in the current period but as time passes interest rate is being affected positively by growth rate in period four and six quarter. After six quarter the shock starts dying. It is observed that one standard deviation sock on World Uncertainty Index (Z) have positive effect on growth at about thee quarter period lag. Moreover impulse response from World Uncertainty Index (Z) to Interest rate(r) is found to be positive at a lag of five quarter. Finally impulse response interest rate(r) to growth rate(Y) is found to be negative at a lag of two quarter period.

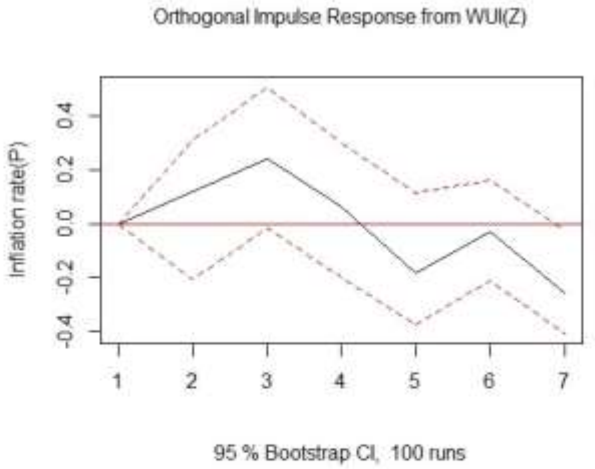
Figure.5(a) to Figure.5(l) (read form left to wright row wise)

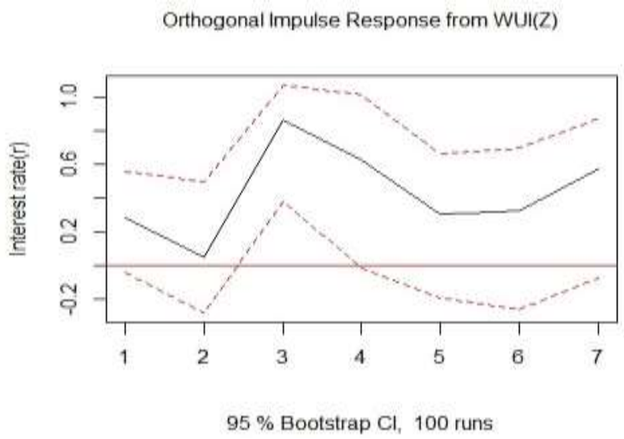


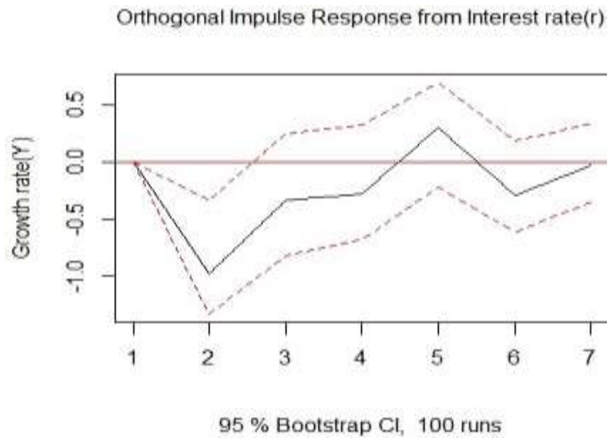

Orthogonal Impulse Response from Growth rate(Y)
Inflation rate(P)
0.2
0.0
-0.2
-0.4
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs

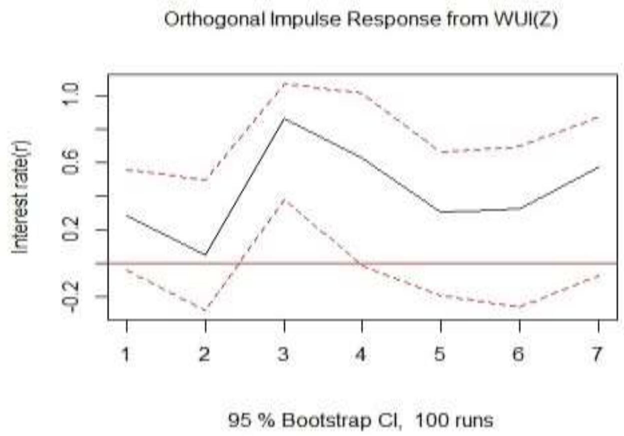

Orthogonal Impulse Response from Growth rate(Y)
Interest rate(r)
1.0
0.6
0.2
-0.2
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs

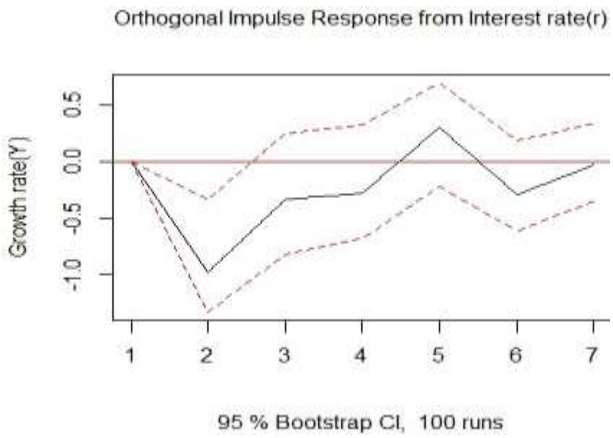

Orthogonal Impulse Response from WUI(Z)
Growth rate(Y)
1.5
1.0
0.5
0.0
-0.5
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs

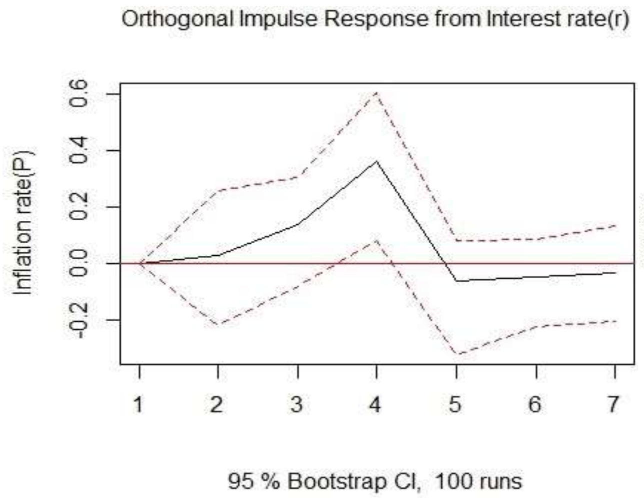

Orthogonal Impulse Response from WUI(Z)
Inflation rate(P)
0.4
0.2
0.0
-0.2
-0.4
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs

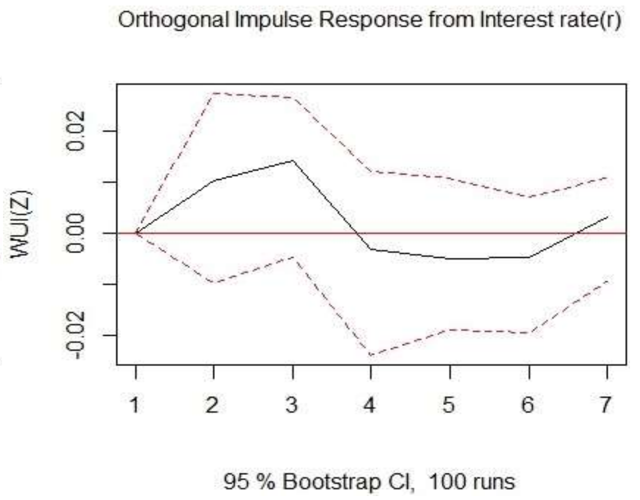

Orthogonal Impulse Response from WUI(Z)
Interest rate(r)
1.0
0.6
0.2
-0.2
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from Interest rate(r)
Growth rate(Y)
0.5
0.0
-0.5
-1.0
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from WUI(Z)
Interest rate(r)
1.0
0.6
0.2
-0.2
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs

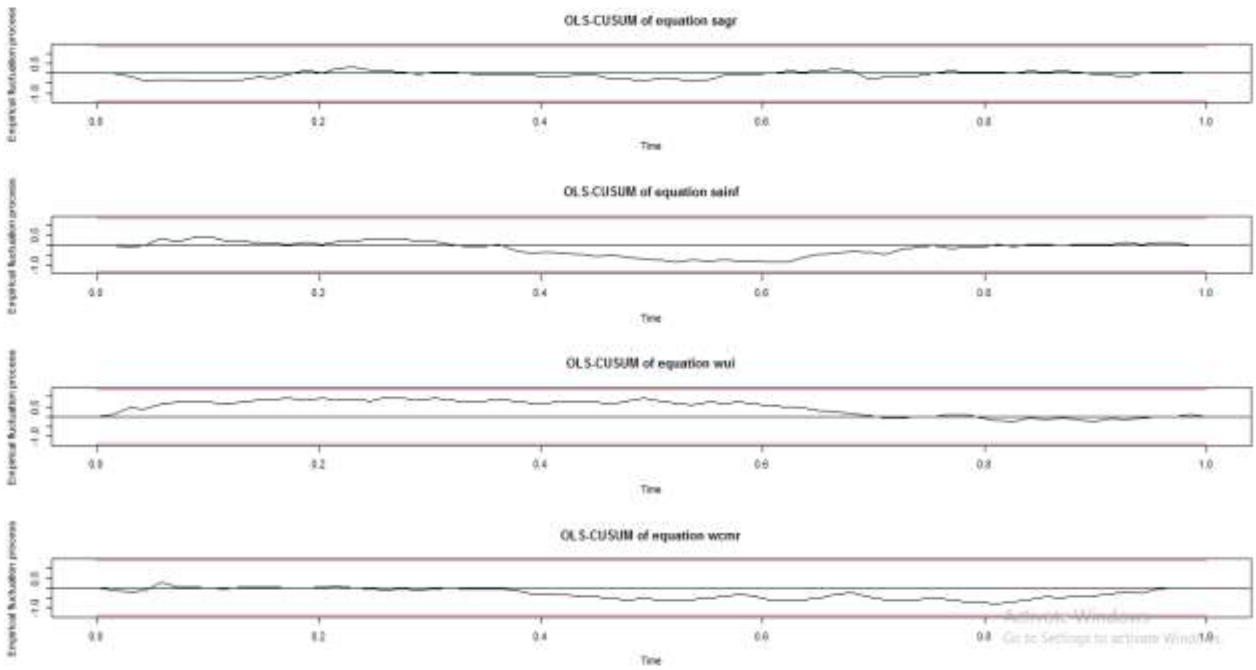

Orthogonal Impulse Response from Interest rate(r)
Growth rate(Y)
0.5
0.0
-0.5
-1.0
1
2
3
4
5
6
7
95 % Bootstrap CI, 100 runs





4.4 Residual Diagnostic:

To test the serial autocorrelation of the residual from the estimate VAR (4) model we computed the multivariate Portmanteau-and Breusch-Godfrey test. The computed Chi-squared value is 154.99 with 192 degrees of freedom having 0.9768 p-value. Therefore, we rejected the null hypothesis of serial autocorrelation. To check homoscedasticity of the residual, we checked for ARCH–LM effect, the calculated Chi-squared value is 503 with 500 degrees of freedom having 0.4461 p-value, therefore residual is homoscedastic since null hypothesis of homoscedasticity cannot be rejected. Moreover, residual is normally distributed confirmed by Jarque–Bera Test, the calculated Chi-squared value is 66 with 8 degrees of freedom with a p-value of 0.3371 therefore null hypothesis of non-normal distribution is rejected. The stability of the model is confirmed by OLS based Cumulative Sum (CUSUM) test on both the eachequation. Results are plotted on figure-6. It can be seen from the figure that the empirical fluctuation process lies with in the 95% confidence interval for every equation the equation.



Discussion:

The empirical findings of our study indicate a positive relationship between the World Uncertainty Index (WUI) and the growth rate, particularly evident at a lag of two quarters, as confirmed by both impulse response function and Granger causality analysis. This outcome contrasts with the findings of prior research, such as Raus (2011), which suggested a negative impact of uncertainty on economic growth. However, our results align more closely with the hypothesis posited by Dotsey and Sarte (2000). This can be justified by assuming two distinct groups of economic agents respond to uncertainty in divergent ways: one group postpones investment decisions due to apprehensions about future economic conditions, while the other group opts for precautionary saving measures and subsequently, these savings are later invested, potentially leading to enhanced economic growth. If the positive effect of delayed investment and increased savings outweighs the negative impact of uncertainty-induced investment delays, then the net effect on economic growth can indeed be positive, as our empirical findings seem to suggest. The other findings of the study includes a negative effect of interest rate on the growth rate at a one quarter lag which is also confirmed by Granger causality and impulse response function, the fact that increasing interest rate is associated with the higher cost of investment and hence a reduction in the investment rate and growth rate in the economy.

Conclusion:

In this paper we have empirically investigated the effect of uncertainty on growth rate, inflation rate and interest rate using a Vector Autoregressive Model (VAR).We have taken World Uncertainty Index (WUI) as a proxy for economic uncertainty and index of industrial production (IIP) growth, Consumer Price Index (CPI) growth and weighted average call money rate as a proxy for growth rate, inflation rate and interest rate respectively. We have taken quarterly data ranging from 1996Q3 to 2021Q1. The result of the empirical findings suggest a positive effect of WUI on growth rate, while interest rate is found to have negative impact on growth rate.

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