IOSR Journal of Economics and Finance (IOSR-JEF)
e-ISSN: 2321-5933, p-ISSN: 2321-5925.
PP 67-73
www.iosrjournals.org

Markov-Switching Approach to Analyze the Inflation Hedging Potential of Copper and Gold Futures

Ritika Jaiswal [1], Rashmi Uchil [2]
Ritika Jaiswal -School of Management National Institute of Technology Karnataka,Surathkal,Mangalore. India
Rashmi Uchil- School of Management National Institute of Technology Karnataka,Surathkal,Mangalore. India

Abstract: *This study incorporates the time-varying cointegration approach under the regime-switching framework to investigate inflation hedging potential of gold and copper futures for the sample period from April 2005 to June 2015. Based on the test results of Brock, Dechert and Scheinkman (BDS) and Schwarz Information Criterion (SIC), linear Vector Error-Correction Model (VECM) for gold futures and nonlinear Markov-Switching Vector Error-Correction Model (MS-VECM) for copper futures are chosen. The results confirm the full inflation hedging potential of gold futures and partial hedging potential of copper futures. In addition, regime dependent analysis of copper futures series signifies the equal adjustment pattern of inflation index in each regime.*

Keywords: *Copper, Gold, Hedge, Inflation, Markov-switching.*

I. Introduction

The price instability is the undesirable macroeconomic phenomena, entails the policy-makers to take distressing policy measures to stabilize the price and to maintain the sustainable economic growth. It is apparent from the hyperinflation of 2008 in Zimbabwe, two-decade prolonged deflation in Japan and deflation in the US after subprime crisis. Inflation in the economy influences the risk inherent in investments. Normally, commodities are considered as natural hedge against the inflation. One of the popular and secured way to invest in commodity is through commodity futures. It can be used as a hedge against inflation, as they are the reflection of commodity spot prices, which pave the direction to the expected future inflation. It is evident from the fact of sluggish growth and high inflation during 1970s due to the oil and energy crisis of 1973 and 1979 respectively, period of the commodity boom and a high inflation rate during 2007-08 subprime crisis and recent fall of inflation in India due to increase in supply of crude oil.

The gold and copper futures are chosen in this study as gold is considered as a safe haven in the time of geopolitical and monetary turmoil. Thus, investors view the gold as an inflation hedge. On the contrary, copper is an industrial metal and it is normally observed that the high inflation rate is driven by the rising cost of raw material and basic commodities.

The following literature provides the overview of inflation hedging potential of stock, bonds, real estate and commodities especially gold.

Mahdavi and Zhou [1] used conventional VECM to perform the study on the role of gold and commodity 1prices as a leading indicator of the inflation rate. Their results suggest that the price of the gold cannot be used as a guide to monetary policy making.

Anari and Kolari [2] assessed the impact of an inflationary shock on stock prices over the time by using VECM and impulse response function. They found that permanent effect of inflationary shock on expected stock return exceed unity, which confirm the long-run hedging potential of stocks against inflation.

Worthington and Pahlavani [3] analyzed the stable, long-run relationship between the gold price and inflation using the Zivot-Andrews test to capture the significant structural breaks and a modified cointegration method to incorporate these breaks. Their results suggest that gold can serve as an inflation hedge.

1 Ritika Jaiswal -*School of Management National Institute of Technology Karnataka,Surathkal,Mangalore. India*
ritika.hm13f07@nitk.edu.in
2 Rashmi Uchil- *School of Management National Institute of Technology Karnataka,Surathkal,Mangalore. India*
rashmi.suchil@gmail.com

Tiwari [4] performed the cointegration analysis with structural breaks and seasonal adjustment to examine the inflation hedging capability of gold in the Indian context. Their findings imply that investors can invest in gold to get the benefit of inflation hedging.

Beckmann and Czudaj [5] employed the MS-VECM approach to analyze the inflation hedging potential of gold. Their findings suggest that the gold is a partial hedge against inflation and this ability is stronger for USA and UK compared to Japan and Euro area.

The study of the inflation hedging potential of commodity futures is meagre. Following studies outline the inflation hedging potential of commodity futures.

Gorton and Rouwenhorst [6] investigated the simple properties of equally weighted index of commodity futures as an asset class using Sharpe ratio. They found, positive correlation of commodity futures with inflation, unexpected inflation and changes in expected inflation.

Erb and Harvey [7] investigated the inflation hedging potential of commodity futures using ordinary least squares. Their findings suggest that compared to individual commodity futures, the commodity futures index with the selected weight of futures acts as a better inflation hedge.

Spierdijk and Umar [8] assessed the inflation hedging properties of commodity futures across three dimensions: investment, horizon and time using the Vector Autoregressive Model. Their work shows the significant hedging ability of commodity futures on energy, industrial metals and live cattle.

Zhou [9] adopted the MS-VECM to investigate the inflation hedging potential of commodity futures index. They concluded the significant inflation hedging ability of energy, industrial and precious metals index.

The afore-discussed literature concentrated on investigating either the long and short-run dynamics of inflation hedging potential of commodity futures index or analyzed the inflation hedging potential of individual commodities without considering the time-varying dynamics. This study augmented the existing literature by incorporating both the linear VECM and nonlinear MS-VECM to measure the time-varying dynamics of the inflation hedging potential of two prominent commodity futures: gold and copper under regime-switching framework.

II. Theoretical Framework

This study incorporates the cointegration approach to evaluate the inflation hedging potential of commodity futures as discussed by Ely and Robinson [10], Mahdavi and Zhou [1], Anari and Kolari [2] and Levin et. al. [11]. From a theoretical point of view, an asset is qualified to be an inflation hedge, if there is an adjustment to any deviation from long-run equilibrium relationship between asset and inflation as required by the investors with long-run investment horizon. From the econometric point of view, integration of asset with inflation at order of 1 confirms at least the partial hedging potential of the asset against inflation. Conversely, short-run dynamics evaluate the inflation hedging potential of the asset at shorter horizon.

The exogenous factors such as economic shocks and major changes in economic policy, bring significant variation in time series of commodity futures and inflation. It causes the presence of different regimes in the economy, such as the bull phase of the subprime crisis and bear phase of the recent economic crisis in China or it can be the period of high and low volatility in returns of the asset. In these cases, regime-switching framework under the MS-VECM is more suitable than the other time-varying model, as it provides a solution for the situations when the regime shifts are stochastic rather than the deterministic.

III. Methodology

We adopt a linear VECM and nonlinear MS-VECM (Hamilton[12], Krolzig[13]) to evaluate the long-run equilibrium relationship of gold and copper futures with inflation. The MS-VECM allows for shift of some estimated parameters between the stochastic, unobservable regimes. These unobservable regimes are generated using a stationary, irreducible ergodic Markov chain. The estimation of an MS-VECM includes the additional process of adjustments of divergence in the long-run equilibrium relationship in each regime.

MS-VECM is the generalization of the basic VECM with finite order of p and r cointegrating vector. Thus, the VECM for a k-dimensional time series vector is $X_t = (X_{1t}, \ldots, X_{kt})$, t = 1, ….. , T and with pth order of autoregression and r cointegrating vector is shown in equation (1):

$$\Delta X_t = \upsilon + \sum_{i=1}^{p} P_i \, \Delta X_{t-1} + \sum_{j=1}^{r} C_j \, V_{t-1} + \varepsilon_t \quad (1)$$

$$\varepsilon_t \sim \text{IID}\,(0, \Sigma)$$

Where, υ is the intercept term, P_i shows the short-run dynamics of the model, C_j measures the speed of error-correction and V_t contains the residuals from the error-correction equation.

In this study, we have generalized the VECM (p, r) by using MS-VECM of M-regimes, p-th order autoregression with r cointegrating vector. This model allows the regime shift in the intercept term, the autoregressive parameter, error-correction speed coefficient and variance-covariance matrix of residuals as shown in equation (2):

$$\Delta X_t = \upsilon (S_t) + \sum_{i=1}^{p} P_i(S_t)\ \Delta X_{t-1} + \sum_{j=1}^{r} C_j\ (S_t)\, V_{t-1} + \varepsilon_t \qquad (2)$$

$$\varepsilon_t \,|\, S_t \sim NID\ (0, \textstyle\sum(S_t)), \qquad t = 1, \ldots\ldots, T$$

Where, ΔX_t shows time t column vector of observation, $S_t = 1,2, \ldots .M$ represents the regime in time t, $\upsilon(S_t)$ shows the vector of regime dependent intercept terms. $P_i(S_t)$ is a row vector of p-th order autoregressive parameters in regime S_t: denotes the state dependent short-run dynamics of the model. $C_j\,(S_t)$ measures the speed of error-correction in regime (S_t) and V_t is the column vector representing the residuals from the error-correction equation.

The regime generating process is guided by Markov stochastic process with a finite number of regimes, $S_t \in \{1,\ldots\ldots\ldots, M\}$ and constant transition probabilities. The transition probability of switching from regime i to regime j at time t+1 is independent of the history of the process, is depicted in equation (3):

$$P_{ij} = P_r(S_{t+1} = j \,|\, S_t = i),\ P_{ij} > 0, \quad \sum_{j=1}^{M} P_{ij} = 1 \quad \forall_{\ i}, j \in (1, \ldots \ldots, M) \qquad (3)$$

The estimated smoothed probability in the Markov-switching model, shows the conditional probability which uses all the information in the sample till future date T contrast to filtered probability based on the observed information upto date t. The classification rule signifies the assignment of each observation in the regime with the highest smoothed probability. In case of two regimes, classification rule specifies the classification of observations to the first regime if P_r ($S_t = 1 \,|\, Y_t$) > 0.5 and to the second if P_r ($S_t = 1 \,|\, Y_t$) < 0.5.

The MS-VECM is estimated with the Grocer toolbox for Scilab (Dubois and Michaux[14]). The parameters of the MS-VECM are estimated by maximum log likelihood function via Expected Maximum (EM) algorithm.

IV. Data and Summary Statistics

The Multi commodity exchange (MCX)[1] is chosen for this study as it covers 79.31% of commodity market in India. This study considers, 123 observed data on a monthly frequency for gold and copper futures price for the sample period from April 2005 to June 2015. The commodity specific wholesale price index (WPI)[2] is taken as the inflation index instead of the consumer price index (CPI) as the commodities under study are not the part of CPI in India.

The futures price series is constructed using the nearby futures contract, as these are the most actively traded contracts. Based on the rolling mechanism employed by MCX, series incorporates the next nearby future price series in a predetermined manner of rolling 20% of each day during the rolling period.

The Summary statistics on returns of gold and copper futures price series confirm that gold futures has the highest average return of 1.18% and lowest standard deviation of 5.15% compared to copper[3]. Thus, higher variance and negative skewness of copper futures shows that the copper futures have more downside risk than gold.

V. Results and Discussions

The results are discussed as follows:

5.1 Unit Root Test

The Augmented Dickey Fuller test is applied to check the stationarity of time series data. This study also incorporates the Zivot-Andrews unit root test to check the null hypothesis of a unit root with a single structural break both in intercept and trend. In both the tests, the null hypothesis of unit root is accepted at a 1% level of significance for the level data of gold, copper and commodity specific WPI and it is rejected when the first difference of the time series is considered. The autoregressive order of one, is selected for both the models of gold-inflation and copper-inflation based on Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQ).

[1] Gold and copper futures price are fetched from the website of MCX (www.mcxindia.com).
[2] WPI values are fetched from the website of Reserve Bank of India (www.rbi.org.in/).
[3]Continuously compounded logarithmic returns are calculated by taking the first difference of natural logarithm of futures price of gold and copper.

5.2 Cointegration Analysis
In the models of gold-inflation and copper-inflation, the Johansen cointegration test concludes the existence of one cointegrating vector at 1% and 5% level of significance respectively, as depicted in Table 1. The expected sign of the coefficient of normalized cointegrating vectors for both the models exhibit the positive relationship in long-run among the commodity and inflation as shown in Table 2. However, gold coefficient equals to unity in magnitude, which confirms the proportional relationship of gold with WPI. Conversely, copper coefficient is less than unity in magnitude, which shows the partial hedging capability of copper futures.

5.3 Test of Nonlinearity
We perform the BDS test as a test of nonlinearity on the residual of VECM with embedding dimension equal to 2 and $\in$ to 2 standard deviation of the data set. The results confirm the presence of linearity and nonlinearity in the residuals of an estimated VECM for the model of gold-inflation and copper-inflation respectively.

5.4 Estimation of VECM and MS-VECM
At the last stage, estimation of VECM and MS-VECM is performed and the best model is chosen among the linear and different variant of nonlinear model based on the AIC, SIC and HQ information criterion.

5.4.1 Gold and Inflation
The test results of AIC and HQ information criterion favor MSIAH(3)VECM(1,1)[4] and MSIAH(2)VECM(1,1) respectively, as the best model specification. From the econometric point of view, the linear VECM (1,1) is taken for gold and inflation, based on the result of SIC information criteria. SIC supports more parsimonious model and protects from over-parameterization by imposing stiffer penalty term associated with a number of parameters than AIC and HQ. Hence, we should follow the SIC test result in the situations where we have the choice between a parsimonious linear and less parsimonious nonlinear one.

The results give the evidence of equilibrium adjustment in the inflation index as the error-correction coefficient, which is the product of cointegrating vector and speed coefficient, has the negative sign and statistically significant as shown in Table 3.This convergence confirms that the movement of gold futures price is a reflection of inflationary expectation and can be used as a hedge against inflation. The short-run dynamics depict the significant positive correlation between changes in WPI and lagged changes in gold. Thus, long and short-run dynamics indicate the full inflation hedging potential of gold futures.

5.4.2 Copper and Inflation
The value of AIC favors MSIAH(3)VECM(1,1) while SIC and HQ indicate MSIAH(2)VECM(1,1) as the best model specification for copper and inflation. Based on the result of SIC, nonlinear MSIAH(2)VECM(1,1) is chosen, with two regimes, heteroskedastic error and an autoregressive of order 1.

The classification of regimes based on smoothed probability depicts that regime 1 shows the periods of stable and low volatility in returns of copper futures. Conversely, regime 2 persists during the period of high volatility such as from 2006m11 to 2007m7, 2007m11 to 2008m4, 2008m9 to 2010m2 and on 2015m1 as shown in Fig.1 and Fig. 2 of smoothed and filtered probability respectively. These periods include the period of a major rise in commodity prices during subprime crisis and major falls of the current economic crisis in China. The ergodic probability and transition matrix suggest the predominance of regime 1 than regime 2. Regime 1 persists for 65.12% of the month and last for 6.67 months on an average. While regime 2 remains for 34.87% of the month lasting for 3.57 months on an average.

The significant and negative sign of the error-correction terms in the WPI index in both the regimes 1 and 2, suggest the convergence of inflation towards the copper futures price as depicted in Table 4. These convergences confirm that the copper futures price movements indicate the signal of the formation of future inflation. Thus, it can be effectively used as a hedge against inflation. The Short-run dynamics are shown by significant positive correlation of changes in WPI and lagged changes in copper prices in regime 2. Hence, the results of cointegrating vector and long and short-run dynamics confirm the partial inflation hedging potential of copper futures.

Notes: To conserve space we do not report the corresponding summary statistics, results of the Unit root test, results of BDS test and results of AIC SIC and HQ of VECM and different specification of MS-VECM for the model of gold-inflation and copper-inflation, however these could be provided upon request.
[4]These models are referred to as Markov-Switching-Intercept-Autoregressive-Heteroskedastic-VECM or MSIAH-VECM, follow the notation as given by Krolzig (1997).

VI. Conclusions

From the empirical test, it is learnt that gold futures exhibit the full inflation hedging potential compared to partial inflation hedging potential of copper futures. In addition, adjustment characteristics of general price level is equal in both the regimes. Finally, one regime of copper futures price movement accounts for stable and low volatility period and second regime represents the high volatility period characterized by several bouts of rise and fall. Based on these findings, it can be suggested that gold and copper futures can be used to forecast the inflation rate. In addition, effectiveness of inflation hedging potential of gold and copper futures does not depend on the time horizon of investment. However, application of data with higher frequency can give more clear view of inflation hedging capability of gold and copper futures.

Our findings have significant policy implication with respect to the formation of a policy framework to enhance the efficiency of a commodity futures market in India. This study can be extended further by the inclusion of other commodity futures in our framework to have a more elaborate view of a commodity futures market in India**.**

Acknowledgement

We would like to thank Éric Dubois (Cour des comptes, PARIS, France) for his significant help in the achievement of the econometric aspects of the paper and useful comments on the text.

References

[1]. S. Mahdavi and S. Zhou, Gold and commodity prices as leading indicators of inflation: tests of long-run relationship and predictive performance, *Journal of Economics and Business*, *49(5)*, 1997, 475-489.
A. Anari and J. Kolari, Stock prices and inflation, *Journal of Financial Research***,** *24(4)*, 2001, 587-602.
[2]. C. Worthington and M. Pahlavani, Gold investment as an Inflationary Hedge: Cointegration Evidence with Allowance for Endogenous Structural Breaks, *Applied Financial Economics Letters***,** *3(4)*, 2007, 259-262.
[3]. K. Tiwari, Gold Investment as an Inflationary Hedge: Cointegration Evidence from India with Allowance for Structural Breaks and Seasonal Adjustment, *Journal of Asian Business Management*, *3*, 2011, 165-176.
[4]. J. Beckmann and R. Czudaj, Gold as an inflation hedge in a time-varying coefficient framework, *The North American Journal of Economics and Finance*, *24*, 2013, 208-222.
[5]. G. Gorton and K. G. Rouwenhorst, Facts and fantasies about commodity futures, *Financial Analysts Journal*, *62(2)*, 2006, 47-68.
[6]. B. Erb and C. R. Harvey, The strategic and tactical value of commodity futures, *Financial Analysts Journal***,** *62(2)*, 2006, 69-97.
[7]. L. Spierdijk and Z. Umar, Are commodity futures a good hedge against inflation?, *Journal of Investment Strategies*, *3(2)*, 2014, 35-57.
[8]. Z. Zhou, Commodity Futures as a Hedge against Inflation: An Application of Markov-Switching Cointegration and Error-Correction Modelling, *Unpublished paper, Department of Finance, Bocconi University, Milan (Italy)*, 2014.
[9]. P. Ely and K. J. Robinson, Are stocks a hedge against inflation? International evidence using a long-run approach, *Journal of International Money and Finance***,** *16(1)*, 1997, 141-167.
[10]. J. Levin, A. Montagnoli and R. E. Wright, Short-run and Long-run Determinants of the Price of Gold, *World Gold Council*, 2006.
[11]. J. D. Hamilton, A new approach to the economic analysis of non-stationary time series and the business cycle, *Econometrica: Journal of the Econometric Society***,** 1989, 357-384.
[12]. H. M. Krolzig, Markov-Switching Vector Auto-regression: Modelling, Statistical Inference and Application to Business Cycle Analysis, *Lectures Notes in Economics and Mathematical Systems, Springer*, 1997.
[13]. É. Dubois and E. Michaux, Grocer 1.6: an econometric toolbox for Scilab, *http://dubois.ensae.net /grocer.html*, 2013.

Table 1: Johansen Cointegration Test

Models	**r (No. of cointegration)**	**Trace Statistics**	**Probability**	**Max-Eigen Statistics**	**Probability**
Gold-WPI	0	26.25	0.00	20.49	0.00
	1	5.76	0.028	5.76	0.028
Copper-WPI	0	25.84	0.00	20.47	0.02
	1	5.37	0.32	5.37	0.32

Table 2: Cointegrating Vectors from Johansen Estimation

Variables	Vector # 1	Vector # 2
Log(WPI)	1	-0.638
Log(Gold)	-1.006	1
Log(WPI)	1	-1.358
Log(Copper)	-0.034	1

Table 3: Results of the VECM Estimation for the Model of Gold and WPI

	Δ Gold	Δ WPI
Intercept	-0.057[-0.104]	-1.09[-3.72]*
Δ Gold(-1)	-0.143[-1.104]	0.261[3.79]*
Δ WPI(-1)	-0.122[-0.852]	-0.161[-2.09]**
Error Correction	0.017[-0.132]	-0.260[-3.75]*
Standard Errors	0.051	0.028
Correlation Δ Gold	1.00	0.39
Δ WPI	0.39	1.00

Values in the square bracket exhibit the ‘t’ statistics and * shows the significance level at 1% and ** at 5%.

Table 4: Results of the MS-VECM Estimation for the Model of Copper and WPI

	Regime 1		Regime 2	
	Δ Copper	Δ WPI	Δ Copper	Δ WPI
Intercept	0.741[3.96]*	0.153[7.10]*	2.32[2.43]**	1.42[13.93]*
Δ Copper(-1)	-0.149[-1.35]	0.021[1.67]	0.408[2.43]**	0.072[2.73]*
Δ WPI(-1)	-0.896[-2.26]**	0.07[1.29]	-0.57[-0.785]	-0.119[-1.07]
Error Correction	0.005[-3.89]*	-0.03[-7.05]*	0.015[-2.42]**	-0.283[-13.87]*
Variance-Covariance Matrix				
Δ Copper	0.0021[3.77]*	0.00003[1.15]	0.0099[4.26]*	-0.00008[-0.34]
Δ WPI	0.00003[1.15]	0.00003[4.98]*	-0.00008[-0.34]	0.0002[4.15]*

	Transition Matrix		Persistence of Regimes		
	Regime 1	Regime 2	Observations	Ergodic Probability	Duration
Regime 1	0.85	0.28	81	0.65	6.67
Regime 2	0.15	0.72	40	0.35	3.57

Values in the square bracket exhibit the ‘t’ statistics and * shows the significance level at 1% and ** at 5%.

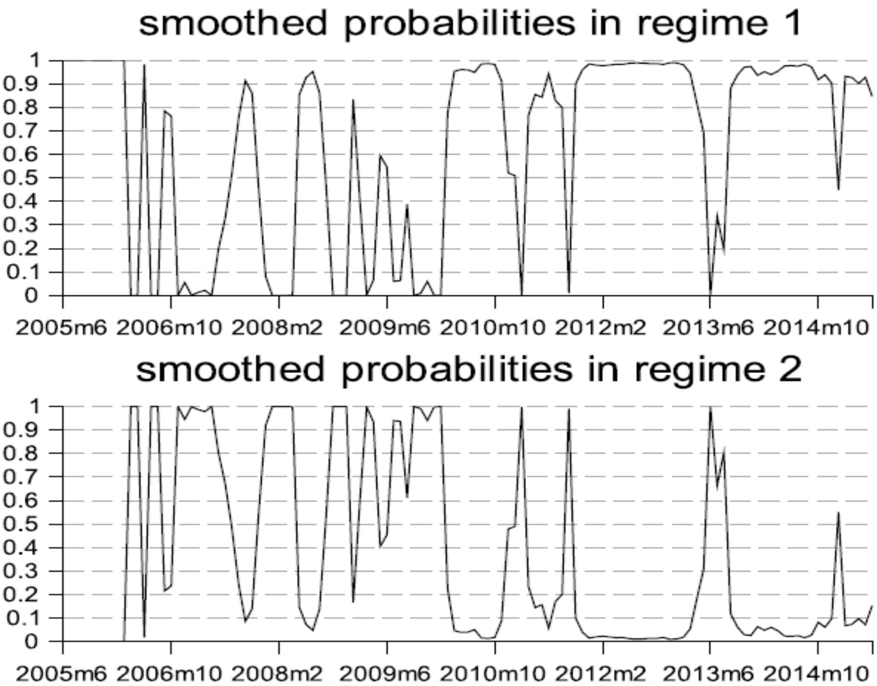

Figure 1: Smoothed Probability of Regimes for the Model of Copper and Inflation

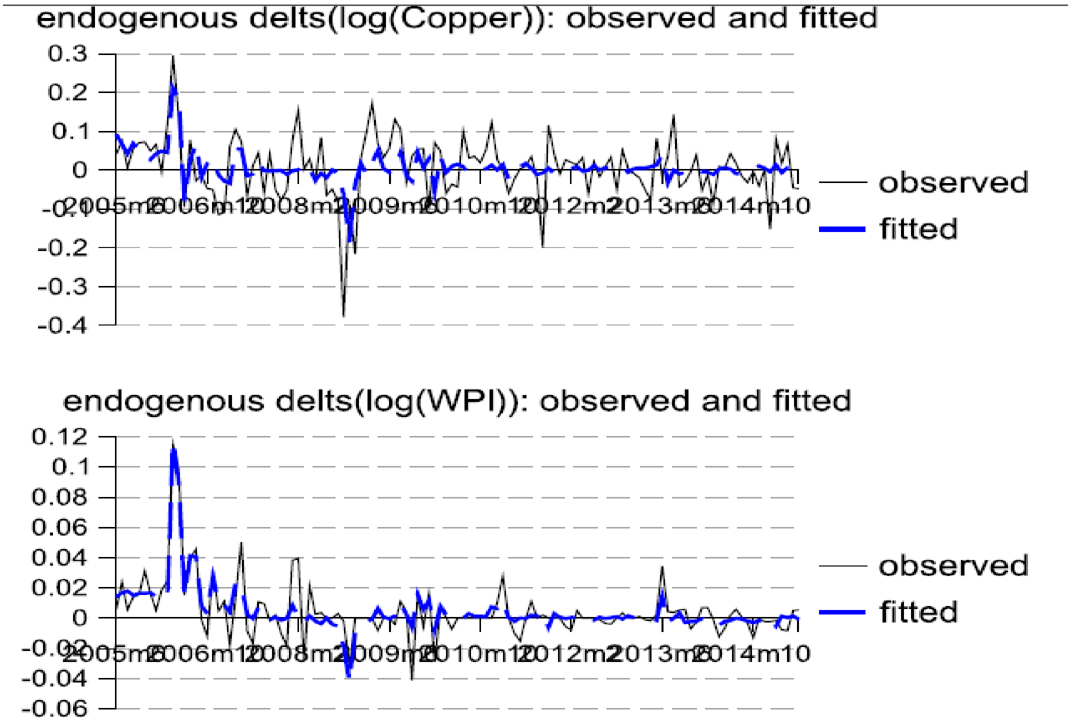

Figure 2: Observed and Filtered Probability for the Model of Copper and WPI