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Study on the relationship among Chinese unemployment rate, economic growth and inflation

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Abstract – This paper attempts to estimate VAR Model of interaction mechanisms of unemployment rate, economic growth and inflation rate in china. Also we identify the co-integrating vectors to establish the long-run relationship among these variables by using annual data from 1978 to 2010, on this base the Error correction model of them is also established. The results show that there is a long-term stable equilibrium relationship among them, in the short term, however, economic growth is positive correlated with unemployment rate while inflation and unemployment rate are negative correlated with inflation.

Keywords: Unemployment rate; Economic growth; Inflation; VAR

1. Introduction

Since the reform and open policy, China has achieved rapid development in economy, whose GDP rose from 364.52 billion yuan in 1978 to 39.7983 trillion yuan in 2010, it is increased nearly 108 times. China has been the world's fastest-growing major economy, with consistent growth rates of around 10% over the past 30 years. Some other macroeconomic variables has also been witnessing a series of change. First of all, high economic growth also brought the price fluctuations. In the first half of 2011, macro economic data shows that, gross domestic product grew 9.6% year-on-year, consumer price index rose 5.4% year-on-year. Especially, the CPI increased 6.4% year-on-year in June, this new high record have been established since nearly three year ago. And the relative macroeconomic data showed that the unemployment rate remains high as the economy growth rate increased. The goal of the macro-economic regulation control is to pursue full employment, price stability and economic growth, balance of the international payments. Many economic experts and scholars study on them from all different angles. Research and analysis on this problem have important theoretical and practical significance in making the macroeconomic policy and evaluating the effectiveness of a economic policy as while as the prediction of future economic situation.

On the basis of existing literatures, this paper studies the relationship of these three macroeconomic variables in China based on VAR model. Through the econometric analysis, the conclusion as well as some suggestions are provided.

The main economic theories about the relationship among macroeconomic variables include the Phillips curve and Okun's law etc, the Phillips curve is a historical inverse relationship between the rate of unemployment and the rate of inflation. Stated simply, the lower the unemployment rate, the higher the rate of inflation.

Which is proposed by William Phillips, the paper (Phillips & A. W, 1958) describes how he observed an inverse relationship between money wage changes and unemployment in the British economy over the period examined. Later, Monetarists revise it by adding expected factors, and propose the adaptive expected Phillips curve. Okun's law was proposed by Arthur M. Okun in 1968 (Okun & Arthur M, 1962), which is an empirically observed relationship relating unemployment to losses in a country's production. The "gap version" states that for every 1% increase in the unemployment rate, a country's GDP will be at an additional roughly 2% lower than its potential GDP.

In China, many economists and scholars carry on some deep research about the relationship of macroeconomic variables. Xiao-peng Hu and Pei-dong Wei (1999) perform the quantitative statistical analysis about China’s economic growth, unemployment and inflation, they study on the short term relationship by the change of symbol of these three variables in the recent three years, and derive long-term stable equilibrium relationship among them based on coefficient analysis. On the basis of reviewing the overall economy situation and policies, LingYu, Wang-Bin Hu (2005) analyze these three macroeconomic variables, but the study is confined to the volatility analysis of each single variable and the correlation analysis between each other. Ling Yu, Peng-xia Xie (2006) carry on correlation statistical analysis among GNP growth rate, inflation and unemployment rate, by calculating the correlation coefficient based on the data during the period 1997-2004. In the paper (Shuang-zheng Wang, 2009), the economic analysis results show that there is a two-way Granger Causality relationship between China's inflation and economic growth based on the data during the period 1978-2008. Lin Ma (2009) regresses real unemployment rate on output gap, and concludes that Chinese economic data does not obey Okun's law. Yan-ping Pu (2006) give the macroscopical explain about the deviation between the real Chinese economy and Okun's law from the perspective of effective employment, and do the co-integration test and Granger test between

effective employment and economic growth. Shen-si Chen (2005)concludes that the GDP growth rate and inflation rate change in the same direction based on cubic regression model, and the change inflation rate lags behind the GDP growth rate. Yu Wang (2008) examines the relationship between economic growth and inflation rate by means of the nearest-neighbour nonparametric regression. Shi Chen and Xiao He (2005) find that the Phillips curve between Chinese registered urban unemployment rate and the consumer price index is not significant. Shuang-zheng Wang (2009) studies inflation rate and economic growth based on VAR model.

We can see from these literatures that, the conclusion would differ when the based model and data differ, and the analysis of the relationship is confined to be bilateral instead of trilateral. In this paper, statistical analysis method was implemented by establishing VAR model to analyze the relationship among these three macro-economic variables in the long-term, and the ECM model to analyze the short-term relationship.

2. VAR model and Vector Error Correction (VEC) Model

Sims (1980) developed the Vector Auto-regression (VAR) in macro-econometrics. According to him, a VAR is an ad hoc dynamic multivariate model, treating simultaneous set of variables equally, in which each endogenous variable is regressed on its own lags and the lags of all other variables in a finite-order system. The objective of the approach is to examine the dynamic response of the system to the shocks without having to depend on "incredible identification restrictions" inherent in structural models. Following Christiano et al (1998a, b), Bernanke and Blinder (1992) and Ford et al (2003), a representative VAR can be expressed as

$$By_t = C(L)y_t + D(L)x_t + \varepsilon_t \quad (1)$$

where y_t is a $(m\times 1)$ vector of endogenous variables, x_t is an n vector of exogenous variables, B, C and D are matrices of the estimated coefficients, L i s a lag operator, and i is then number of lag or the order of the VAR. The error term ε_t is a vector of innovations that are i. i. d.

Excluding the vector of exogenous variables, as we do in this paper by estimating, we can obtain the reduced form of the VAR

$$y_t = A(L)y_t + v_t \quad (2)$$

where $A(L) = B^{-1}C(L) = A_1L + \cdots + A_iL^i$, $v_t = B^{-1}\varepsilon_t$.

Eq. (2) can be rewritten as a MA representation

$$y_t = \frac{1}{I - A(L)}v_t = K(L)v_t \quad (3)$$

Eq. (3) gives a structural form (an estimated VAR) from which we can estimate the impulse response functions and variance decomposition functions, assuming that the estimated VAR is stationary or non-stationary. However all variables are integrated in I(1) with co-integrations, and can be simulated by the VEC Model.

To simulate the process of dynamic responses of variables to a shock by using Eq. (3), it is generally assumed that the shocks should be orthogonal (uncorrelated), because the two shocks usually come at the same time. For the structural form of Eq. (3), the requirement is then that the structural error term $v_t = B^{-1}\varepsilon_t$ has the following property:

$$E(v_t v_t') = (B^{-1})\varepsilon_t\varepsilon_t'(B^{-1})',\ E(v_t v_t') = I_n. \quad (4)$$

This process uses the Choleski decomposition, with which the structural residuals can be identified through the matrix B by decomposing the covariance matrix of the residuals. To achieve this, according to Sims(1980) the B^{-1} should be a lower-triangular.

If all variables in our VARs are integrated with order 1 [I(1)], and if the co-integration relationships among them exist, we can use Vector Error Correction Model (VECM) to estimate the impulse response and variance decomposition functions.

According to Hamilton (1988), if each time series in an $(n\times 1)$ vector y_t, is individually I (1), say non-stationary with a unit root, while some linear combination of the series $a'y_t$ is stationary, or I(0), for some nonzero $(n\times 1)$ vector α, then y_t is said to be co-integrated.

After iterations we can obtain

$$\Delta y_t = A(L)y_{t-1} - \sum_{j=1}^{\infty} A_j^*\Delta y_{t-j} + \varepsilon_t \quad (4)$$

The matrix $A(L)$ controls the co-integration characters. Cochrane (1995, 2005) discusses three cases for this Eq. (4):

Case 1: $A(L)$ is full rank and any linear combination of y_{t-1} is stationary. In this case, we run a normal VAR in levels .

Case 2: The rank of $A(L)$ is between 0 and full rank, and there exist some linear combinations of y_t that are stationary; thus, y_t is co-integrated, and the VAR in differences is mis-specified in this case. With the rank of $A(L)$ less than full rank, $A(L)$ can be expressed as $A(L) = \alpha\beta'$.

Eq. (4) then becomes the error-correction representation form

$$\Delta y_t = \alpha\beta' y_{t-1} - \sum_{j=1}^{\infty} A_j^*\Delta y_{t-j} + \varepsilon_t \quad (5)$$

where β is the matrix of co-integration. When we know the variables are co-integrated by pre-test with matrix of β, we need to run an error-correction VAR.

Case 3: The rank of $A(L)$ is zero, and Δy_t is stationary with no co-integration. In this case, we can run normal VAR in first difference.

Given the importance of co-integration and unit roots of variables, in the next section, we will conduct unit root tests and co-integration tests.

Another critical problem of the VAR Model is the choice of lags. Ivanov, Kilian *et al* (2005) suggested six criteria for lag order selection: the Schwarz Information Criterion (SIC), the Hannan-Quinn Criterion (HQC), the Akaike Information Criterion (AIC), the general-to-specific sequential Likelihood Ratio test (LR), a small-sample correction to that test (SLR), and the Lagrange Multiplier (LM) test. Some econometricians

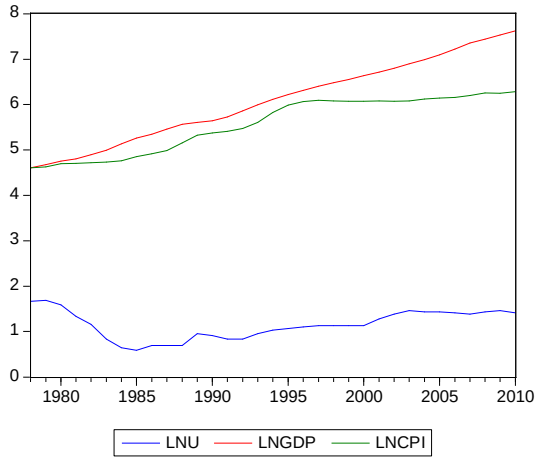
argue that the SIC should be applied to small sample and the AIC should be used for large sample, but other econometricians' empirical work come to opposite conclusions. In this study, we first let the VAR meet the conditions for stationary and then choose the number of lags referring to the AIC and SIC standard.

3. Empirical analysis

3.1. Data

This paper mainly studies the relationship among China's unemployment rate, economic growth and the inflation rate. We select China's annual economic data during the period 1978-2010 as samples. All the raw data are all derived from the China statistics bureau website. In order to reduce the probability that data is not statistic heteroscedastic, then the model could be more reasonably established, unemployment rate, GDP series and CPI index series are taken natural logarithm. Figure 1 shows the three series.

Figure 1. Macroeconomics variables



3.2. Unit root test

We use our ADF test to test stationarity of the series of these macroeconomic variables. And, the lag is chosen by the criterion of AIC and SIC. The unit root test for lnU, lnGDP and lnCPI is showed in table 1.

Table 1. Unit root test

Difference P-value	lnU	lnGDP	lnCPI
Original series	0.3666	0.9895	0.9598
1-st difference	0.0040	0.0020	0.0377

As we can see in table 1, the P-values of original series are bigger than 5% and the P-values of 1-st difference are smaller than 5%, which indicates we can reject the null hypothesis of no unit root, i.e., lnU, lnGDP and lnCPI are I(1) series.

3.3. Long-term relationship

Recalling the co-integration tests in Section 2 and table 1, all the variables in our models are I(1). Therefore, we can employ Johansen's technique to identify the cointegrating vectors and discuss the long-run relationships by setting up the VEC Models.

Table 2. Cointegration test

Hypothesized No. of CE(s)	Eigenvalue	P-value(Trace)	P-value (Max-Eigen)
None	0.542241	0.023693	0.017747
At most 1	0.234850	0.434064	0.349185
At most 2	1.59E-06	0.996811	0.996811

As we can see in table 2, the P-values of Trace Statistic and Max-Eigen Statistic are smaller than 5% for the null hypothesis of none of CE(s), which indicates we can reject it. And the P-values of Trace Statistic and Max-Eigen Statistic are bigger than 5% for the null hypothesis of at most 1of CE(s), which indicates we can accept it. Both Trace test and Max-eigenvalue test indicate 1 cointegrating eqn(s) at the 5% level. Then their ECM model can be established based on co-integration as (1):

$$\begin{aligned} ECM &= \ln U + 0.042371 \ln GDP + 0.744919 \ln CPI \\ &\quad (0.30551\text{\textdiamond} \qquad \text{\textdiamond}0.42749\text{\textdiamond} \quad (6) \\ &\quad \text{Log Likelihood} \quad 185.3841 \end{aligned}$$

From Eq. (6) we can see, in the long run, the unemployment rate is negative correlated to economic growth but to a little extent, when gross domestic product growth increases 1% , the unemployment rate will falls by 0.04%; The unemployment rate is negative correlated to inflation rate, when the CPI increases by 1%, the unemployment rate will falls by 0.74%; Economic growth is positive correlated to inflation rate, that is to say, the higher economic growth rate, the lower the unemployment rate is, but at the same time it also can bring higher inflation.

3.4. Short-term relationship

The co-integration relationship implies the existence of the long term equilibrium relationship of the variables and the short term disequilibrium of the generation of dynamic process. We establish vector error correction model to describe the short-term dynamic disequilibrium among these three macroeconomics variables.

We select lags of this VEC model of lnU, lnGDP and lnCPI, by the criterion of AIC and SC and determine the optimal lag length to be 2, then establish VEC(2) model. The results are as follows:

1) Short-term equation of unemployment rate

$$\begin{aligned} \Delta \ln U_t &= -0.319139 ECM_t + 0.09160 \Delta \ln U_{t-1} \\ &+ 0.217234 \Delta \ln U_{t-2} - 0.378737 \Delta \ln GDP_{t-1} \\ &+ 0.702249 \Delta \ln GDP_{t-2} + 0.638006 \Delta \ln CPI_{t-1} \\ &- 0.956046 \Delta \ln CPI_{t-2} - 0.015898 \end{aligned} \quad (7)$$

In the short term, the coefficients of the unemployment rate of both first-order lag and second-order lag are positive, Error correction model coefficient is negative, which indicates when the disequilibrium occurred in the previous period the economy will be more closer to the

equilibrium automatically. Economic growth rate is positive related to unemployment rate in the short term. Although the first-order lag of GDP coefficient is negative, the absolute value of the coefficient of the second-order lag is bigger than that of first-order lag. That is to say, high economic growth does not lower the unemployment rate, but raises the unemployment rate. Inflation rate and unemployment rate are negatively related. This is a case of coexistence of high inflation and low unemployment rate, and the coexistence of high unemployment rate and low inflation rate.

2) Short-term equation of economic growth

$$\begin{aligned}\Delta \ln \mathrm{GDP}_t &= 8.30\text{E-}05 ECM_t - 0,013460 \Delta \ln U_{t-1} \\ &-0.006764 \Delta \ln U_{t-2} + 0.922408 \Delta \ln GDP_{t-1} \\ &-0.296508 \Delta \ln GDP_{t-2} - 0.265638 \Delta \ln CPI_{t-1} \\ &+0.227372 \Delta \ln CPI_{t-2} + 0.037901\end{aligned} \quad (8)$$

In the short term, the unemployment rate is negative related to economic growth, so that the high unemployment rate will cut down economic growth. To economic growth itself, the lagged period of GDP has positive influence on current period, while the two-lagged period of GDP has negative influence on current period which is greater than the former. The lagged period of inflation rate has positive influence on economic growth at current period, but the two-lagged period of inflation rate has negative influence on economic growth at current period which is greater than the former. Therefore, in the short term the rising of price index could bring the economy growth down.

3) Short-term equation of inflation rate

$$\begin{aligned}\Delta \ln \mathrm{CPI}_t &= -0.031355 ECM_t - 0.007104 \Delta \ln U_{t-1} \\ &+0.030480 \Delta \ln U_{t-2} + 1.194271 \Delta \ln GDP_{t-1} \\ &-0.749313 \Delta \ln GDP_{t-2} + 0.781604 \Delta \ln CPI_{t-1} \\ &-0.103202 \Delta \ln CPI_{t-2} - 0.026233\end{aligned} \quad (9)$$

In the short run, the change of unemployment rate for first-order lag has a reverse effect on the CPI index while it has a positive impact for second-order lag, but its positive impact which affects for a small degree is greater than negative. Economic growth has a positive effect on the CPI index, namely GDP index rose can also cause price index increase. For the price index itself, the promoting function of first-order lag price index to the current period is obvious, as error correction coefficient is negative, so when price index rise, error correction mechanism will make the future of the existence of the change of the price index fell, playing a role of convergence.

3.5. Granger Causality Test

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another (Granger, C.W.J, 1969). Ordinarily, regressions reflect mere correlations, but Clive Granger, who won a Nobel Prize in Economics, argued that there is an interpretation of a set of tests as revealing something about causality.

So we investigate the existence of Granger-causality among lnU, lnGDP and lnCPI, the results are shown in table 3.

Table 3. Granger Causality Test

Null Hypothesis	F-Statistic	P-value
lnGDP does not Granger Cause lnU	7.07195	0.0035
lnU does not Granger Cause lnGDP	2.84925	0.0761
lnCPI does not Granger Cause lnU	5.17886	0.0128
lnU does not Granger Cause lnCPI	1.33485	0.2806
lnCPI does not Granger Cause lnGDP	3.41252	0.0483
lnGDP does not Granger Cause lnCPI	7.01937	0.0037

We can see in table 3, unemployment dose not Granger cause economic growth and inflation, both economic growth and inflation can Granger cause unemployment, so there exists one-way Granger Causality between them. There is two-way Granger Causality between economic growth and inflation.

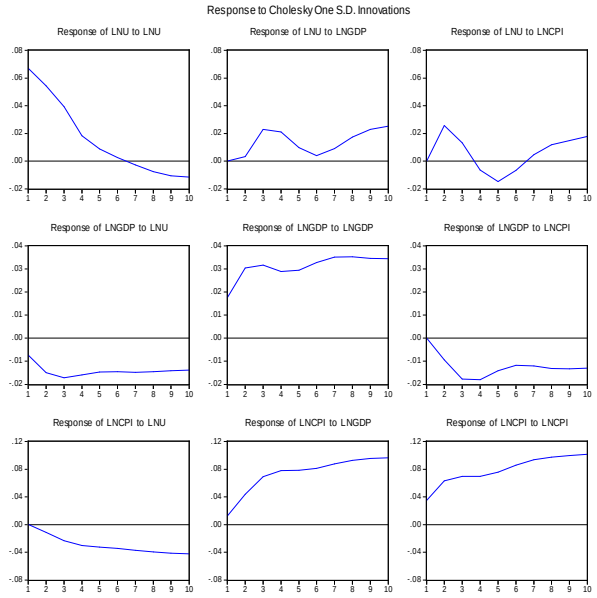
3.6. Impulse response function and variance decomposition

An impulse response refers to the reaction of any dynamic system in response to some external change, or some impact has affected on the model of the system. It describes how the economy reacts over time to exogenous impulses, which usually called as 'shocks'. Impulses that are often treated as exogenous from a macroeconomic point of view include changes in government spending, tax rates, and other fiscal policy parameters. And variance decomposition is the further evaluation of the importance of different structure impact through the analysis of each structure of endogenous variable changes impact contribution. And variance decomposition indicates the amount of information each variable contributes to the other variables in a vector autoregression (VAR) models is also used for this study here.

1) Impulse response function

The graph of impulse response function is shown in figure 2. It can be seen from figure 1 that, he changes of the unemployment rate has unstable and small impact on economic growth and inflation. The change of GDP has negative impact on the unemployment rate and it tends to stable in the next period, so we can increase the rate of the economy growth by reducing unemployment rate. The economic growth has negative impact on the inflation rate, which was increasing since the first period until the fourth period then decreasing to be negative and stable after the sixth period. The change of inflation rate has negative impact on the unemployment rate, which becomes greater and greater. We can know that the rise of the consumer price index (CPI) can also bring down the unemployment rate. The impact of inflation on the economic growth in the short term is positive, which can tell us, mild or "moderate" inflation can promote the development of the economy to a certain extent.

Figure 2. Impulse response function



2) variance decomposition

The results of variance decomposition are shown in table 4-6.

Table 4. Variance decomposition of unemployment rate

Period	S.E.	lnU	lnGDP	lnCPI
1	0.067110	100.0000	0.000000	0.000000
2	0.090254	91.70269	0.130953	8.166353
3	0.101985	86.73927	5.182394	8.078337
4	0.105916	83.37779	8.764724	7.857484
5	0.107755	81.23650	9.307471	9.456027
6	0.108060	80.83588	9.391324	9.772795
7	0.108576	80.12801	9.996224	9.875762
8	0.110857	77.33185	12.06681	10.60134
9	0.114679	73.09508	15.29858	11.60633
10	0.119357	68.40259	18.62250	12.97491

It is legible in table 4 that, not considering the contribution of unemployment rate itself, the contribution of economic growth to unemployment rate is increasing gradually all the period, and reaches maximum of 18% at tenth period, at the same period, the contribution of inflation rate to the unemployment rate is close to 13%.

Table 5. Variance decomposition of economic growth

Period	S.E.	lnU	lnGDP	lnCPI
1	0.019018	14.68606	85.31394	0.000000
2	0.039968	17.32712	77.20453	5.468356
3	0.056615	17.79945	69.69359	12.50696
4	0.067980	17.80974	66.46011	15.73016
5	0.076850	17.54996	66.75139	15.69866
6	0.085594	17.01866	68.45426	14.52708
7	0.094449	16.40376	70.04667	13.54957
8	0.102716	15.86588	71.06716	13.06696
9	0.110125	15.43131	71.74896	12.81973
10	0.116909	15.07788	72.32459	12.59753

Table 5 shows us that, not considering the variance contribution of economic growth itself, the unemployment rate contributes about 15% to economic growth, and the variance contribution of the inflation rate to economic growth is about 12%.

Table 6. Variance decomposition of inflation rate

Period	S.E.	lnU	lnGDP	lnCPI
1	0.037386	0.002251	11.44447	88.55328
2	0.086010	1.634222	27.96939	70.39639
3	0.132515	3.745266	39.07013	57.18460
4	0.171463	5.336126	43.92827	50.73560
5	0.205825	6.197521	45.04519	48.75728
6	0.239894	6.596584	44.69441	48.70901
7	0.274557	6.836457	44.30042	48.86312
8	0.308399	7.059825	44.18876	48.75141
9	0.340369	7.264169	44.14806	48.58777
10	0.370559	7.423117	44.02989	48.54699

Table 6 shows us that, the variance contribution of inflation rate to itself is about 48%, the variance contribution rate of economic growth to inflation rate is about 44%, the contribution of unemployment rate to inflation rate is about 7%.

4. Conclusion & suggestions

Through the above analysis, we can get the following conclusions:

1) There is only one-way Granger causality between unemployment and economic growth as while as inflation and unemployment, which equals to that the unemployment does not Granger cause economic growth and inflation, but economic growth and inflation can Granger cause the unemployment. And there exists two-way Granger causality between economic growth and inflation .

2) In the long term, there is a equilibrium relationship among Chinese unemployment rate, economic growth and inflation rate. Excluding other factors, unemployment rate and economic growth is negatively related, so are unemployment and inflation rate; Economic growth is negatively related to unemployment and positively related to the inflation rate, so the fast economic growth can improve upon employment, but meanwhile it can also bring the pressure of high inflation rate. Inflation are negative related with both unemployment and economic growth, that is to say, high inflation rate can improve upon employment.

3) In the short term, high economic growth and high unemployment rate can coexist, which implies the economic growth is positive related with unemployment rate, which obviously violates the Okun's law. It reminds the policy maker we they make economic policy the China's situations should be considered. The inflation rate is negative related with economic growth, so we can draw the conclusion that Chinese economy does not exhibit "Tobin effect" in the short term.

4) It can seen that from the impulse response function and variance decomposition of these macroeconomic variables

that the shock to the unemployment rate and economic growth mainly caused by the change of themselves, and the economic growth has greater impact on inflation rate than the unemployment rate on inflation rate.

On the whole, Chinese current economic situation is optimistic. Gross domestic product grew by 9.6% in the first half year, 6.55 million urban residents became employed, and the inflation rate was controllable.

Three suggestions are offered:

1) The economic restructuring should be further carried out, promote the sustainable and healthy development of the Chinese economy.

2) The price level should be kept stable.In the pursuit of economic growth and price stability is still the primary task of macroeconomic regulation.

3) The employment rate should be improve upon and the labor resources should be optimized, employment channels should also be expanded.

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