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The Nexus between Growth and Unemployment in USA

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Abstract: Nexus between growth and unemployment is inverse but empirically this relationship is not true in all economies in all the time. The author attempted to relate US unemployment with growth during 1948-2016 using bivariate and log regression models, Bai-Perron Model, Granger Causality test, Johansen cointegration test, vector auto regression and vector error correction models. Even, author finds out the relation between unemployment gap, output gap and growth in USA during 1948-2016. US unemployment rate, GDP and growth rate have been taken from Bureau of US census during 1948-2016. US natural rate of unemployment was taken from Fed Bank of St. Louis during 1949-2016. The paper concludes that US unemployment rate has been increasing at the rate of 0. 507 per cent per year and it has one upward structural break in 1971. It follows Okun's law. US unemployment and growth rate are negatively related during 1948-2016 which is significant at 5% level. There is no causality and no cointegration between them. VAR model is stable and stationary. Residual test showed non-normality, heteroscedasticity and autocorrelations. Moreover, author showed negativerelation between growth and unemployment gap in USA during 1949-2016. They have no causality and cointegration. TheirVAR model is stable andstationary. The residual test proved heteroscedasticity, non-normality and auto-correlation problems. In USA, output gap influenced unemployment gap negatively during 1949-2016 significantly. It has significant bi-directional causality and one cointegrating equation. In Vector error correction model, error corrections are significant with high speed having stability, autocorrelation and non-normality. Therefore, jobless growth was not observed in USA during 1948-2016.

Keywords: Output Gap, Unemployment Gap, Cointegration, Vector Error Correction

Introduction

Classists determined unemployment by the gap between the intersection of the labor supply and labour demand at a given real wage. Classical theory which was based on Say's Law (1821) followed by Marshall (1890) and Pigou (1914) who thought that unemployment appears because the real wage is above the competitive level, where labor supply and labor demand cross out. Pigou (1914) believed that full employment prevails automatically

in the labour market when the demand and supply of labour are equal. Marshall (1890) and Pigou (1914) explained that output and employment are determined by the interactions among labour, output and money markets. Each market involves a built-in equilibrium mechanism to ensure full employment in the economy. On contrary, Keynes (1936) arguedthat wages are often inflexible i. e. sticky downwards. Workers resist nominal wage cuts through minimum wage laws and trade union legislation. For example, if there were a fall in demand for labour, trade unions would reject nominal wage cuts. Wages would stay at fixed wage rate, and unemployment would result.

If unemployment rate is higher than natural unemployment rate (NAIRU), then real GDP is below the potential rate and output gap is negative. Opposite is also true. Over longer periods of time, it is clear that if a NAIRU exists at all, it certainly moves around. Economists around the world differ on the importance of NAIRU. The Classical school believes that the economy will tend to return to an equilibrium position whenever it is pushed away, and thus favor the concept of a natural rate and other economists question whether an economy is really a stable system at all. The dynamic nature of the economies was explained by John Maynard Keynes (1936) and Joseph Schumpeter (1936). The concept of Robinson (1937) on NAIRU was an earlier version of NAIRU, because in any given conditions of the labour market there is certain more or less define level of employment at which money wages will rise. Keynesian theory of unemployment is related with an interrelation between aggregate demand, income distribution, capital accumulation, capacity utilization and economic activity without harming inflation.

Okun (1962) believed that if unemployment rate is higher than NAIRU then real GDP will be less than the potential GDP which implies that the output and employment is positively related. He verified that real GDP would rise nearly 2 percentage points faster than the rate of growth of potential GDP during the period when unemployment rate would decline by 1% which means if the potential rate of GDP growth is 2%, GDP must grow at the rate of 4% to achieve a one percentage point decrease in unemployment rate. Afterwards, long run relation between growth and employment had been glorified by Hicks (1950) who showed cyclical patterns of upswings and downswings of national income with the impact on employment in different ceilings especially on full employment.

The quantitative relationship between employment growth, inflation and output growth was analyzed by Phillips (1958) in a macro-dynamic and non-optimal disequilibrium way where role policy makers are

important. Besides, inflation expectation is difficult to assume so that target rates of inflation, unemployment and output to the government became crucial. Modified Phillips model now describes the relationship among the output gap, unemployment gap and inflation expectation. It is analyzed that recession leads to a large negative output gap with high unemployment and inflation although empirical evidences are not identical to all economies. To avoid cyclical behavior, economists should treat them as instrumental variables along with anti-cyclical monetary and fiscal policies.

Review of Literature

Abaidoo (2012) found that both GDP growth and corporate profit growth are significant to increase the potential for lower unemployment rate in USA during 1960-2011 using marginal effect of Probit estimates. Knotek (2017) studied that Okun's law was unstable over time during recessions and expansions. During 1947-1960 in USA, when output was 1% below potential with unemployment rate was 0. 3 to 0. 75 per cent above its full employment rate. On the other hand, US data during 1961-2007 expects unemployment would be 0. 5 percentage point above the full employment rate for a 1% fall of output from potential. It proves instability in the derivation of H. P. Filter in the trends of unemployment and output series in the gap version of Okun's law. In applying Okun's law, Gocerand Erdal (2015) analysed the relationship between youth unemployment and economic growth by using new generation panel data analysis and cointegration tests. They found that 1% increase above economic growth rate is associated with a 1.13% decrease in youth unemployment in 18 European countries during 2006-2012 and a 2.06% decrease in youth unemployment in EU-28 during 1996-2012 which conclude that growth rate of above average will reduce unemployment assuming there was 50-60 per cent youth unemployment rate in these countries. Ayoyinkaand Stephen (2017) fitted Okun's law in Nigeria during 1970-2009 and found that there is a long run negative relationship between unemployment and output showing Okun's coefficient as 1.75% which is significant but unstable. Cashell (2006) studied that 1% difference in growth rate led to 0. 3% change in unemployment in USA during 1950-2005. But to maintain a stable unemployment rate with sufficient growth rate of 3.4%, an increase in the growth rate to 4.4% requires to decrease unemployment rate by 0.3% per year. Similarly, if growth rate drops to 2.4% , then unemployment rate must increase by 0.3% per year. It was found that during 1949-2005, NAIRU ranges between 5-6 per cent , inflation and unemployment follows Phillips curve norm with ranging inflation 3-14 per cent during 1970-1982. It is similar with expert opinions where growth rate near 3% and unemployment rate

ranging 5% to 6% would be consistent with stable rate of inflation. Kitovand Kitov (2011) estimated Okun's law in USA during 1951-2010 and found two structural breaks in 1975 and 1995 respectively. He fitted Okun's law as $\Delta U=1.113-0.406\Delta \ln G$ during 1951-1979 which is significant and $\Delta U=0.866-0.465\Delta \ln G$ during 1979-2010 which is also significant. Unemployment rate will be constant if threshold growth rate is calculated as (0.866/0.465)=0. 89 per year. When $\Delta \ln G$ is larger than this threshold rate, the rate of unemployment in US starts to fall. Using NBER statistical analysis, Federal Reserve Bank of Cleveland (2012) studied that in USA during 1990-2011, output growth increased by 1.6% while unemployment rate declined more than 0.9 %. It also calculated Okun's equations during 1948-2011 and 1970Q1-2011Q4 and found significant inverse relationship. Owyang, Vermannand Sakhposyan (2013) tested Okun's coefficients in several data sets in USA . Firstly, they estimated during 1947-1960 and found that one per cent increase in real GDP growth led to 0.3% decrease in unemployment. They found the coefficient as 0.28 during 1948-2013Q_1. In both the cases, they used Bureau of Economic Analysis and Bureau of Labour Statistics and suggested that Okun's coefficient should be smaller in magnitude during periods of economic expansion and economic recession. NBER analysed that coefficients were 0.16 and 0.17 during expansion and recession respectively in USA. Using employment population ratio as a measure of the extent of employment generation, Swaneand Vistrand (2006) examined the GDP-unemployment growth relationship in Sweden and found a significant and positive relationship between GDP and employment growth. Maditoand Khumalo (2014) analysed the growth-unemployment relationship during 1967-2013 in South Africa with the help of cointegration test and VECM and found significant negative relation along with 62% error corrections. Abdul-Khaliq, Soufanand Abu-Sahib (2014) studied growth-unemployment in 9 Arab countries during 1994-2010 and found significant negative relation and showed that 1% increase in economic growth led to decrease the unemployment rate by 0. 16%. Khan, Saboor, Mianand Anwar (2013) examined that 1% rise in unemployment rate led to 0. 36% decrease in growth rate in Pakistan during 1976-2010 which is significant with Okun's law. Mihaela and Mihaela (2013) studied growth-unemployment relationship in Romania during 2000-2011 and found the significant negative coefficient of -0. 753. Pinar, Serkan, Deniz and Murat (2014) examined econometric relationship between growth and unemployment in EU in 2013 and Turkey during 2001-2011 and found a positive long run and negative short run relationships which were significant. In EU, a 1% increase in unemployment led to 0.35% increase in growth rate in the long run and in Turkey it led to a 0.26% decrease in growth rate in the short term respectively.

In studying historical relationship between growth and unemployment, Levine (2013) concluded that the negative relationship was changed in different economic structures of the countries.

Objective of the Paper

Since the empirical relationship between unemployment rate and growth is not always negative in all economies in allthe periods, then the author attempted to studythe relationship between growth and unemployment rates in USA during 1948-2016 which was extended to show the relationship between output gap and unemployment gap in USA and between unemployment gap and growth in USA during the specified period. The author also analyzed the structural break of US unemployment rate during 1948-2016. All these relationships were established through Granger Causality test, cointegration test and vector error correction models and Bai-Perron model respectively.

Research Methodology and data

Author used bivariate simple regression, log regression models and Bai-Perron model (2003) to explain growth rate, nexus and structural breaks. Also author used Granger Causality test (1969), Johansen (1988, 1996) unrestricted rank cointegration test , vector auto regression model and vector error correction model for finding relationship between growth rate and unemployment rate for USA and their short run and long run causalities. Residual test for autocorrelation, heteroscedasticity and normality (Hansen & Doornik, 1994) have been also done. Impulse response functions were fitted for testing stationary as an impact of shocks. Unit circle was found out to check stability of the VEC. Even, author tested to find out the relation between unemployment gap, output gap and growth in USA during 1948-2016. Output gap is measured by deducting Hodrick Prescott(1997) filtered trend value from the actual output (or it is a difference between actual and potential rate of growth). Unemployment gap is measured by deducting natural growth rate of unemployment from the actual unemployment rate (or natural rate of unemployment is called NAIRU i. e. non accelerating inflation rate of unemployment). Following Ball & Mankiw(2002), NAIRU is calculated from the regression of change in inflation on unemployment during the specified period where difference between unemployment rate and the coefficient of unemployment rate of the regression equation is the unemployment gap. The data on US unemployment rate, GDP and growth rate have been taken from Bureau of US census during 1948-2016. US natural rate of unemployment was taken from Fed Bank of St. Louis during 1949-2016.

Econometric Observations and Analysis

Growth-Unemployment in USA

In USA, unemployment growth rate has been stepping up at the rate of 0. 507% per annum during 1948-2016 which is significant at 5% level which is estimated below,

Log(U)=1. 545167+0. 005070t

(24. 40)* (3. 22)*

R^2=0. 134, F=10. 40*, DW=0. 56, U=unemployment rate of USA, t=year, *=significant at 5% level.

On the other hand, GDP growth rate of USA during 1948-2016 has been increasing at the rate of 0. 407% per annum which is not significant at 5% level and is shown below,

Log(G)=-0. 012008+0. 004074t

(-0. 017) (0. 24)

R^2=0. 00086, F=0. 058 , DW=1. 87 , G= growth rate of GDP of USA,

The unemployment rate of USA during 1948-2016 is showing one upward structural break in 1971 which is estimated by Bai-Perron model(2003) using HAC standard errors and covariance with maximum 5 breaks. The estimated values are given in Table 1.

Table 1
Structural break of US unemployment rate

Variable	*Coefficient*	*Standard Error*	*T statistic*	*Probability*
		1948-1970…23obs		
C	1. 520289	0. 072049	21. 10087	0. 00
		1971-2016…46obs		
C	1. 823794	0. 055187	33. 04749	0. 00

Source: Author, R^2=0. 269, F=24. 75, DW=0. 66,

This structural break in 1971 is plotted in Figure 1.

Moreover, Okun's law is statistically significant in USA during 1948-2016 at 5 % level which is estimated below.

ΔU = 0. 014156-0. 136661 Δlog(G)

(0. 118) (-4. 409)*

R^2=0. 227, F=19. 443*, DW=1. 516, G=GDP growth rate, U=unemployment rate, *=significant at 5% level.

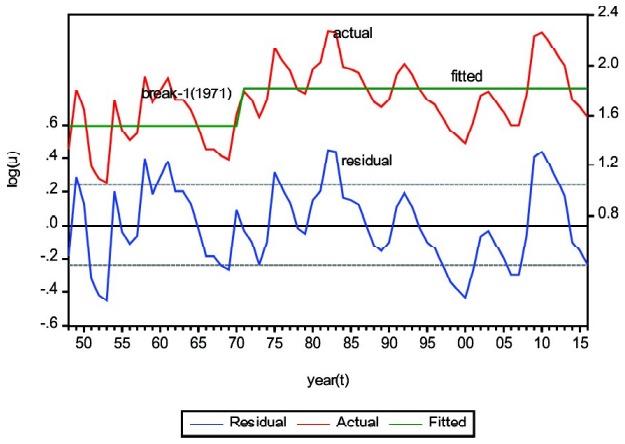

Figure 1: Structural break in US unemployment

Source: Plotted by author

It suggests that 0. 1366 per cent decrease in the change of unemployment rate in USA is significantly associated with one percent increase in GDP growth in USA during 1948-2016. This relationship defers from the original work of Okun (1962) for USA. In Trinidad and Tobago during 1980-2012, it was found that 1% percent decrease in real GDP led to 0.16% increase in unemployment significantly (Blackman & Salazni, 2014).

Growth-unemployment relationship is negative in USA during 1948-2016 which has been found by regression equation which is statistically significant at 5% level. It states that one per cent increase in GDP growth rate per year during 1948-2016 in USA led to 0. 034 per cent decrease in unemployment rate per year.

Log(U)=1.727-0. 03448log(G)

(54.61* (-3.008)*

R^2=0. 118 , F=9.049*, DW=0.421 , U=unemployment rate (% of labour force), G= GDP growth rate of USA% per year, *=significant at 5% level.

In the following Figure 2, the fitted line of this relation is plotted clearly.

This is similar to the study of Basuand Foley (2011) who verified that over three business cycles in unemployment and GDP relation during 1948-2010 in US Economy clearly showeda breakdown of Okun's Law with structural changes.

Economic growth and unemployment rate in USA showed no bi-directional causality which has been found out by Granger Causality test which is given below in the Table 2.

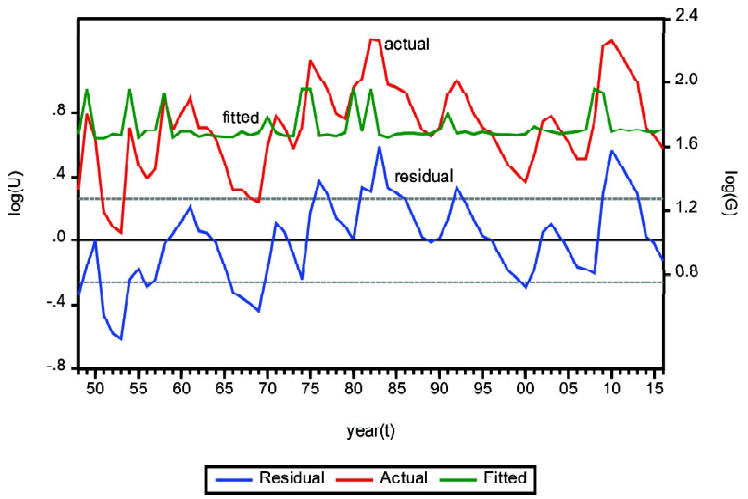

Figure 2: The Fitted line

Source: Plotted by author

Table 2
Granger Causality Test

Null hypothesis	*Observations*	*F statistic*	*Probability*
logG does not Granger cause logU	68	4. 9443	0. 0297
logU does not Granger cause logG		4. 98843	0. 0290

Source: Calculated by author

In USA, growth rate (logG) and unemployment rate (logU)is not cointegrated in the order one which was found by Johansen unrestricted rank test between them during 1948-2016 where both Trace and Max Eigen statistic have two cointegrating equations each which are significant at 5% level. It is shown below.

Table 3
Johansen Cointegration Test

Hypothesised no of CEs	*Eigen value*	*Trace Statistic*	*0. 05 level critical value*	*Probability***
None*	0. 305091	31. 59861	15. 2646	0. 000
At most 1*	0. 108449	7. 576343	3. 8414	0. 005
		Max Eigen Statistic		
None*	0. 305091	24. 02227	14. 2646	0. 0011
At most 1*	0. 108449	7. 576343	3. 8414	0. 005

Source: Calculated by author, *=significant at 5% level, , ** denotes Mckinnon-Haug-Michelis (1999) p value.

Since they are not cointegrated , therefore, estimate of vector auto regression is needed. The estimated VAR is given below.

$\log G_t$=-4. 80584+0. 16045$\log G_{t-1}$+2. 83968$\log U_{t-1}$

(-2. 16)* (1. 26) (2. 23)*

R^2=0. 07, F=2. 63 , SC=4. 98, AIC=4. 88

$\log U_t$=0. 55847-0. 018365$\log G_{t-1}$+0. 679683$\log U_{t-1}$

(3. 86)* (-2. 22)* (8. 21)*

R^2=0. 59 , F=48. 24* , SC=-0. 479 , AIC=-0. 57, *=significant at 5% level

$\log U_t$equation is a good fit where U_t is significantly related with U_{t-1} and G_{t-1}while $\log G_t$ equation is not a good fit. It is related with U_{t-1}significantly. Moreover, the VAR is stable because all roots(0. 543553, 0. 296581) lie inside the unit circle which is plotted in Figure 3.

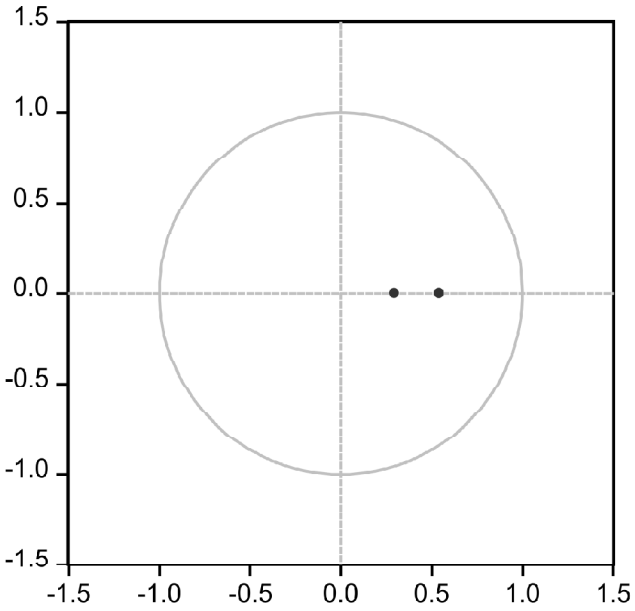

Figure 3: Stable VAR

Source: Plotted by author

VARresiduals test for autocorrelations showed existence of autocorrelation and partial autocorrelation functions in which vertical lines passed through both the axes in an asymmetric manner and are clearly shown in Figure 4.

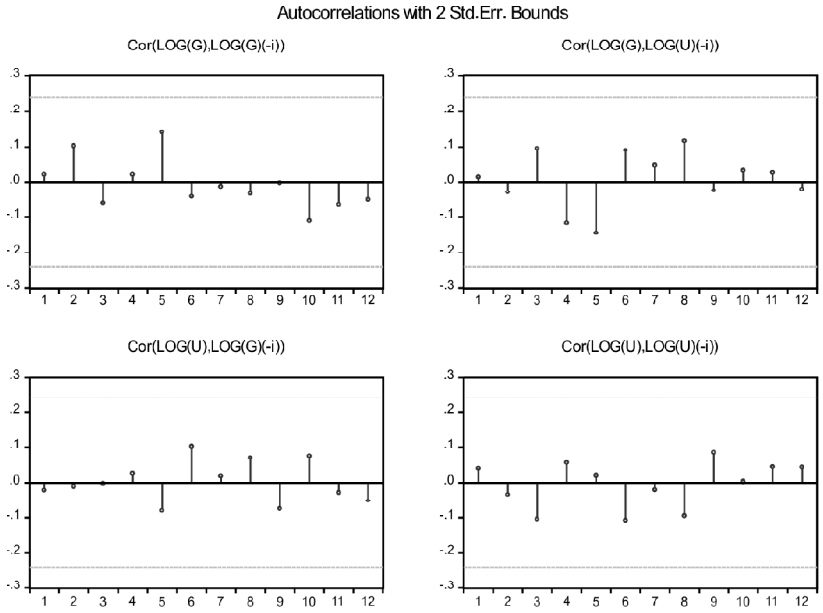

Figure 4 : ACF and PACF

Source: Calculated by author

VAR residual normality test through Hansen-Doornik model assures no normality because component two of Chi-square distribution of Skewness, Kurtosis and Jarque-Bera are not significant which are arranged in the Table 4.

Table 4
Normality test

Component	*Skewness*	*Chi-square*	*Degree of freedom*	*Probability*
1	-1.907526	25.40046	1	0.00
2	-0.298609	1.161799	1	0.28
Joint		26.56225	2	0.000
Component	kurtosis	Chi-square	Degree of freedom	probability
1	6.138645	65.90618	1	0.00
2	3.91562	3.732249	1	0.053
Joint		69.63843	2	0.000
Component	Jarque-Bera	Degree of freedom	Probability	
1	91.30664	2	0.00	
2	4.894048	2	0.086	
Joint	96.20069	4	0.00	

Source: Calculated by author

The impulse response functions of VAR model are converging to equilibrium where the respone of growth to unemployment and the response of unemployment to growth tend to equilibrium which means the VAR model is stationary which is shown by Figure 5.

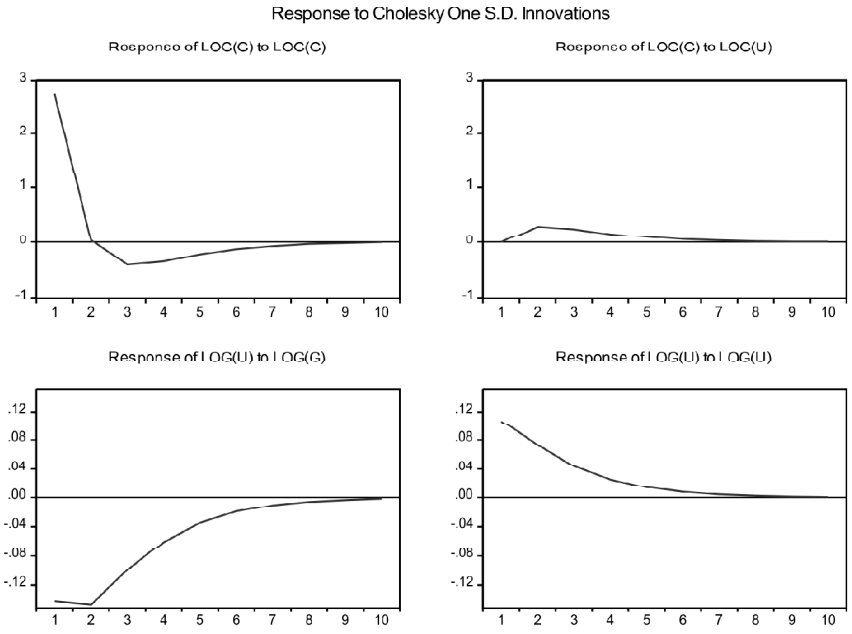

Figure 5 : Impulse response functions

Source: Plotted by author.

Unemployment Gap and Growth in USA

Unemployment gap and growth in USA from 1949 to 2016 are inversely related which is significant at 5% level.

U_1=1. 218003-0. 282592G

(4. 22)* (-3. 88)*

R^2=0. 18 , F=15. 06* , DW=0. 55 , *=significant at 5% level, U_1=unemployment gap of USA.

In Figure 6, the fitted line of unemployment gap and growth is plotted below which is not linear

Unemployment gap and growth rate of USA showed unidirectional causality during 1948-2016 which was found by Granger causality test that is shown in Table 5.

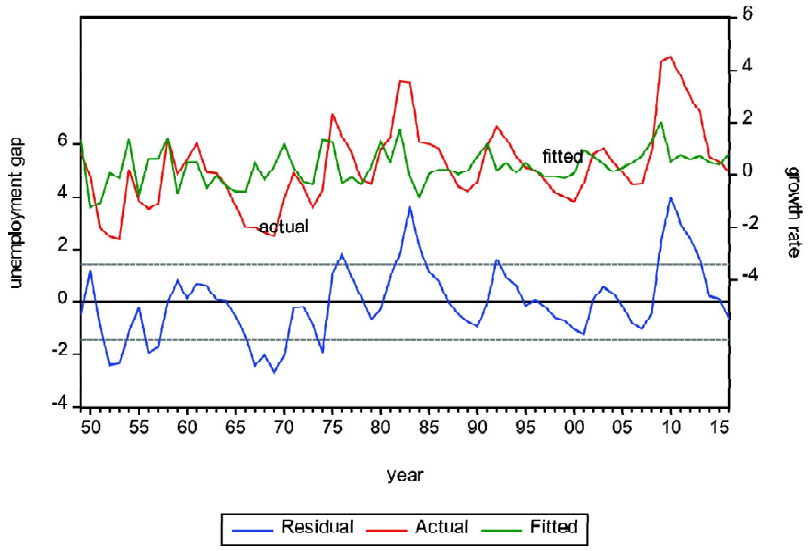

Figure 6: Fitted line

Source: Plotted by author

Table 5
Granger Causality test

Null Hypothesis	*Observation*	*F-statistic*	*Probability*
G does not Granger cause U_1	67	17.5946	9. E-05
U_1 does not Granger cause G		3.40688	0. 0696

Source: Calculated by author

Even, the unemployment gap and growth rate during 1951-2016 in USA are not cointegrated which was found by Johansen cointegration rank test

Table 6
Johansen Cointegration Test

Hypothesised no of CEs	*Eigen value*	*Trace Statistic*	*0. 05 critical value*	*Probability***
None*	0.360094	37.57562	15.4947	0.00
At most 1*	0.115642	8.110969	3.8414	0.00
		Max Eigen Statistic		
None*	0.360094	29.46465	14.2646	0.00
At most 1*	0.115642	8.110969	3.8414	0.00

*denotes rejection of null hypotheses at 5% level, ** denotes Mckinnon-Haug-Michelis (1999) p value.

Source: Calculated by author

where Trace and Max Eigen statistic contain two cointegrating equations each which are significant at 5% level which proves that there is no cointegration between the two.

Since there is no cointegration between unemployment gap and growth in USA during 1948-2016, so the vector auto-regression model is to be tested. The estimated equations of the VAR between unemployment gap and GDP growth rate are given below;

U_{1t}=0.88373-0.233497G_{1t-1}+0.6345U_{1t-1}

(3.875)* (-4.14)* (8.12)*

R^2=0.66 , F=64.87* , AIC=2.70, SC=2.80

G_t=2.3454+0.26989G_{1t-1}+0.33883U_{1t-1}

(4.50)* (2.09)* (1.90)*

R^2=0.08, F=2.88, AIC=4.35, SC = 4.44 , *=significant at 5% level

The equations of VAR are of good fit where both G_t and U_{1t} are significantly related with their previous period. The t values of the coefficients of G_{t-1} and U_{1t-1} are significant. This VAR is also a stable model since all roots (0.4522 ± 0.214204i) lie in the unit circle which is shown in the Figure 7.

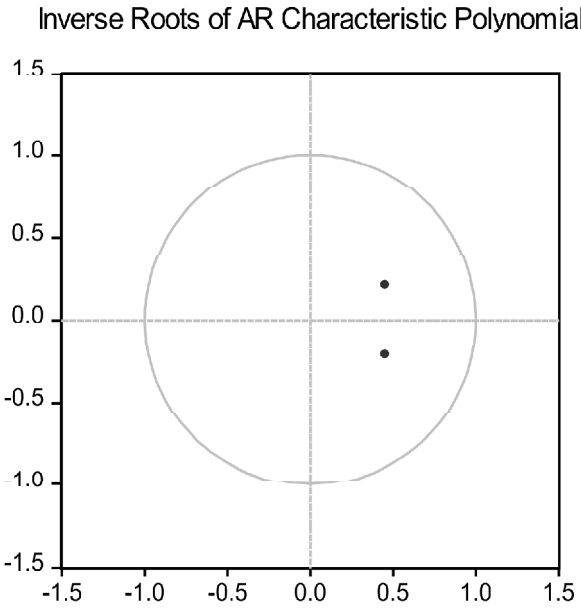

Figure 7: Unit Circle of VAR model

Source: Plotted by author

Residual test confirmed that the VAR model suffers from auto correlations problems which are plotted in Figure 8 where vertical lines are asymmetric.

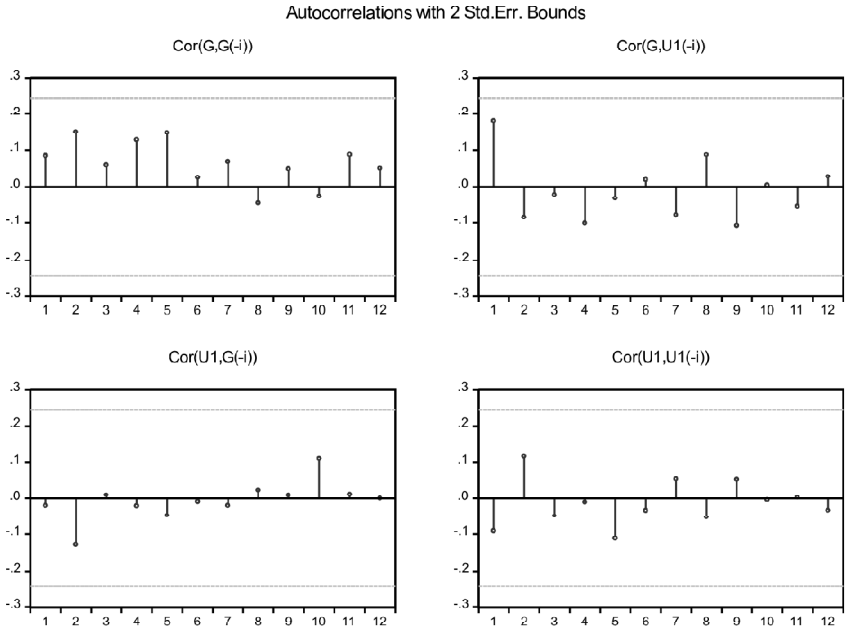

Figure 8: Autocorrelations

Source: Plotted by author

Residual test of VAR rejected its normality which was found by Hansen-Doornik test that is seen in Table 7. Component one of Chi-square of Skewness, all components of Chi-square of Kurtosis and component of one of Jarque-Bera showed insignificant.

Table 7
Normality test

Component	*Skewness*	*Chi-square*	*Degree of freedom*	*Probability*
1	0. 356669	1. 615677	1	0. 237
2	1. 168418	12. 84428	1	0. 0003
Joint		14. 45995	2	0. 000
Component	*Kurtosis*	*Chi-square*	*Degree of freedom*	*Probability*
1	3. 003423	0. 004447	1	0. 946
2	3. 494706	0. 09244	1	0. 761
Joint		0. 096899	2	0. 952

Component	*Jarque-Bera*	*Degree of freedom*	*Probability*
1	1. 620124	2	0. 4448
2	12. 93672	2	0. 0016
Joint		4	0. 0057

Source: Calculated by author

The impulse response functions showed that the VAR is stationary since they are converging since response of growth to unemployment gap and response of unemployment gap to growth tend to equilibrium.

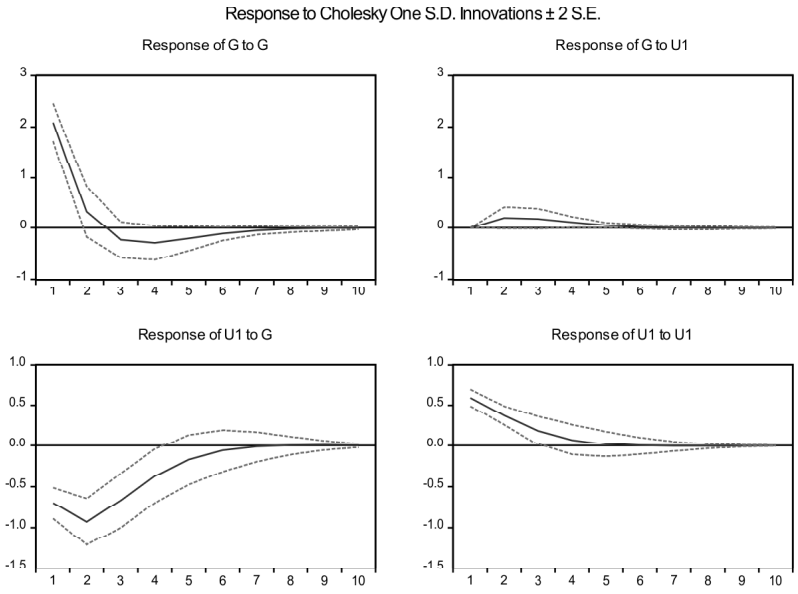

Figure 9 : Impulse response functions

Source: Plotted by author.

Unemployment Gap and Output Gap in USA

When unemployment rate is higher than the natural unemployment rate then the real GDP is lower than the potential GDP and the output gap is negative and the converse is true. Following Okun's laws it can be said that there is negative relation between output gap and the unemployment gap.

Unemployment gap of USA from 1949-2016 has significant negative impact from output gapwhich is estimated as given below,

Y_1=0.331870-9.770739x_1

(1.90) (-3.49)*

R^2=0.15 , F=12.21* , DW=0.39, AIC=3.59, SC=3.66, *=significant at 5% level, x_1=output gap and Y_1=Unemployment gap

The fitted line is nonlinear which is plotted in Figure 10.

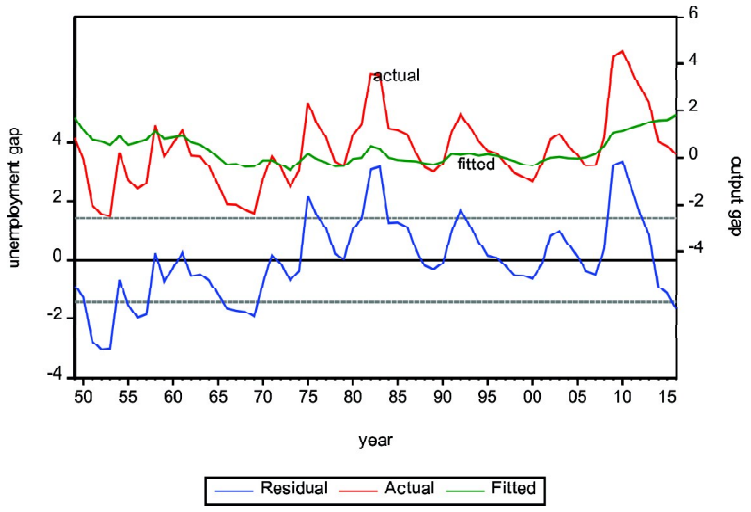

Figure 10: Unemployment and output gap

Source: Plotted by author

In U.S.A., both the output and unemployment gaps during 1948-2016 have bi-directional causalities which were verified by Granger causality test which is shown in Table 8.

Table 8
Causality test

Null Hypothesis	*Observations*	*F Statistic*	*Probability*
X_1 does not Granger cause y_1	67	1.19150	0.2791
Y_1 does not Granger cause x_1		0.27668	0.6007

Source: Calculated by author

Johansen unrestricted rank test suggests that unemployment gap and output gap in USA during 1948-2016 are cointegrated where Trace statistic and Max Eigen Statistic showed one cointegrating equation in each case which are significant at 5% level.

Table 9
Cointegration between output gap and unemployment gap

Hypothesised no of CEs	*Eigen value*	*Trace statistic*	*0.05 Critical Value*	*Probability***
None*	0.389677	32.98494	15.4947	0.00
At most 1	0.005987	0.396331	3.8414	0.52
		Max Eigen Statistic		
None*	0.389677	32.58861	14.2646	0.00
At most 1	0.005987	0.396331	3.8414	0.52

Source: Calculated by author, *=significant at 5% level, , ** denotes Mckinnon-Haug-Michelis (1999) p value.

Since unemployment gap and output gap are cointegrated then the estimated equations of VECM are,

$$\Delta x_{1t}=-0.000956+0.898668\Delta x_{1t-1}+0.014095\Delta y_{1t-1}-0.02198EC$$

(-0.40) (4.65)* (3.63)* (-2.54)*

$R^2=0.27$, F=7.71, SC=-4.86 , AIC=-5.0

$$\Delta y_{1t}=0.00599-37.125\,\Delta x_{1t-1}-0.316259\,\Delta y_{1t-1}+2.08263EC$$

(0.05) (-4.23)* (-1.79)* (5.31)*

$R^2=0.33$, F=12.59, AIC=2.62, SC=2.75, *=significant at 5% level

Both the equations in VECM are good fit. All the t values of coefficients are significant at 5% level where error corrections however slow speed are also significant. Therefore, there is a tendency towards equilibrium. This VECM is a stable model where all roots (1. 0, 0. 801049, 0. 196761±0. 509653i) lie inside the unit circle which is plotted in Figure 11.

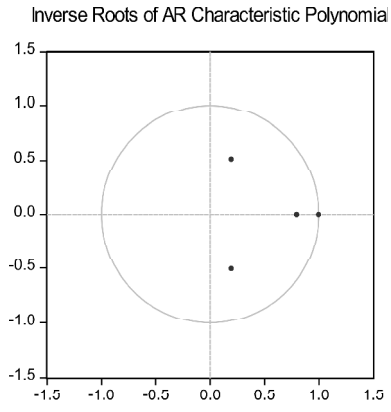

Figure 11: Unit circle

Source: Plotted by author

The response of output gap to unemployment gap is diverging towards equilibrium but the response of unemployment gap to output gap moves converging to equilibrium although VECM is nonstationary.

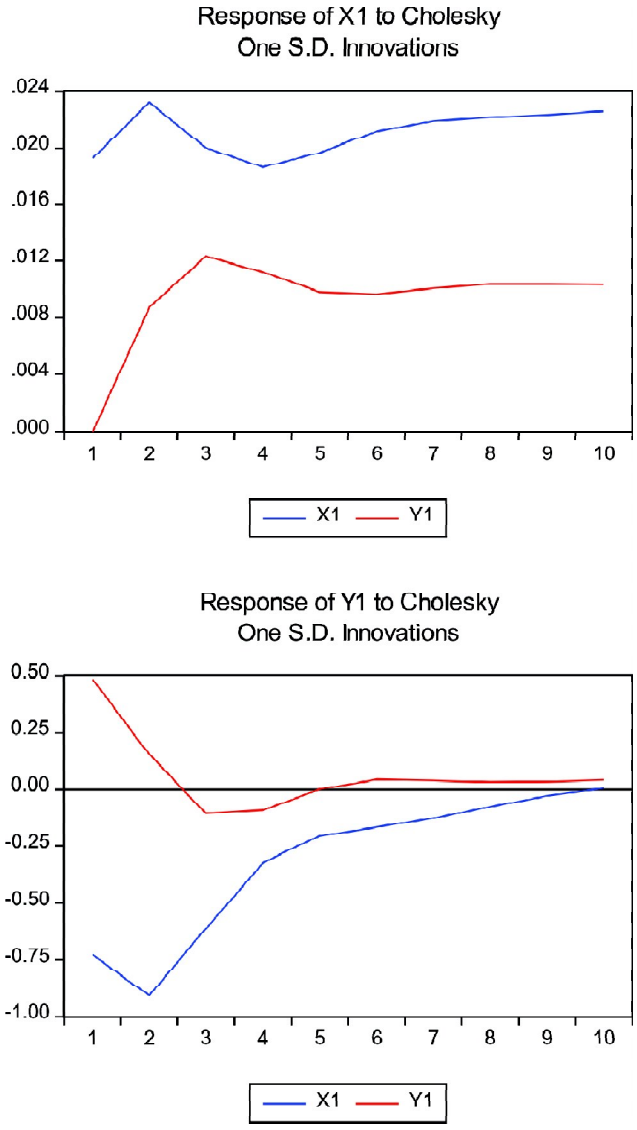

Figure 12 : Impulse response functions

Source: Plotted by author

But, the residuals have autocorrelation problem due to asymmetric shocks which is plotted in Figure 13.

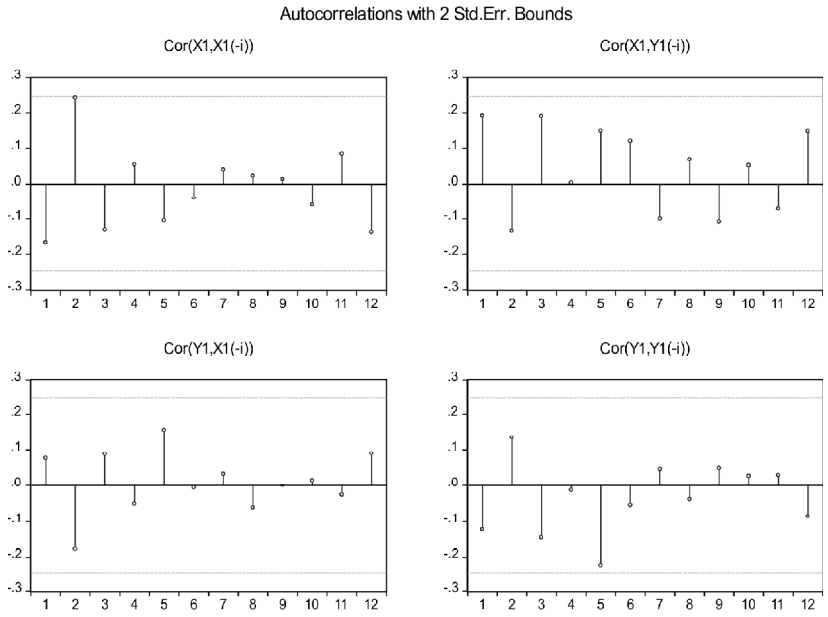

Figure 13: Residual test for correlogram

Source: Plotted by author

And the residual test for Hansen-Doornik normality is rejected for the VECM because some components are insignificant which is seen in Table 10.

Table 10
Normality test

Component	*Skewness*	*Chi-square*	*Degree of freedom*	*Probability*
1	-0. 446445	2. 44138	1	0. 11
2	0. 882136	8. 158359	1	0. 00
Joint		10. 59974	2	0. 00
Component	*Kurtosis*	*Chi-square*	*Degree of freedom*	*Probability*
1	2. 405252	3. 132394	1	0. 07
2	4. 161769	0. 176513	1	0. 67
Joint		3. 308907	2	0. 19
Component	*Jarque-Bera*	*Degree of freedom*	*Probability*	
1	5. 573774	2	0. 06	
2	8. 334872	2	0. 01	
Joint	13. 90865	4	0. 00	

Source: Calculated by author

Limitations and future research

There are some different critical views regarding computation of output gap and unemployment gap respectively because there are various views and axioms on these gaps especially on NAIRU. Secondly, Okun's coefficients can be estimated in expansionary and recessionary phases of cycles which are not computed here. It is left for future research. Even, the policy implications based on these observations of the models computed here are not explained. These crucial works on U. S. macroeconomic stability are of great possibility of research in the offing.

Conclusions

The paper concludes that US unemployment isstipulating at the rate of 0. 507 per cent per year during 1948-2016 and it has one upward structural break in 1971. US unemployment and growth rates are negatively related during 1948-2016 which is significant at 5% level. There is no causality between the two even they arenot cointegrated in the orderone. Vector auto regressionis a good fit, stable and stationary. Non-normal distribution, heteroscedasticity and autocorrelation are confirmed by Residual tests. Moreover, relation between growth and unemployment gap in USA during 1949-2016 suggests that the relation is negative and significant at 5%. They have no causality and cointegration. Their VAR model is stable with significant VAR process. The residual test showed heteroscedasticity, non-normality and auto-correlation problems. In USA, output gap influenced unemployment gap negatively during 1949-2016 significantly. It has significant bi-directional causality and one cointegrating equation. In Vector error correction model, error corrections are significant with high speed of adjustment having stability, autocorrelation and non-normality. Therefore, jobless growth interpretation is not satisfied in USA during 1948-2016 whatever the empirical observations are insignificant or significant.

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Key Words Explanation

Output gap-It is a difference between actual and potential rate of output.

Unemployment gap-It is measured by deducting natural growth rate of unemployment from the actual unemployment rate.

Cointegration-If there is a linear combination of nonstationary random variables, then the variables are cointegrated.

Vector Error Correction-It is a technique of restricted vector autoregressive designed for use to describe the interrelationship among stationary variables.