ECONOMIC FACTORS PREDICTING INFLATION IN THE US, ENGLAND, FRANCE, AND GERMANY

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ABSTRACT

In this study, the authors investigated the relationship between inflation and macro-economic factors (namely, short and long term interest rates, unemployment, GDP, and percent debt) for France, Germany, England, and the United States. Time series and autoregressive analysis procedures were used to determine, for each country, the best predictive model over a 5 year period relating inflation as the dependent variable to macro-economic factors as the independent variables. Results showed that for England and the United States, GDP and year were good predictors of inflation. In France, factors that predicted inflation were growth rate and 10-year bond rate and in Germany the factors for predicting inflation were 10-year bond rate and inter bank rate. The models were very good in predicting inflation for the US and England. Prediction of inflation for France and Germany, was not as good as that for England and the United States

INTRODUCTION

Inflation rate is a major economic variable or indicator used in decision making. Inflation has an effect on economic growth. Therefore, control of inflation is of primary concern for any economy. Most economists agree that inflation is related to money growth. The reserve bank in the US and central banks in other countries use interest rate in order to regulate inflation dynamics. There is interest on the part of these institutions to accurately forecast inflation rate for decision making. There have been many attempts in the literature to model inflation in order to understand its dynamics. These modeling attempts were mostly univariate in the sense that inflation was expressed as a function of its own lags. There are factors or exogenous variables that can affect inflation dynamics. Interest rate, GDP, and unemployment are among such factors. Hence, multivariate models including such exogenous variables to simulate inflation dynamics may be more accurate than univariate models. In this paper, we use time series multivariate modeling techniques to study the relationships between inflation and economic variables in order to predict the dynamics of inflation in developed countries, namely the US, Great Britain, France, and Germany. We also test the predictive accuracy of each model.

REVIEW OF RELEVANT LITERATURE

Pincheira and Medel (2015) evaluated the inflation forecasting ability of univariate time series models in the US and several other countries. The authors used what they termed Driftless Extended Seasonal ARIMA (DESARIMA) model and showed that their model short horizon

forecasts were better than existing univariate models in the literature. Forecasting accuracy was mixed over longer horizons. The forecasting accuracy was higher in countries where inflation was stable. Ang et al. (2007) used ARIMA models, regression, structure models, and survey-based measures in forecasting inflation in the US. They reported that surveys outperformed the other methods in forecasting. Anderson et. al. (2007) applied univariate autoregression time series models to evaluate the accuracy of the Ricksbank's forecasts.

Bipradas (2014) used a GARCH model and Granger test to study the relation between inflation, inflation uncertainty, and output growth in India. Results showed that there was no significant relationship between inflation uncertainty and growth rate. However, there was evidence that an increase in inflation increased inflation uncertainty.

Muthucattu et al. (2014) applied a co-integration and vector error correction modeling approach to study the effects of exchange rate (Australian dollar/ Fijian dollar), consumer price index in Australia, GDP plus (import – export), and a dummy 0,1 variable for the devaluation years in Fiji. Results showed that inflation in Fiji was affected by the exchange rate and the GDP.

Pintilescu et. al. (2014) used Granger causality tests and a vector autoregressive (VAR) model to study the relationships among inflation, GDP and their uncertainties in ten European countries with emerging economies. Uncertainty of GDP or inflation was estimated from the conditional variance using a Garch model. Results showed that inflation Granger-causes inflation uncertainty, confirming the Friedman–Ball hypothesis. Ikechukwu and Adedoyin (2014) modeled inflation using a univariate ARIMA time series model and a VAR bivariate model where the series were inflation and broad money supply in Nigeria. Results indicated that VAR was a better model for inflation than the univariate ARIMA.

Deepak and Joice (2014) investigated factors that could affect inflation in India using quarterly data over the years 1997-2014. Authors used a structural vector autoregression (SVAR) model where the factors were crude oil prices, output gap, and monetary policy. Further, they modeled inflation dynamics over time by considering an SVAR with time varying parameters. Simionescu (2014) used the Granger test to show that unemployment caused inflation and inflation caused unemployment in Romania. Accordingly, a VAR (1) was used to model the bivariate time series.

Kichian and Rumler (2014) showed that the New Keynesian Phillips Curve (NKPC) equation outperformed the random walk and other conventional time series models in forecasting inflation in Canada. Odhiambo (2013) studied the relationship between inflation and economic growth in the presence of unemployment in South Africa. Using the Granger causality test, it was found that there was a bi-directional causal relationship (in the short or long run) between inflation and economic growth. Hossain (2014) reported that the persistence of inflation in Australia is not due to a unit root, but to a slow dissipation rate after a shock. Results indicated that there was a feedback between inflation and inflation volatility and that the latter effects unemployment and economic growth. Durčová (2012) using vector autoregression modeling approach studied the effect of a shock in interest rate on 3-month money market and Euribor interest rates, GDP, nominal effective exchange rates (NEER), and inflation in Germany, France, Netherlands, Belgium and Luxembourg. Results did not show a clear effect of a shock in interest rate on the

chosen macro markers. Any manifested effect was weak, which did not indicate an efficient transmission mechanism of the shock with regard to the selected economic variables.

Kalimeris D. (2012) investigated the relationship among inflation, inflation uncertainty and government bond rates in Greece in the last 19 years. The author used a time series approach, namely the E-GARCH and the VAR methods. Results showed a strong relationship between government bonds and inflation as well as inflation uncertainty. Also, there was a relationship between inflation and inflation uncertainty. Vizek and Broz (2009) studied the quarterly inflation in Croatia. They reported that inflation inertia and inflation of Croatian trading partners were important for explaining inflation behavior in the short run. Also, excess money, output gap, nominal exchange rate, and broad money contributed to the inflation dynamics in the short run.

Baghestan and AbuAl-Foul (2010) reported on factors used in federal reserve long term inflation forecasts. They included growth forecasts of unit labor cost and aggregate demand as well as monetary policy and the preceding inflation forecast. Zhang and Clovis (2009) modeled the inflation dynamics in the US using an AR process. Results showed that there was a significant decline in inflation over the recent period which may have been associated with US monetary policy.

Christiano and Fitzgerald (2003) studied the inflation dynamics before and after 1960 in the US. They reported that inflation was lower in the early period (before 1960) than in the later period. Also, inflation and unemployment were negatively correlated in the early period, but were positively related in the later period. These results were reported to have been accounted for by the notion that monetary policy in the early period was committed to low inflation, while not so in the later period.

METHODS

Time series model

A time series model relating an output series y to k input series x_i (i = 1, 2, …,k) can be expressed in general as

$$y_t = \sum_i^k c(B)_i \, x_{it} + a_t \quad (1)$$

Here, $c(B) = \sum c_j B^j$, where B is the backshift operator, $Bx = x_{t-1}$.

The function $c(B)_i$ with its lags is determined from the cross correlations between x_{it} and y_t , (i = 1,2,’’’k), namely the significance at a given lag and the pattern of the cross correlations over lags (Wei, 1994).

Once $c(B)_i$ is identified, one can express a_t in Eq. (1) as

$$a_t = y_t - \sum_i^k c(B)_i \, x_{it} \quad (2)$$

and identify the appropriate time series model for Eq. (2). With a_t known, one can determine the final model in Eq. (1). The time series variables are assumed to be stationary. Differencing is used if needed to make a series stationary,

Autoregression

Another modeling approach for time series is the use of linear multiple regression where the error is auto correlated. The model takes the form

$$Y_t = a + b_1X_1t + b_2X_{2t} + \dots b_kX_{kt} + V_t, \quad (3)$$

where

$$V_t = \Phi_1V_{t-1} + \Phi_2 Vt_{-2} + \dots + \Phi_1V_{t-n} + e, \quad (4)$$

and e is random noise.

Here, V_t is an autoregressive model.

The order n is determined from the Durbin-Watson statistic

Data Analysis

Data for this study were obtained from the Federal Reserve Economic Data- St. Louis Fed for England, France, Germany, and the United States. It spanned the time period 1955-2014.

In this analysis, CPI or inflation was the dependent variable. The independent variables were GDP, or growth rate for France, percent debt, short and long term interest rates, and unemployment rate. Each data set was modeled using the time series approach (Equations 1 and 2). The auto regression approach (Equations 3 and 4) and the autoregressive model (Equation 4). In all cases the last five years were left out of the data and used to check the prediction accuracy of the model. From the models developed for each data set, only the model that gave the best prediction is presented. Only independent variables that had a significant effect on the dependent variable were retained in each model. The R-squared goodness of fit values for all auto regression models presented below were good (larger than 0.9). The SAS software was used for the data analysis

MODELS

United States

The best model for the US was the autoregressive model expressed as

$$CPI_t = -1472 + 0.7582\ Y_t + 0.00329\ GDP_t + V_t, \quad (5)$$

where Y_t is year t and

$V_t = 0.9694\ V_{t-1} + e_t$

or

$V_t = e_t / (1 - 0.9694\ B),$ (6)

where B is the back shift operator ($BV_t = V_{t-1}$) and e is random noise.

Combining (6) and (5) and simplifying, one obtains the model

$$CPI_t = -45.04 + 0.9694\ CPI_{t-1} + 0.7582\ Y_t - 0.7350\ Y_{t-1} + 0.00329\ GDP_t - 0.00319\ GDP_{t-1} + e_t \quad (7)$$

England

The autoregression model (form Equations 3 and 4) was the best model in predicting inflation.

The model obtained is expressed as

$CPI_t = -2991 + 1.5286\ Y_t + .0127\ GDP_t + V_t,$ (8)

Where

$V_t = 1.804\ V_{t-1} - 0.8368\ V_{t-2} + e_t$

$= e_t / (1 - 1.804\ B + 0.8368\ B^2)$ (9)

Here, $BV_t = V_{t-1}$ and $B^2V_t = V_{t-2}$

Combining (8) and (9) and simplifying, one obtains the following model

$$CPI_t = -98.1 + 1.804\ CPI_{t-1} - 0.8368\ CPI_{t-2} + 1.5286\ Y_t - 2.7576\ Y_{t-1} + 1.2791\ Y_{t-2} + 0.0127\ GDP_t - 0.0229\ GDP_{t-1} + 0.0106\ GDPt\text{-}2 + e_t \quad (10)$$

France

The best model was determined using the auto regression analysis. The model is expressed as

$$INF_t = -1.0397 - 0.2927\ GR_t + 0.8598\ BR_t + V_t, \quad (11)$$

where, INF is inflation, GR is growth rate, BR is 10-year bond rate and

$$V_t = 0.8697\ V_{t-1} + e_t$$

$$= e_t / (1 - 0.8697B) \quad (12)$$

Substituting (12) in (11) and simplifying, one obtains

$$INF_t = -0.1355 + 0.8697\ INF_{t-1} - 0.2927\ GR_t + 0.2545\ GR_{t-1}$$

$$+ 0.8598\ BR_t - 0.7478\ BR_{t-1} + e_t \quad (13)$$

Germany

The best model was obtained from the time series analysis outlined in Equations (1) and (2) above. The model is expressed as

$$CPI_t = 0.1969\ BR_t + 0.2912\ IBR_t + a_t, \quad (14)$$

where BR is 10-year bond rate, IBR is inter bank rate and

$$a_t = e_t/(1 - 0.7614\ B) \quad (15)$$

Combining (11) and (12) and simplifying, one obtains the expression

$$INF_t = 0.7614\ INF_{t-1} + 0.1969\ BR_t - 0.1499\ BR_{t-1}$$

$$+ 0.2912\ IBR_t - 0.2217\ IBR_{t-1} + e_t \quad (16)$$

RESULTS AND DISCUSSION

Figures in the Appendix are plots of CPI and other independent variables that appeared in the model for each country over years. It is interesting to see that there is an upward trend for the

US and England, but no trend for Germany and France. This may have to do with differences in monetary and fiscal policies between EU members (France and Germany) and non-EU members (England and the US). EU countries have austere measures dictated by the Maastricht treaty of 1992.

Table 1 presents the observed and predicted values for CPI or inflation for the years that were not included in the data set used to determine the model equation.

The model equation used to predict CPI for England is equation (10). It is seen that the model which includes year and GDP as independent variables gave an excellent prediction of inflation over 5 years. Year may be regarded as a proxy for other factors not in the data set. The effect of GDP on inflation is as expected. It is interesting that interest rate was not a factor affecting inflation in this case. The CPI in the model relates to its two lags, to the first and second lags of year and to the first and second lags of GDP. The positive effects of GDP and year on CPI from equation (8) are reflected in the trends in Figure 1.

Table 1
Observed and predicted values for CPI or inflation for each country. Predicted values are obtained from the model for each country

England	Year	Observed	Predicted	Absolute value: (Obs-Pred)/Pred
	2010	100.00	100.19	0.0019
	2011	104.48	103.25	0.012
	2012	107.48	105.91	0.015
	2013	110.17	108.70	0.013
	2014	111.78	111.59	0.0017
United States	2010	100.00	100.41	0.0041
	2011	103.15	103.07	0.00078
	2012	105.29	105.96	0.0064
	2013	106.83	108.54	0.016
	2014	108.56	111.48	0.027
France	2009	2.17	2.33	0.074
	2010	1.52	1.36	0.105
	2011	2.12	1.90	0.104
	2012	1.95	1.44	0.262
	2013	0.86	0.96	0.116
Germany	2010	1.11	0.71	0.360
	2011	2.08	1.33	0.360
	2012	2.01	1.84	0.085
	2013	1.51	2.15	0.424
	2014	0.91	2.31	1.538

As for England, prediction of CPI for the United States from the model in equation (7) was very good. Here again year and GDP were the factors affecting the dynamics of inflation. Interest rate had no effect in this case. From equation (7), it is seen that CPI is related to its own lag, to

year and its first lag, and to GDP and its first lag. The positive effects of GDP and year on CPI from equation (5) are reflected by the trends in Figure 2.

The prediction for inflation in France from the model in equation (13) was not as good as that for the US and England. The prediction error can be as high as 26% of the observed value. The factors determining the inflation dynamics are the growth rate and the 10-year bond rate. Inflation in the model is related to its own lag, to BR and its lag, and to growth rate and its lag.

The negative effect of growth rate and the positive effect of bond rate from equation (11) are reflected in the trends in Figure 3.

The model for Germany from equation (16) showed that inflation was related to its own lag, 10-year bond rate and its lag as well as inter bank rate and its lag. The model, however, was a poor predictor of inflation. The positive effects of BR and IBR from equation (14) are supported by the trends in Figure 4.

It is interesting to note that inflation was harder to predict for the two European countries, France and Germany, which have a strict monetary and fiscal policies as dictated by the Maastricht treaty. Their economic policy falls more under austerity by comparison to the US and England. Further, both Germany and France had their central banks before joining the EU and one European central bank after joining. As a result, the monetary or fiscal policy was not the same over the years used in this study. Also, the re-unification of Germany in 1990 caused a severe stress on its economy. All these events may explain the presence of other factors, not in the data set, that may have contributed to the dynamics of inflation

CONCLUSION

Time series analysis was used to model and predict inflation over years for the United States, England, Germany, and France. The models developed were very good in predicting inflation 5 years ahead for England and the United States. Prediction for France was fair and that for Germany was poor. The reason for less than satisfactory predictions for Germany and France may have been due to the fact that Germany and France belong to the EU and have austere monetary and fiscal policies dictated by the Maastricht treaty and they do not have their own central bank. Also, the German unification in 1990 may explain the presence of outside factors, not in the data set, that had an influence on the dynamics of inflation in this country. For the US, England and France, GDP and its lags had an effect on inflation. For Germany, only 10-year bond rate and inter bank rate had an effect on inflation. Both these variables, however, were poor predictors of inflation.

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APPENDIX

Figure 1
England. CPI (black dot), GDP (10 billions of Pounds), + symbol

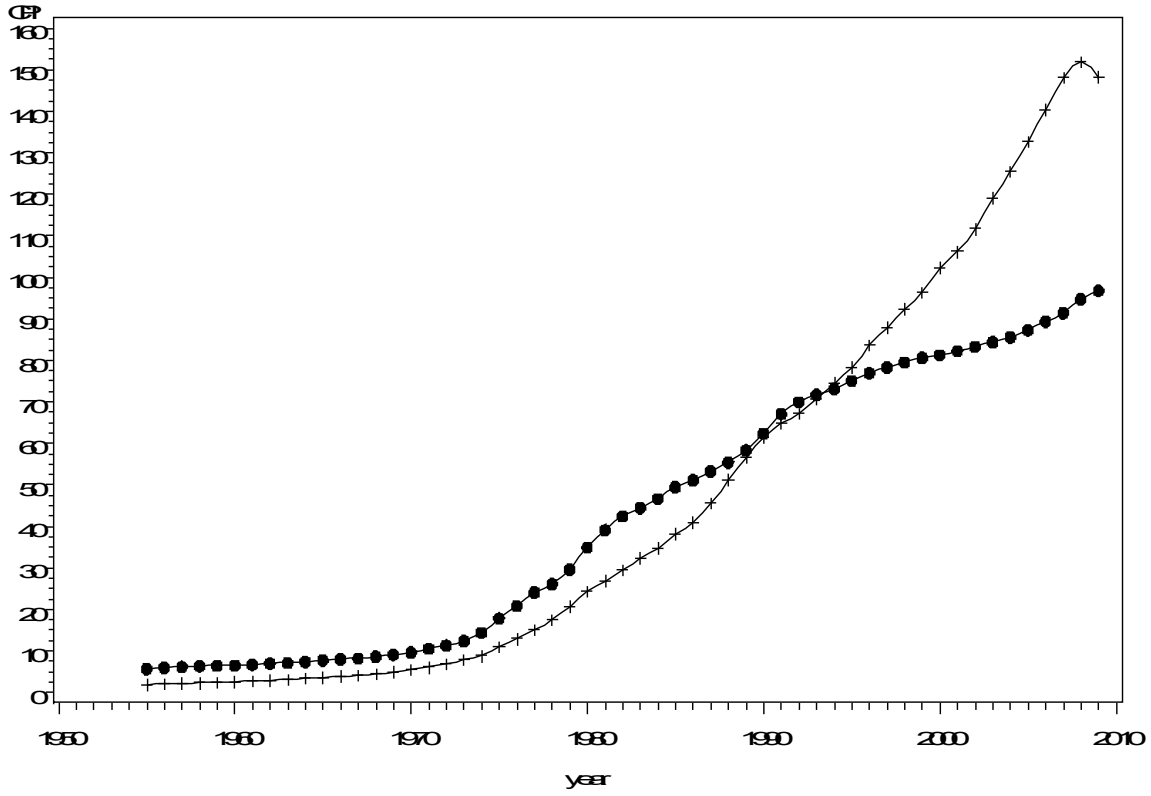

Figure 2
United States. CPI (black dot), GDP (100 billions of Dollars), + symbol

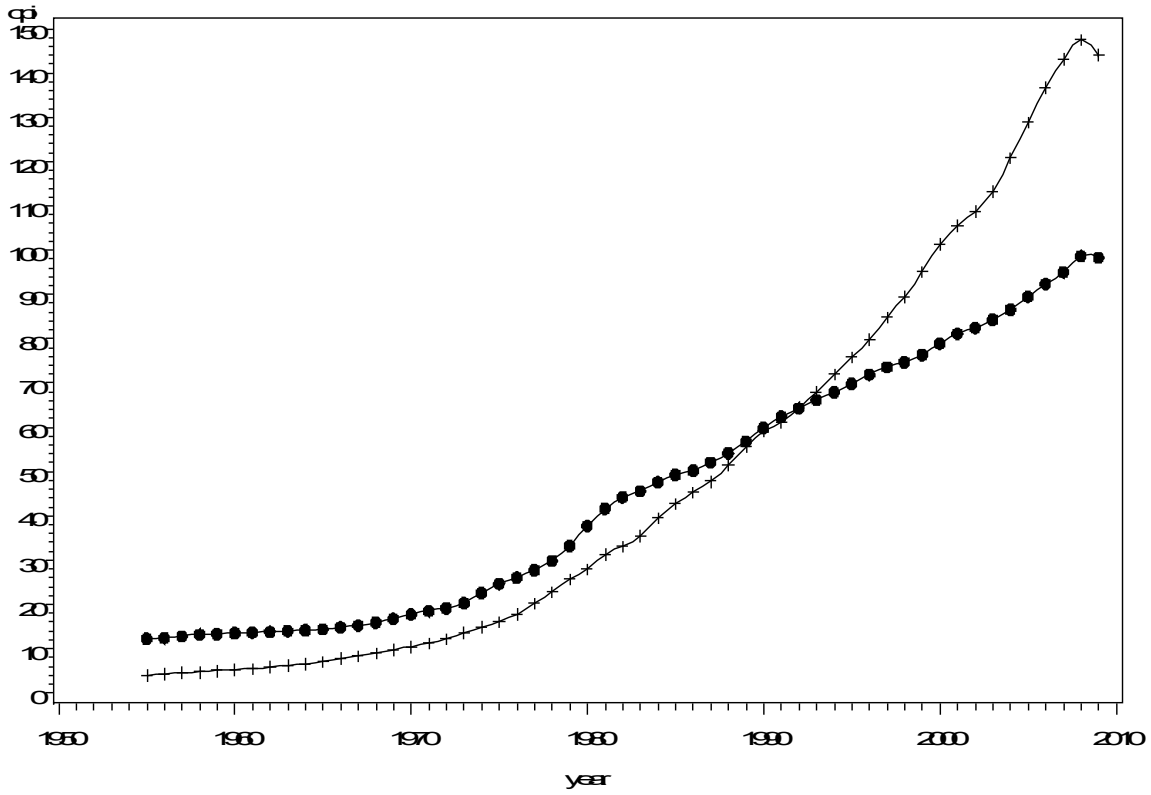

Figure 3
France. CPI (black dot), GDP growth rate (+ symbol), and bond rate (open circle)

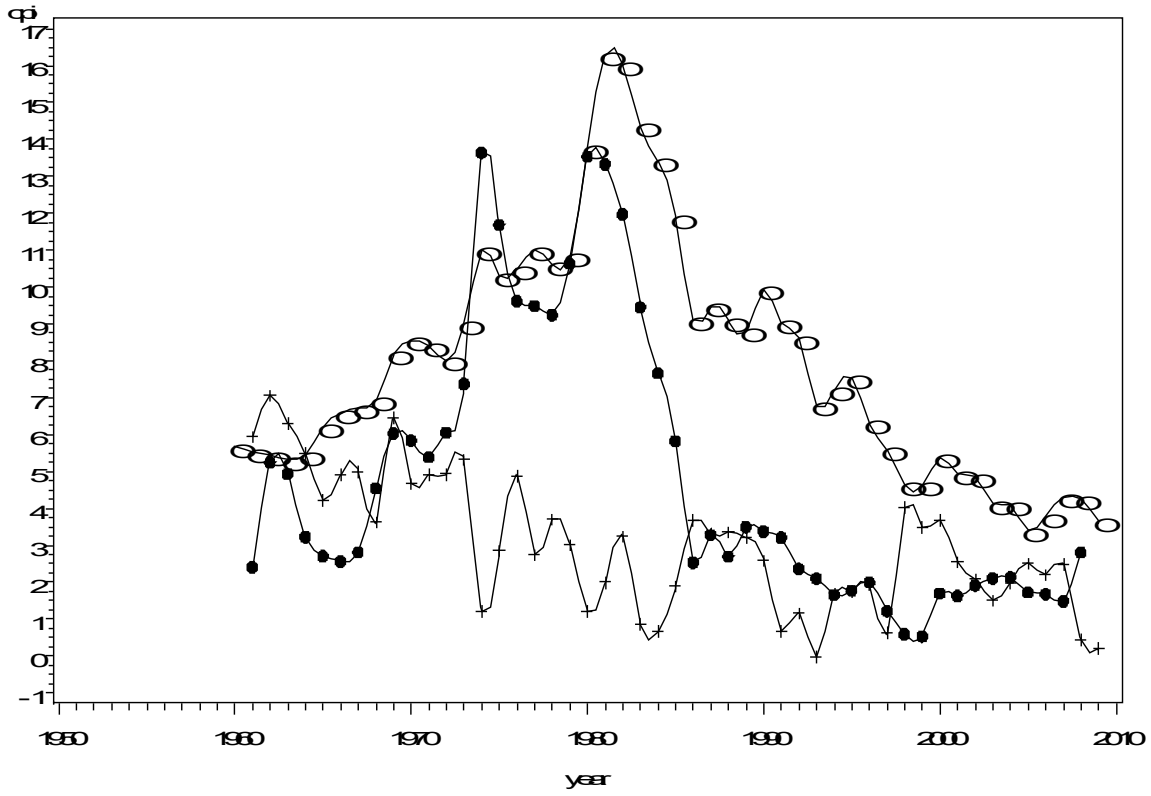

Figure 4
Germany. CPI (black dot), inter bank rate (+ symbol), and bond rate (open circle)