HÖGSKOLAN DALARNA

Impulse-Response function Analysis: An application to macroeconomy data of China

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D-level Essay in Statistics

Department of Economics and Society, Högskolan Dalarna, Sweden

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Abstract

In this thesis, we make a comprehensive view of economic development, and choose four typical indicators to analysis China's macroeconomy. The four variables is gross domestic product (GDP), Consumer Price Index (CPI), money supply (M2) and seven-day interbank rate. This thesis uses vector auto regression (VAR) to model these four economic indicators from 1996 to 2008. And we do Granger causality test to determine the Granger-cause between variables. Then we explain the relationship among these four factors with impulse response function (IRF), which give an overview of China's macroeconomic system. According to economic theory and the results of impulse response function, there are complicated and significant relationships among these four variables. At last, we make a forecast to China's macroeconomic in 2009, and compare the forecast value with real value to evaluate the forecast effect of this model.

Key words: impulse response function (IRF), macroeconomic of China, vector auto regression (VAR), Granger causality test.

Contents

1.Introduction:

Macroeconomy deals with the performance, structure, behavior and decision-making of the entire economy, which can be a national, regional, or the global economy. Because the macroeconomic includes many sophisticated relationships, only one variable is hard to represent how the whole economy functions. In this thesis, we make a comprehensive view of economic development, and choose four aggregated indicators to analysis China's macroeconomy. The four variables are gross domestic product (GDP), Consumer Price Index (CPI), money supply and seven-day interbank rate.

To build the model for these four variables, we use the method of vector auto regression (VAR). VAR is an econometric model used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate AR models.

This thesis focuses on the China's macroeconomic system. It uses four important economic indicators, which are the monthly data from 1996 to 2009, to represent the China's macroeconomic system. The aim of this thesis is to model and forecast those economic indicators with VAR models, explain the relationship among these four factors, and give an overview of China's macroeconomic system.

Chapter 2 of this essay describes the specifications of the data we got and how to transform the data, and then present a descriptive statistical analysis of these four variables; chapter 3 builds vector autoregression (VAR) models; chapter 4 explains the relationship between these four factors with impulse response function (IRF); Chapter 5 considers Granger causality test to the models; Chapter 6 forecasts macroeconomy of China in 2009, and compares the forecast value with real value to evaluate the forecast effect of this model; Chapter 7 uses the results we get in previous chapter to explain the relationship between those factors and the forecast.

2. Data

2.1 The Source of data

The data we employed in this thesis are monthly observation of china's gross domestic product [1], consumer price index [2], Money supply (M2) [3], seven-days interbank rate[4].

The source of Quarterly GDP is China Statistical Yearbook. Monthly CPI is from National Bureau of Statistics in China. Monthly money supply is from People's Bank of China. The average monthly seven-day interbank rate is from People's Bank of China.

According to the data we collect and the request of model, we decide to use monthly data of the four variables from 1996 to 2009 to build model. Because we can just find quarterly and yearly data of GDP in China, we have to create artificial monthly data in some way. Below is the process of creating artificial monthly data.

For GDP, the original data we got is quarterly observation from 1996 to 2009. To obtain the artificial monthly data, we use the monthly growth rate of TRSCG to calculate monthly GDP. Total retail sales of consumer goods (TRSCG) can reflect one

[1] The gross domestic product (GDP) is a measure of a country's overall economic output.
[2] The consumer price index (CPI) is a measure estimating the average price of consumer goods and services purchased by households.
[3] Money supply is the total amount of money available in an economy at a particular point in time. M2: represents money and "close substitutes" for money.
[4] seven-days interbank rate refers to the short-term funds lending rate among banks in seven days.

country's economic output in some degree. We can collect the quarterly and monthly data of TRSCG. We assume GDP and TRSCG have similar monthly growth rate. To verify it, we use Pearson's product moment correlation coefficient to test correlation between the quarterly data of TRSCG and GDP, the result is 0.9859266. That's mean there are high correlation between them. So we use this monthly growth rate of TRSCG and quarterly GDP to calculate the artificial monthly GDP.

2.2 Description of data

Every variable have 168 sample sizes. In order to analyze them, we plot the figure 1 contain the four linear graph of four variables

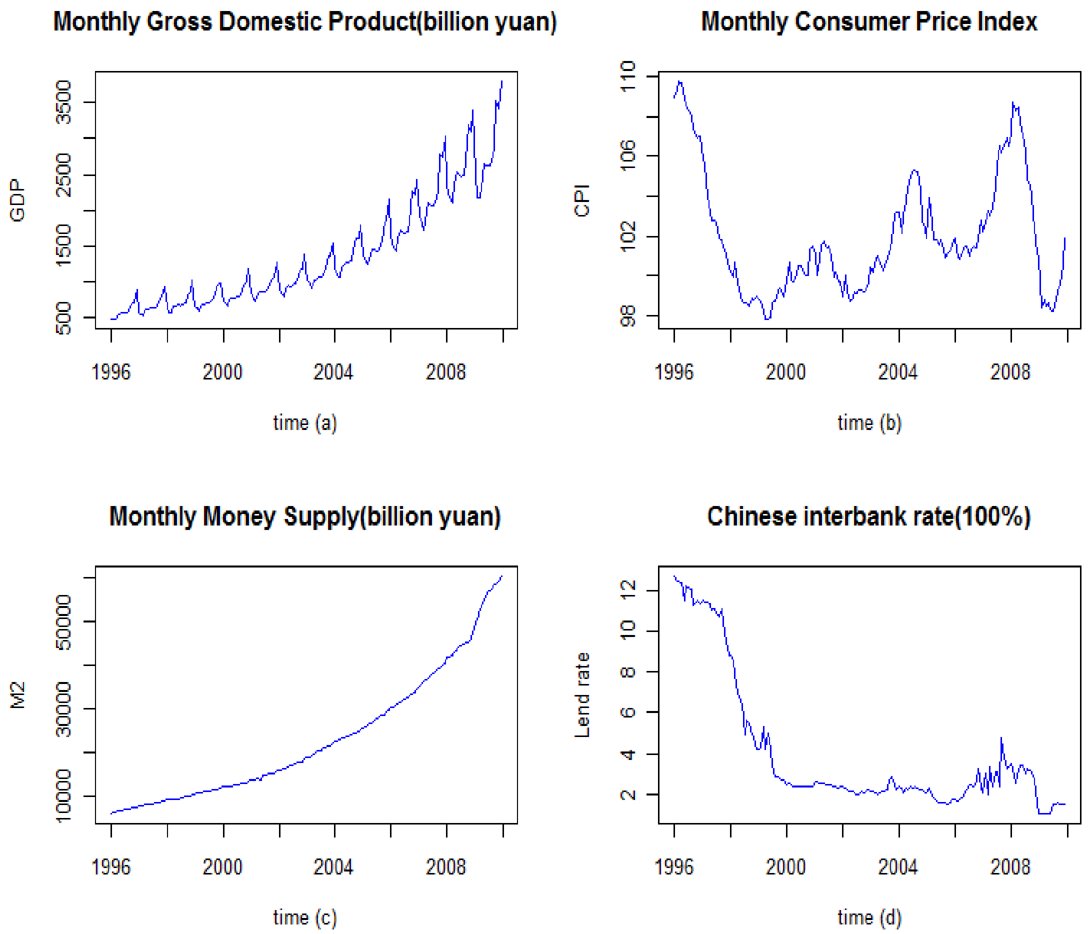

Figure 1 monthly data from 1996 to 2009

From the graph (a) of the figure 1, we can have that gross domestic product has a steady growth in the overall. And the quantity of almost every January, February, December have are decreased and that of every August, September, November are increased. Since, there is a holiday on January or February, and the gross domestic product is reduced. And at the end of year, gross domestic product is ascending.

From the graph (b) of the figure 1, we can have that the consumer price index stayed more or less constant, except a sharp decreasing from1996 to 1997. Refer to the relevant documentation, Chinese government introduced a new policy, allowing the market to independent pricing, Prices increase are until the end of 1996, however, Chinese economy has never appeared in a previously encountered problem: deflation, the prices of many goods do not rise declined. This situation continued until the end of 2004.

From the graph (c) of the figure 1, we can have that the money supply on the whole has exponentially grown. The money supply from Jan 1996 to Dec 2009, the growth from 5840.1billion to 60622.50 billion is an increase of 10 times.

From the graph (d) of the figure 1, we can have that Chinese interbank rate. From 1996 to 1998, it shows sharp decreasing, from 12.6% to 4.22%. Then trend of data is almost stationary.

3. Modeling

3.1 Vector autoregression

Vector autoregression (VAR) is an econometric model used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate

AR models. All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. Based on this feature, Christopher Sims advocates the use of VAR models as a theory-free method to estimate economic relationships, thus being an alternative to the "incredible identification restrictions" in structural models

A VAR model describes the evolution of a set of k variables (called endogenous variables) over the same sample period (t = 1, ..., T) as a linear function of only their past evolution. The variables are collected in a k × 1 vector y_t, which has as the ith element y_i,t the time t observation of variable y_i. For example, if the ith variable is GDP, then y_i,t is the value of GDP at t.

A (reduced) p-th order VAR, denoted VAR(p), is

$$y_t = c + \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + \varepsilon_t$$

where c is a k × 1 vector of constants (intercept), Φ_i is a k × k matrix (for every i = 1, ..., p) and et is a k × 1 vector of error terms

The i-periods back observation y_{t-i} is called the i-th lag of y. Thus, a pth-order VAR is also called a VAR with p lags.

{y_t} is covariance-stationary if Ey_t and E(y_t-Ey_t)(y_{t-j}-Ey_{t-j})’ are independent of t for any j.

3.2 Transformation of data

To get a better result of fitting and make these four variables in the same order of magnitude, we make appropriate transformations to GDP and M2, whose units are billion . And the interbank rate and CPI stay the same.

Set $gdpgrowth = 100 * \log\left(\frac{GDP\,[t]}{GDP\,[t-1]}\right)$ (GDP growth rate)

$$mgrowth = 100 * \log\left(\frac{M2[t]}{M2[t-1]}\right) \text{ (M2 growth rate)}$$

After transformation we get the data plot as below.

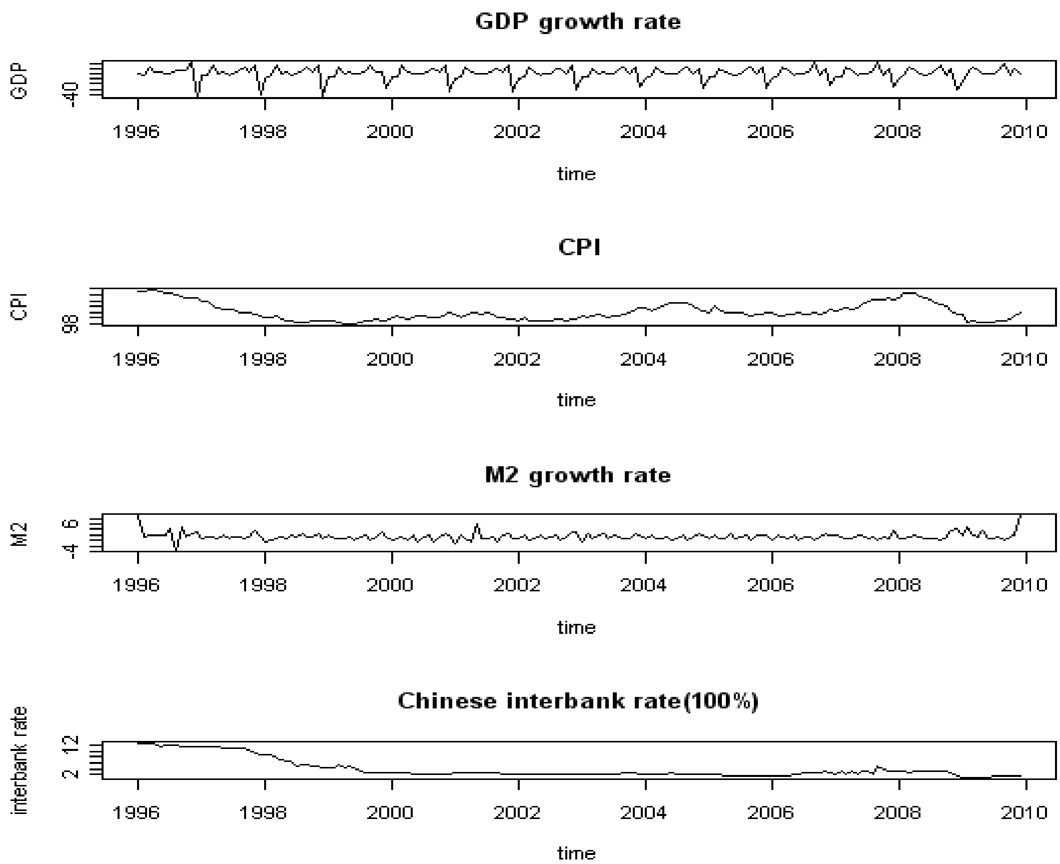

Figure 2 the data after transformation

From the graph, after transformation, the growth trends of GDP and money supply have disappeared. Most important thing is the order of magnitude for all variables are the same, which improve the results of models and IRF greatly.

3.3 VAR Lag Order Selection

An important preliminary step in model building and impulse response analysis is the selection of the VAR lag order. In this thesis we use some commonly used lag-order selection criteria to choose the lad order, such as AIC, HQ, SC and FPE.

Using Akaike Information Criterion to choose lag order.

$$AIC = -2\left(\frac{logL}{T}\right) + \frac{2k}{T}$$

Using Schwartz Criterion to choose lag order.

$$SC = -2\left(\frac{logL}{T}\right) + \frac{klogT}{T}$$

Using Hannan-Quinn to choose lag order

$$HQ = -2\left(\frac{logL}{T}\right) + 2k\frac{Ln\,(logT\,)}{T}$$

We use "VARselect" in R get the results below:

AIC(n)	HQ(n)	SC(n)	FPE(n)
12	11	2	12

Base on AIC and FPE, the lag order we chosen is 12. Because the data we used are monthly data, the result is reasonable. Base on SC and HQ, we will try the models with lag order equal to 11 or 2 as well.

3.4 Models selection

In R, VAR model has four types: having trend, having constant, having both and having none. According to the analysis above, we choose the type of having both.

The results of model with lag order=12:

response	**GDP growth**	**CPI**	**M2 growth**	**Interbank rate**
Adjusted R-squared:	0.9587	0.9419	0.4565	0.9747
p-value	< 2.2e-16	< 2.2e-16	1.541e-07	< 2.2e-16

The results of model with lag order=11:

response	**GDP growth**	**CPI**	**M2 growth**	**Interbank rate**
Adjusted R-squared:	0.9621	0.9406	0.4514	0.9758
p-value	< 2.2e-16	< 2.2e-16	5.616e-08	< 2.2e-16

The results of model with lag order=2:

response	**GDP growth**	**CPI**	**M2 growth**	**Interbank rate**
Adjusted R-squared:	0.09623	0.9555	0.1287	0.9831
p-value	0.004708	< 2.2e-16	0.0006197	< 2.2e-16

Because the data we uesd are monthly data, the model with lag order being 12 has more practical meaning than that with lag order being 11. What's more, judging from adjusted R-squared, the moder with lag order being 12 is better.

3.5 Estimation for the model

Responsible:	GDP growth rate		CPI		M2 growth rate		Interbank rate	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
gdpgrowth.11	-0.73629	1.00E-09	0.024376	0.3701	-0.0315	0.3277	0.03575	0.04855
cpi.11	0.73377	0.0875	0.893996	4.45E-13	0.025061	0.8423	-0.0455	0.51827
mgrowth.11	0.61001	0.0802	-0.01783	0.8365	-0.22655	0.0286	0.155415	0.00759
lendrate.11	0.25862	0.6829	0.189689	0.2321	-0.18577	0.3218	0.48959	9.06E-06
gdpgrowth.12	-0.7695	1.25E-10	0.029435	0.2704	-0.05577	0.079	0.038032	0.03271
cpi.12	0.14037	0.7979	-0.04697	0.7317	0.061695	0.7034	0.090235	0.31999
mgrowth.12	-0.0691	0.8508	-0.05602	0.5419	0.080199	0.4606	0.048655	0.42315
lendrate.12	0.70438	0.3159	-0.07932	0.6505	-0.10741	0.6041	0.34428	0.00362
gdpgrowth.13	-0.78591	1.92E-10	0.026583	0.3355	-0.04188	0.2005	0.040945	0.02639
cpi.13	-0.48288	0.3782	-0.10892	0.4262	-0.03293	0.8386	-0.05218	0.56369
mgrowth.13	0.20691	0.5525	0.104408	0.2317	0.126052	0.2222	0.06153	0.28579
lendrate.13	0.78124	0.2882	-0.18054	0.3257	0.287244	0.1871	0.221331	0.07003
gdpgrowth.14	-0.7554	6.32E-10	0.023123	0.4003	-0.03301	0.3104	0.03398	0.06339
cpi.14	0.33779	0.5382	0.139571	0.3096	-0.00642	0.9684	-0.00195	0.9828
mgrowth.14	-0.36149	0.2791	0.057703	0.4885	-0.16759	0.091	0.047417	0.38938
lendrate.14	-0.35029	0.6446	0.272437	0.1531	0.257854	0.252	-0.18263	0.14735
gdpgrowth.15	-0.77688	1.11E-10	0.026561	0.3225	-0.05521	0.0838	0.033872	0.05803
cpi.15	-0.25673	0.6403	0.090279	0.511	-0.18468	0.2567	0.007125	0.93736
mgrowth.15	0.10752	0.7437	-0.00427	0.9586	-0.05583	0.5658	0.07009	0.19858
lendrate.15	-0.7118	0.3509	0.100813	0.5963	-0.18345	0.4156	0.052439	0.67667
gdpgrowth.16	-0.7766	2.75E-10	0.025571	0.3535	-0.03784	0.2464	0.045082	0.01465
cpi.16	0.38951	0.4869	-0.09099	0.5156	-0.03907	0.8132	0.075885	0.41226
mgrowth.16	-0.30942	0.3333	-0.00573	0.9427	0.09591	0.3104	0.065296	0.21705
lendrate.16	0.60551	0.4134	-0.12913	0.4849	-0.09093	0.6773	-0.16839	0.16981
gdpgrowth.17	-0.73567	1.53E-09	0.022922	0.4051	-0.05472	0.0948	0.034213	0.06201
cpi.17	-0.19609	0.7269	0.00762	0.9567	0.39243	0.0197	0.013896	0.88083
mgrowth.17	-0.49489	0.1155	0.023432	0.7641	-0.01605	0.862	0.044707	0.38704
lendrate.17	-1.11002	0.1354	0.034001	0.8539	0.33412	0.1284	0.210088	0.08762
gdpgrowth.18	-0.75208	1.95E-10	0.023254	0.3787	-0.04606	0.1418	0.032008	0.06859
cpi.18	-0.93072	0.1059	0.076737	0.5914	-0.17611	0.2986	-0.14135	0.13657
mgrowth.18	-0.26824	0.3949	-0.00714	0.9277	-0.15003	0.1091	0.088524	0.09093
lendrate.18	0.38923	0.6035	0.107014	0.5677	-0.02227	0.9198	-0.05495	0.65695

gdpgrowth.l9	-0.81861	9.41E-12	0.025156	0.3407	-0.0195	0.5318	0.037022	0.03558
cpi.l9	0.39769	0.501	0.001999	0.9892	-0.40542	0.022	0.058705	0.54741
mgrowth.l9	-0.12258	0.6924	-0.1051	0.1765	0.053998	0.5556	0.058268	0.25617
lendrate.l9	-0.70982	0.3337	0.019754	0.9141	-0.27413	0.2074	0.039636	0.74322
gdpgrowth.l10	-0.70443	1.14E-08	0.033821	0.2316	-0.06415	0.0565	0.034692	0.06476
cpi.l10	0.64004	0.2745	-0.11704	0.4232	0.226056	0.1922	0.050664	0.59948
mgrowth.l10	-0.24854	0.412	-0.01191	0.8748	0.042051	0.6382	-0.01418	0.77657
lendrate.l10	0.47495	0.5213	-0.04442	0.8101	-0.17231	0.4314	-0.05373	0.6602
gdpgrowth.l11	-0.69342	3.13E-09	0.027141	0.3075	-0.07719	0.0154	0.043554	0.01449
cpi.l11	-0.21872	0.7195	0.116313	0.4452	0.424442	0.0201	-0.08948	0.37439
mgrowth.l11	0.07325	0.8021	0.146181	0.0476	-0.0055	0.9492	-0.0223	0.64414
lendrate.l11	-0.15943	0.8204	-0.12934	0.4617	0.150489	0.469	0.08493	0.46452
gdpgrowth.l12	0.16887	0.0998	0.018351	0.4715	-0.03675	0.224	0.038194	0.02509
cpi.l12	-0.28102	0.5373	-0.2535	0.0278	-0.27844	0.0407	0.049649	0.50928
mgrowth.l12	0.40021	0.0894	0.083409	0.1555	0.043523	0.5291	-0.02473	0.52219
lendrate.l12	0.24342	0.6843	0.00791	0.9578	0.020309	0.9086	-0.08614	0.38424
const	-24.1052	0.2714	27.69078	1.89E-06	0.827395	0.898	-2.04584	0.57098
trend	0.0614	7.36E-05	0.008473	0.0242	0.006216	0.1585	-0.0056	0.02415

4. Impulse response function

4.1 Impulse response function

Impulse response function (IRF)of a dynamic system is its output when presented with a brief input signal, called an impulse. More generally, an impulse response refers to the reaction of any dynamic system in response to some external change.

A VAR was written in vector MA(∞) form as $y_t = \mu + \varepsilon_t + \Psi_1\varepsilon_{t-1} + \Psi_2\varepsilon_{t-2} + \cdots$. Thus, the matrix Ψ_s has the interpretation $\frac{\partial y_{t+s}}{\partial \varepsilon'_t} = \Psi_s$ that is, the row I, column j element of Ψ_s identifies the consequences of one unit increase in the jth variable's innovation at date t (ε_{jt}) for the value of the ith variable at time t+s(y_{it+s}),holding all other innovations at all dates constant.

$\frac{\partial y_{i\,t+s}}{\partial \varepsilon'_{jt}}$ as a function of s is called the impulse response function. It describes the response of y_{it+s} to a one-time impulse in y_{jt} with all other variables dated t or earlier held constant.

4.2 Empirical analysis:

The impulse response function of VAR is to analysis dynamic affects of the system when the model received the impulse. As our VAR model, we have four variables. We can work the response between these variables. In order to display the response function clearer, we plot the chart as figure 4 and figure 5.

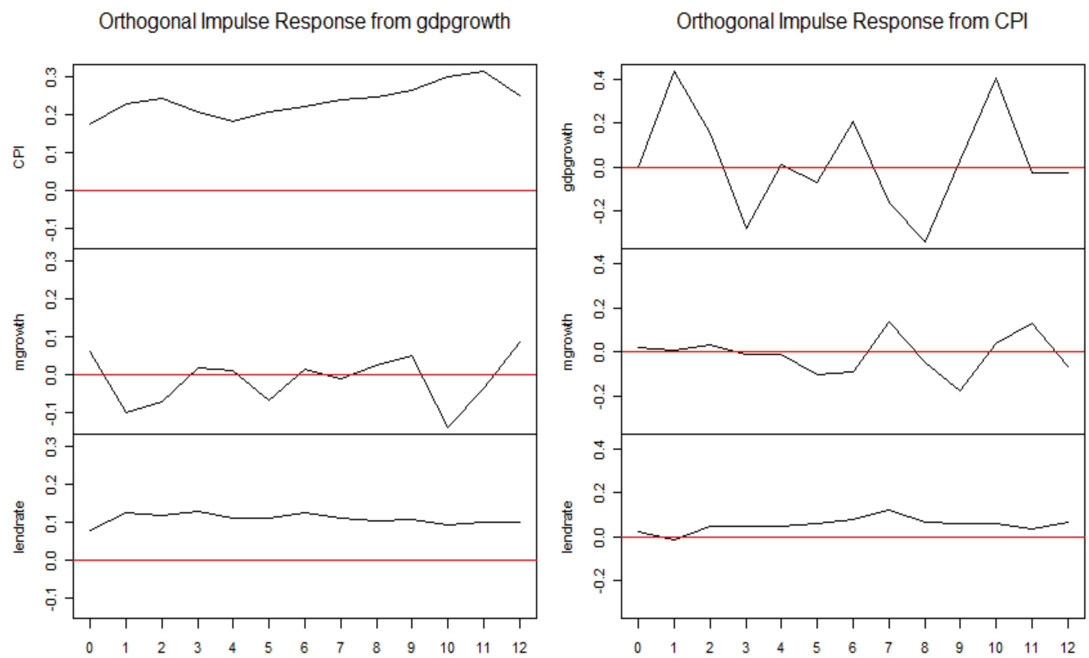

Figure4 the impulse response of GDP growth rate and CPI to other variables

From the figure 4, the left is the impulse response of GDP growth rate to CPI, money supply rate and interbank rate. When the impulse is GDP growth rate, the every response of inflation is all positive at each time responsive period; almost half response of money supply rate is positive, the value fluctuate around the line zero; the every response of interbank rate is positive. The right is the impulse response of CPI to GDP growth rate, money supply rate and interbank rate. When the impulse is CPI, the response of GDP growth rate has an obvious fluctuation, there is a highest positive effect on the first month, lowest negative effect on the eighth month; the response of money supply rate has an smooth fluctuation, there is more varied on the second half year; almost response of interbank rate are positive except the first month and the change is smooth.

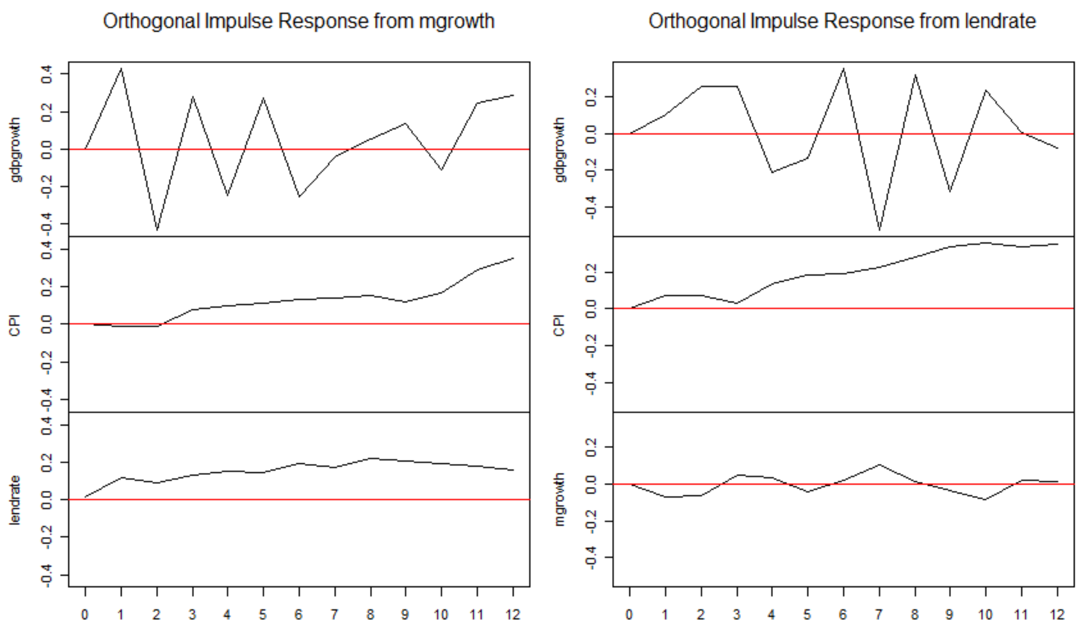

Figure 5 the impulse response of money supply rate and interbank rate to other variables

From the figure5, the left is the impulse response of money supply rate to CPI, GDP growth rate and interbank rate. When the impulse is money supply rate, the response of the GDP growth rate has an obvious fluctuation, there is highest positive effect on the first month, lowest negative effect on the second month,; the almost response of the CPI is positive, and there is distinct effect on the second half year; the response of interbank rate has an smooth fluctuation and is all positive. The right is the impulse response of interbank rate to GDP growth rate, money supply rate and CPI. When the impulse is interbank rate, the response of GDP growth rate has an obvious fluctuation, there is a highest positive effect on the sixth month, lowest negative effect on the seventh month; the response of money supply rate has an smooth fluctuation.

5. Testing procedures

5.1 Granger causality test

Granger causality test is a technique for determining whether one time series is useful in forecasting another. Two causality tests are implemented. The first is a F-type Granger-causality test and the second is a Wald-type test that is characterized by testing for nonzero correlation between the error processes of the cause and effect variables. Granger causality test can be applied in a multivariate context. Suppose that the variables of a VAR are categorized into two groups, as represented by the (n_1*1) vector y_1, and the (n_2*1) vector y_2. The VAR may then be written $y_{1t} = c_1 + A_1' x_{1t} + A_2' x_{2t} + \varepsilon_{1t}$,$y_{2t} = c_2 + B_1' x_{1t} + B_2' x_{2t} + \varepsilon_{2t}$. The group of variables represented by y1 is said to be block-exogenous in the time series sense with respect to the variables in y_2 if the element y_2 in are of no help in improving a forecast of any variable contained in y_1 that is based on lagged values of all the elements of y_1 alone. In the VAR model above, y_1 is block-exogenous when $A_2 = 0$.

5.2 Testing analysis

Granger causality test is a technique for determining whether one time series is useful in forecasting another. It can determine whether there is causality relationship between variables. We work the Granger causality test, the result as following table(confidence interval is 94%)

Cause variable	F-test	p-value	Null hypothesis	Decision
gdpgrowth (GDP growth rate)	1.5217	0.03013	gdpgrowth do not Granger-cause inflation mgrowth lendrate	Reject the null hypothesis
Inflation (CPI)	1.4327	0.05415	inflation do not Granger-cause gdpgrowth mgrowth lendrate	Reject the null hypothesis
Mgrwoth(Money-supply growth rate)	1.5468	0.02536	mgrowth do not Granger-cause gdpgrowth inflation lendrate	Reject the null hypothesis
Interbank rate	1.4245	0.05702	lendrate do not Granger-cause gdpgrowth inflation mgrowth	Reject the null hypothesis

From this result, we can have that when the cause variable is GDP growth rate, the p value of the test is 0.03. It is less than 0.06, we can reject the null hypothesis. That's mean GDP growth rate have Granger cause relationship with CPI, Money-supply growth rate and Interbank rate. When the cause variable is CPI, the p value of the test is 0.05415. It is less than 0.06, we can reject the null hypothesis. That's mean CPI have Granger cause relationship with GDP growth rate, Money-supply growth rate and Interbank rate. When the cause variable is CPI, the p value of the test is 0.02536. It is less than 0.06, we can reject the null hypothesis. That's mean Money-supply growth rate have Granger cause relationship with GDP growth rate, CPI and Interbank rate. When the cause variable is CPI, the p value of the test is 0.05702. It is less than 0.06, we can reject the null hypothesis. That's mean Interbank rate have Granger cause relationship with GDP growth rate, Money-supply growth rate and CPI.

6. Forecast

Forecasting is the process of estimation in unknown situations, which is commonly used in discussion of time-series data. We use our VAR model to forecast the four variables: GDP, CPI, M2, and interbank rate, the result as the following figure 6, figuer7, figure 8, figure 9

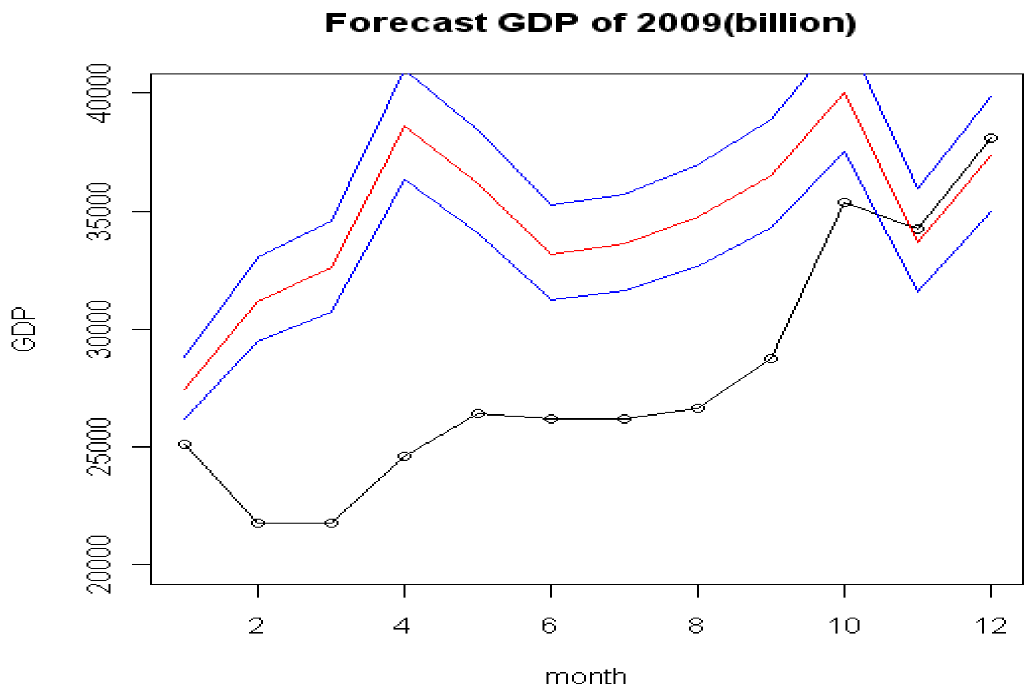

Figure 6 Forecasting of GDP

From the figure 6, the black line is the true value of GDP in 2009, the red line is the predicted value, and the blue lines are the 95% confidence interval. We can have that Predictive validity is not perfect, while the predicted value have similar changed tendency as the true value. The true and predicted values are both low on the first half year, and have growth on the second half year.

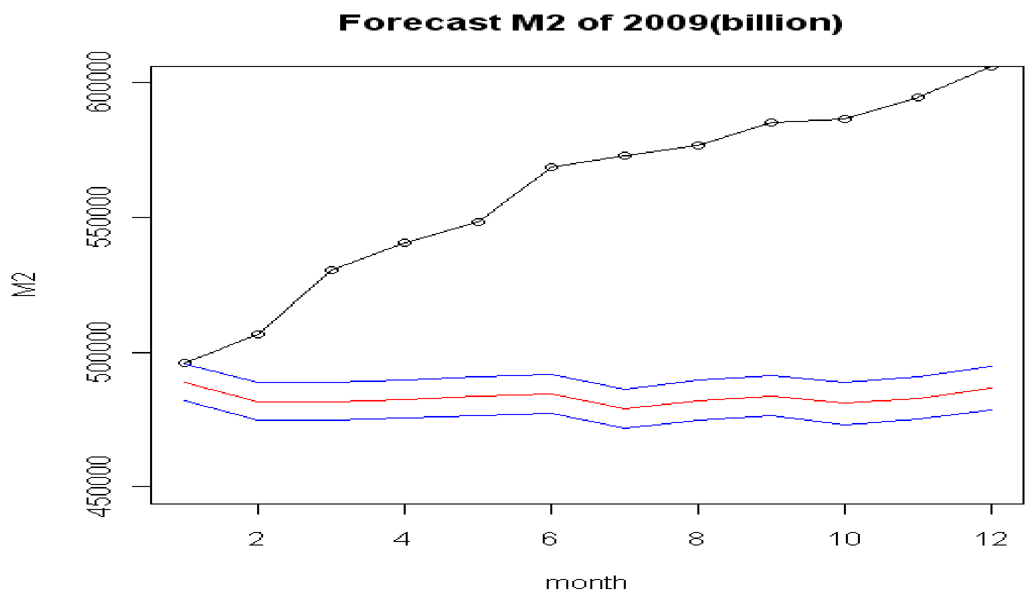

Figure 7 Forecasting of Money supply

From the figure 7, the black line is the true value of money supply in 2009, the red line is the predicted value, and the blue lines are the 95% confidence interval. We can know that the predicted value has smooth vary and the true value has obvious growth. Money supply is affected by the economic policy easily. Therefore, it is difficult to get reasonable predicted value through just using the model to forecast a whole year value

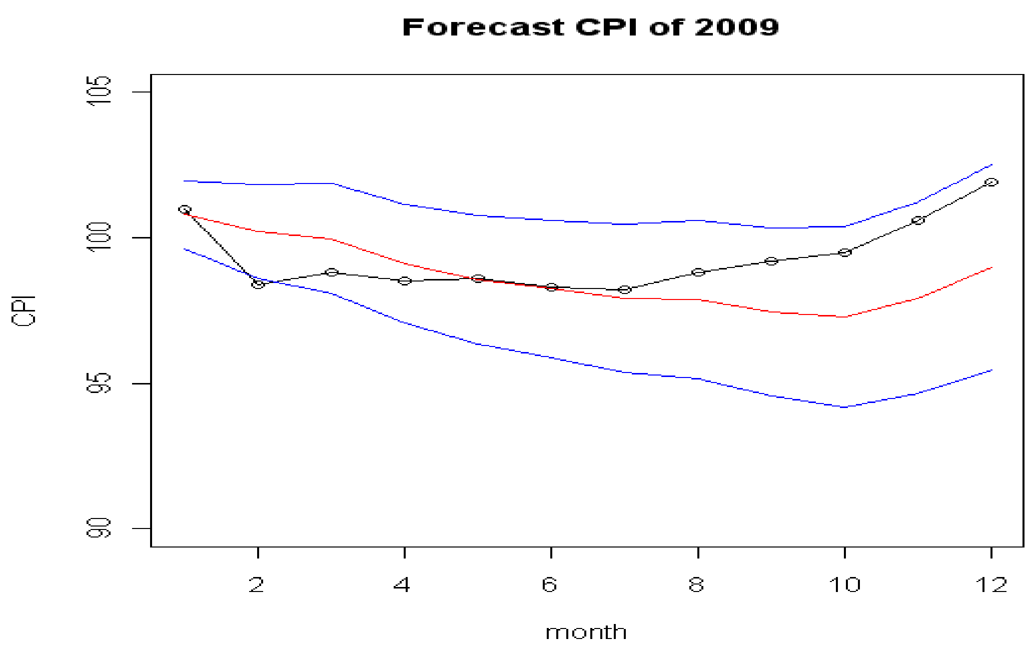

Figure 8 Forecasting of CPI

From Figure 8, the black line is the real value of CPI in 2009, and the red line is the predicted value, and the blue lines are the 95% confidence interval. The effect of CPI forecasting is the best one in these four variables. The trends of the whole year between these two lines are similar, and the real values and the predicted values are closed. The good forecasting results suggest that this model is suitable to forecast some stabilized variables, such as CPI.

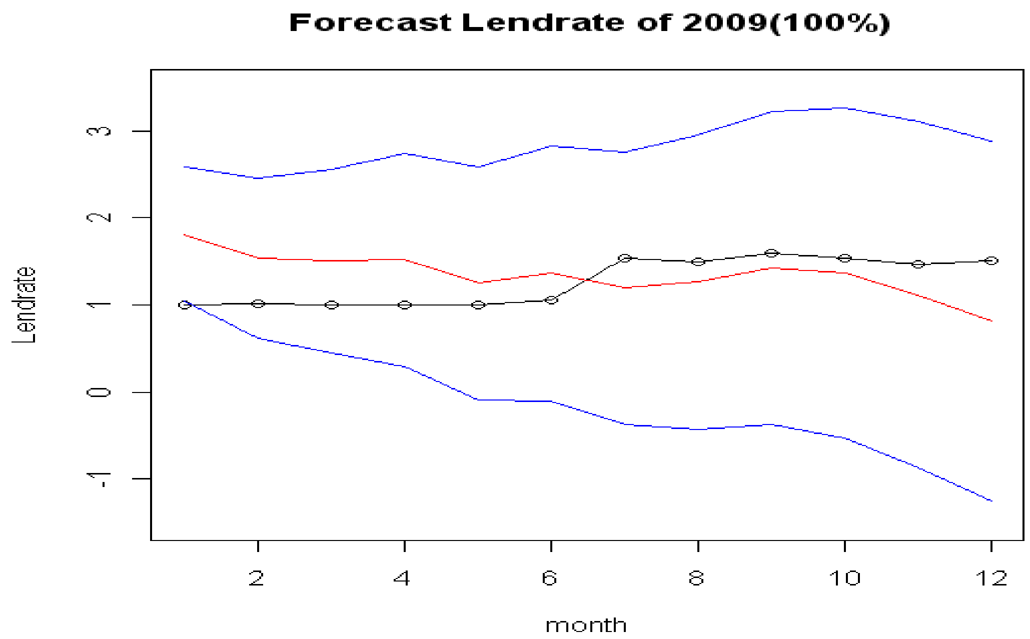

Figure 9 Forecasting of lend rate

From Figure 9, the black line is the real value of interbank lend rate in 2009, and the red line is the predicted value, and the blue lines are the 95% confidence interval. The true value is in the 95% confidence interval and the trend of predicted value is similar with the true one. But the interbank lend rate can be influenced by economic policy significantly, so it is hard to be predicted by the statistics models.

7 Conclusions

GDP growth rate does have an accelerative effect on CPI for the whole year. The effects from GDP growth rate to money supply growth rate are obviously fluctuating, more than a half time the effects are negative. GDP growth rate does have a very smooth and positive effect on interbank rate for the whole year.

The effects from CPI to GDP growth rate are obviously fluctuating. There is a highest positive effect on the first month, lowest negative effect on the eighth month. The effects from CPI to money supply growth rate are smoothly fluctuating in first half year, and more varied on the second half year. And CPI does have a smooth effect around zero on interbank rate for the whole year.

The money supply growth rate has remarkable effect on the GDP growth rate and it is about half positive effect except the second month, fourth month, sixth month and tenth month. While, money supply growth rate has accelerated positive impact on the CPI, it arrived at the highest value on the end of the year. Money supply growth rate has smooth impact on interbank rate on the every month.

The interbank rate also has remarkable effect on the GDP growth rate and there is positive and negative effects, has a highest positive value on the sixth month and lowest negative value on the seventh month. Interbank rate has monotone effect on CPI, it arrived at the highest value on the end of the year. Interbank rate has double influence, the positive effect and negative effect distributed equably in the whole year.

From the effects of forecasting these four variables, we get that predictive validity of CPI and interbank lend rate are sound, the predictive value have similar trend as the observation value of 2009, while the predictive validity of GDP and money supply are not good. Both Money supply and interbank lend rate are affected by the economic policy significantly. Therefore, it is not reasonable to use this model to forecast these two variables money supply and interbank lend rate.

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Appendix: R codes

```
rm(list=ls(all=TRUE))
data=read.table("data.txt",header=T)
attach(data)

#transform data
n<-length(GDP)
gdpgrowth<-numeric(0)
```

```
mgrowth<-numeric(0)
for (i in 2:n) {
gdpgrowth[i-1]<-100*log(GDP[i]/GDP[i-1])
mgrowth[i-1]<-100*log(MoneyS[i]/MoneyS[i-1])
}
lendrate<-Lendrate[2:n]
cpi<-CPI[2:n]
data1 <- data.frame(gdpgrowth,cpi,mgrowth,lendrate)


#plot
gdp<-ts(gdpgrowth,start=c(1996,1),end=c(2008,12),frequency=12)
cpi<-ts(CPI,start=c(1996,1),end=c(2008,12),frequency=12)
mg<-ts(mgrowth,start=c(1996,1),end=c(2008,12),frequency=12)
lr<-ts(Lendrate,start=c(1996,1),end=c(2008,12),frequency=12)

par(mfrow=c(4,1))
plot.ts(gdp,main="GDP growth rate",xlab="time",ylab="GDP")
plot.ts(cpi,main="CPI",xlab="time",ylab="CPI")
plot.ts(mg,main="M2 growth rate",xlab="time",ylab="M2")
plot.ts(lr,main="Chinese interbank rate(100%)",ylab="interbank rate",xlab="time")

#model
VARselect(data1,lag.max=12,type="both")
m1=VAR(data1, p =12, type = "both")
summary(m1)
m2=VAR(data1, p =11, type = "both")
summary(m2)
m3=VAR(data1, p =2, type = "both")
summary(m3)

#test

causality(m1, cause = "gdpgrowth")
causality(m1, cause = "mgrowth")
causality(m1, cause = "cpi")
causality(m1, cause = "lendrate")


#irf
impu1=irf(m1, impulse = "gdpgrowth", response = c("cpi", "mgrowth", "lendrate"), boot =FALSE,n.head=12)
impu2=irf(m1,impulse = "cpi", response = c("gdpgrowth", "mgrowth", "lendrate"),n.ahead = 12, boot =FALSE)
impu3=irf(m1,impulse = "mgrowth", response = c("cpi", "gdpgrowth", "lendrate"), n.ahead = 12,boot =FALSE)
impu4=irf(m1,impulse = "lendrate", response = c("cpi", "mgrowth", "gdpgrowth"),n.ahead = 12, boot =FALSE)
```

```
plot(impu1,xlim=seq(1,12))
axis(1,xaxp=seq(1,13))
plot(impu1)
plot(impu2)
plot(impu3)
plot(impu4)

#forecast
a=predict(m1, n.ahead = 12, ci = 0.95)
gdpp<-numeric(12)
gdppu<-numeric(12)
gdppl<-numeric(12)
m2p<-numeric(12)
m2pu<-numeric(12)
m2pl<-numeric(12)
cpip<-numeric(12)
cpipu<-numeric(12)
cpipl<-numeric(12)
lendp<-numeric(12)
lendpu<-numeric(12)
lendpl<-numeric(12)
for (i in 1:12){
gdpp[i]<-exp(a$fcst$gdpgrowth[i,1]/100)*34013.08
gdppu[i]<-exp(a$fcst$gdpgrowth[i,3]/100)*34013.08
gdppl[i]<-exp(a$fcst$gdpgrowth[i,2]/100)*34013.08
m2p[i]<-exp(a$fcst$mgrowth[i,1]/100)*475166.6
m2pu[i]<-exp(a$fcst$mgrowth[i,3]/100)*475166.6
m2pl[i]<-exp(a$fcst$mgrowth[i,2]/100)*475166.6
cpip[i]<-a$fcst$cpi[i,1]
cpipu[i]<-a$fcst$cpi[i,3]
cpipl[i]<-a$fcst$cpi[i,2]
lendp[i]<-a$fcst$lendrate[i,1]
lendpu[i]<-a$fcst$lendrate[i,3]
lendpl[i]<-a$fcst$lendrate[i,2]
}

data2=read.table("datat.txt",header=T)

plot(data2$GDP,main=" Forecast GDP of 2009(billion)",xlab="month",ylab="GDP",ylim=c(20000,40000))
lines(data2$GDP)
lines(gdpp,col=2)
lines(gdppu,col=4)
lines(gdppl,col=4)
```

```
plot(data2$MoneyS,main=" Forecast M2 of 2009(billion)",xlab="month",ylab="M2",ylim=c(450000,600000))
lines(data2$MoneyS)
lines(m2p,col=2)
lines(m2pu,col=4)
lines(m2pl,col=4)


plot(data2$CPI,main=" Forecast CPI of 2009",xlab="month",ylab="CPI",ylim=c(90,105))
lines(data2$CPI)
lines(cpip,col=2)
lines(cpipu,col=4)
lines(cpipl,col=4)

plot(data2$Lendrate,main=" Forecast Lendrate of 2009(100%)",xlab="month",ylab="Lendrate",ylim=c(-1.5,3.5))
lines(data2$Lendrate)
lines(lendp,col=2)
lines(lendpu,col=4)
lines(lendpl,col=4)
```