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by

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In the aftermath of the Great Recession, commodity prices have stabilized; however, the reasons are debatable. This paper concentrates on finding the relationship between Federal Reserve monetary policy and other macroeconomic indicators to both a broad commodity price index and an agricultural commodity price index by employing a vector error correction model. Excessive liquidity and the recent long period of ultra-low interest rates appear to have played a statistically significant role in affecting prices in the commodities markets. The responses of commodity prices to monetary policy that we estimate generally conform to earlier findings, but the sensitivity of the responses appears different in the face of the unprecedented scope of recent Fed activism.

Keywords: Commodity prices, Federal Reserve, Large Scale Asset Purchases, Zero Interest Rate Policy, Excessive Liquidity

Introduction

High prices of commodities in general, and agricultural commodities in particular, have been a serious concern for many people worldwide over the past decade. However, while many economists have been investigating the role of financial speculators, global demand growth, and supply shocks in these commodity price increases, monetary policies have received less attention.

Yet, over the past six years the U.S. government and the Federal Reserve have been engaged in a series of extraordinary policies designed to first stabilize and then stimulate the economy as a response to the severe recession of 2007-09. Specifically, the large scale asset purchases (LSAP) implemented by the Federal Reserve have more than quadrupled its balance sheet to $4.5 trillion driving down interest rates and the value of the dollar and boosting different asset class prices including commodities. Under this set of macroeconomic policies, an index of commodity prices tracked by IMF has increased by 90% from the bottom in 2008. These policies have involved unprecedented levels of federal spending, money supply growth, interest rates, growth in the Fed's balance sheet, and direct intervention by the Federal Reserve into debt markets. These actions had the primary goal of increasing employment and economic growth but instead of achieving these goals, the actions are suspected of having a number of unintended consequences in terms of market distortions.

This paper focuses on the impacts of these extraordinary policies on both an all commodity price index and an agricultural commodity price index for the period of 1992 to 2013. To check robustness and to compare periods of different monetary policy, we estimate models with and without the 2008-2013 period. Previous studies (Scrimgeour, 2010; Frankel, 2006; Schuh, 1974) have found that lower interest rates and looser monetary policy lead to higher commodity prices. This suggests that the recent policies should have been positive for commodity producers and negative for commodities consumers. However, the policies of the past five years go beyond the limits of past data, so relying on past empirical results to guide us is rather dangerous. Thus, a new study that incorporates the most recent public policies and data is important for confirming the impacts of these policies.

Some Federal Reserve officials and economists claim that commodity prices have been rising in the last six years due to increased worldwide demand and the recovering world economy (Bernanke, 2011; Glick and Leduc, 2012; Yellen, 2011); however, the effects of additional liquidity in the markets and a commitment to long-term low interest rates have not been fully studied. Moreover, since previous studies found a link between interest rates and commodity prices, long-term zero interest rate policy should have had an effect on commodity prices.

In our empirical results, we find a significant long-term relationship between the Federal Reserve balance sheet and commodity prices that implies a 2.2% increase in the all commodities price index and a 2.0% increase in the agricultural commodity price index in response to a one percent increase in the Fed's balance sheet. Interest rate changes appear to move the general commodity price index and the agricultural commodity price index in opposite directions, perhaps because of the different nature of agricultural and industrial commodities.

The results of this paper will be of particular interest to policymakers of major central banks, of which the vast majority have been implementing loose monetary policies in the post Great Recession period, as well as to producers and consumers of commodities whose prices are being affected by central banks. The remainder of the paper is organized as follows: section 1 provides some theoretical grounding from the literature while section 2 describes the data used and rationale behind using a vector error correction model. The next section includes empirical results, followed by impulse response functions. Finally, the paper ends with some concluding remarks.

Literature Review

Schuh (1974) was one of the first to explore the links between commodity prices and monetary policy. He found that the value of the dollar has an inverse effect on US agricultural exports; an overvalued dollar will cause a decline in exports due to the unfavorable exchange rates for foreigners. An undervalued dollar may cause higher demand and prices for agricultural commodities.

Frankel (1986) generalized Dornbusch's model in a closed economy by separating commodities into flexible and fixed price categories. He found that the fixed price category, which contained industrial commodities, responds more slowly to monetary shocks than flexible price commodities such as agricultural commodities. A decline in the money supply in the short-run leads to higher interest rates which depress commodity prices. They also tend to overshoot the new long run equilibrium when subjected to unanticipated monetary shocks. Later, Frankel (2006) continued research of monetary policies on commodity price indices and found that for a 1 percent increase in real interest rate, the CRB price index goes down by 6 percent with a speed of adjustment of 0.16 per year.

Chambers and Just (1982) used a three-block recursive model of wheat, corn and soybean markets to examine the relationship with exchange rates, domestic credit on agricultural trade, inventories and domestic disappearance. They found that tight monetary policy lowers prices of agricultural commodities spurring domestic demand whereas unfavorable exchange rates seriously undermine U.S. exports.

Orden and Fackler (1989) used vector autoregressive (VAR) models in evaluating different monetary effects on agricultural prices. Dynamic impacts of behavioral shocks were used to assess the impact of money expansion, lower interest rates, and the depreciation of the dollar on commodities prices. They suggest that positive money supply shocks increase agricultural prices in a period of over a year.

Lapp (1990) created a model of imperfect information and rational expectations in agricultural commodities price determination. Monetary policy in 1951-85 is found not to have played a particular role in changes in relative agricultural prices. In particular, Lapp found only one period with a significant positive impact of unexpected money growth on prices.

Dorfman and Lastrapes (1996) used a Bayesian approach to model uncertainty in the proper specification of a VAR model combined with long run money neutrality restrictions to estimate the effects of money supply shocks on prices of livestock and crop markets. The results show that agricultural producers benefit from expansionary monetary policy. In particular, livestock prices rise significantly in response to positive monetary shocks. Crop prices initially react on a smaller scale, but eventually adjust to a new equilibrium.

Saghaian et al. (2002) used Dornbusch's overshooting model augmented with agricultural prices to study overshooting of prices in an open economy within a vector error correction model. They found that a 1 percent increase in money supply leads to a 0.43 percent increase in agricultural prices and a 0.73 percent increase in industrial prices. The agricultural commodities adjust faster than industrial prices when affected by monetary shocks, as in Frankel (1986).

More contemporary studies suggest that the Federal Reserve plays a significant role in commodities markets. Anzuini, et al. (2013) employed a standard VAR system identifying unexpected monetary shocks and found increases of 4 to 7 percent in commodity prices per 100 basis points of loosening monetary policy.

Orden (2002) researched the impact of exchange rates on agricultural trade. General convention states that the exchange rates and interest rates affect domestic prices in the

US. Monetary policy has a non-neutral effect on prices and can explain some of the variability in the agricultural prices.

Scrimgeour (2010) used the model of Rigobon and Sack (2004) to identify the effect of unexpected interest rate moves on commodities prices. A one percent unexpected interest rate increase is associated with a five percent expected decrease in commodity prices, however metal prices tend to respond more than agricultural commodities.

Irwin (2011) studied the commodity market, specifically how index funds were contributing to record high commodity prices. Speculative positions in the commodity index funds were not found to be a significant driver of the prices in the 2007-08 spike. “Financialization” of commodity markets, foreign demand and US monetary policy generally were named as reasons of the rise in the commodity index funds.

Gospodinov and Jamali (2013) studied monetary policy shocks on commodity prices, convenience yields and the positions of traders. The analysis shows that monetary policy strongly affects the positions of futures traders. An expansionary monetary policy shock which associates with lower interest rates uniformly increases speculating pressure for the metals and energy commodities and the adjustment of net long positions appears to be a channel through which monetary policy changes propagate to commodity prices.

An overwhelming majority of the literature suggests that Federal Reserve policies have significant effects on commodity prices; however, some speeches and studies including those by the Fed economists Bernanke (2010), Yellen (2011), and Glick and Leduc (2012) show that the Long-Term Asset Purchase program has an insignificant or even negative impact on commodity prices. Glick and Leduc (2012) concluded that LSAP announcements signaled lower future growth that led to lower long-term yields and a depreciating dollar, causing a decline in commodity prices. This event study examined commodities price reactions to unconventional monetary policy policies on announcement days; however, it did not track post-event price reactions, so its conclusions only apply to extremely short-run impacts.

Model details

A vector error correction model (VECM) is a good choice for our application because such a model not only allows for overshooting by commodity prices but it estimates the parameters of long-run relationships among the variables as well as the short-run adjustment coefficients (Saghaian, et al., 2002). As with most macroeconomic data, we are dealing with nonstationary time series data for the most part and the VECM is designed for such data. Johansen tests suggest that there are long-term cointegrating relationships between our variables. Cointegration implies a long run equilibrium at which the cointegrated variables have a stable relationship. (Engle and Granger, 1987). The implicit assumption of a dynamic relationship between money supply, interest rates and commodity prices is that all relevant variables are captured in our VECM. Short-run deviations from equilibrium relationships are captured with the impulse response functions derived from the estimated coefficients of the VECM. VECMs estimate both the long-run equilibrium relationship between a set of economically-related variables and the speed at which variables return to equilibrium ratios following a shock that disturbs the variables from a previous equilibrium.

So, both theory and empirical findings suggest that there is cointegration among the variables we wish to study here and that the equilibrium relationships can be estimated by a multivariate VECM which Engle and Granger presented as

$$\Delta p_t = \alpha\beta' p_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta p_{t-i} + \delta t + v + e_t \quad (1)$$

where p_t is a (kx1) vector holding the series to be studied, α and β are (k x r) matrices of parameters Δ is the difference operator, Γ_i is a matrix of to be estimated, the error term e_t is assumed to be i.i.d. with mean 0, t is a linear time trend. When the variables in p_t are cointegrated, α has dimensions of (K x r) with r < K and v and δt can be rewritten as

$$v = \alpha\mu + \gamma \quad (2)$$

$$\delta t = \alpha\rho t + \tau t \quad (3)$$

where μ and ρ are r x1 parameter vectors and γ and τ are Kx1 parameter vectors. Furthermore, $\gamma'\alpha\mu = 0$ and $\tau'\alpha\rho = 0$ and since there are no restrictions posed on v and δt, we can capture linear and non-linear trends which implies trend stationarity of cointegrating relationships.

In order to estimate the free parameters in β of the r cointegration equations, we need a minimum of r^2 identifying restrictions on the model. We employ Johansen's (1995) scheme of identification which is simply

$$\beta' = (I_r, \tilde{\beta}) \quad (4)$$

where $\tilde{\beta}$ is a matrix of cointegrated vectors and I_r is identity matrix.
When there are no restrictions on α, the log likelihood function presented in Johansen's work can be written (Johansen (1995):

$$L = -\frac{1}{2}\left[TKln(2\pi) + Tln(|\Omega|) + \sum_{t=1}^{T}(R_{0t} - \alpha\,\tilde{\beta}' R_{1t} - \Psi Z_{2t})'\Omega^{-1}(R_{0t} - \alpha\tilde{\beta}' R_{1t})\right] \quad (5)$$

where

$R_{0t} = p_t - M_{02}M_{22}^{-1}p_{t-2}$

$R_{1t} = p_{t-1} - M_{12}M_{22}^{-1}p_{t-2}$

$M_{ij} = T^{-1}\sum_{t=1}^{T} p_{it}\, p'_{jt}, \quad i,j \in (0,1,2)$

$\Psi = (\Gamma_1, \dots, \Gamma_{p-1}, v, w_1, \dots, w_m)$ is Kx(K(p-1)+1+m) matrix

$\tilde{\beta} = \beta$ is K x r matrix of cointegrated vectors

Finally, the normalized parameters of the cointegrating vector can be derived from Johansen's formula:

$$\tilde{\beta}' = (I_r, \breve{\beta}') \quad (6)$$

where I_r is the r × r identity matrix and is $\breve{\beta}$ a (k − r) × r matrix of identified parameters. Another important vector is the set of adjustment parameters which defines the period of prices normalizing to its long-term value.

$$\hat{\alpha} = S_{01}\hat{\beta}\left(\hat{\beta}' S_{11}\hat{\beta}\right)^{-1} \tag{7}$$

where $S_{ij} = (1/T)\ \sum_{t=1}^{T} R_{it}\, R'_{jt} \quad i, j \in \{0,1\}$.

Data description

The dataset consists of monthly observation from 1992(01) to 2013(12) for a total sample of 264. In order to organize data in the same frequency, a cubic spline interpolation method was applied to quarterly data. The International Monetary Fund all commodity price broad index which includes industrial metals, foodstuffs, beverages, agricultural raw materials and fuels is used to track prices. It reports benchmark prices that are representative of the global market, determined by the largest exporter of a given commodity.

Also, the food and beverage price index of IMF is used as an agricultural index in a separate model to determine the effect of monetary policy on agricultural prices. This index includes cereal, vegetable oils, meat, seafood, sugar, bananas, oranges, coffee, tea, and cocoa. The US dollar index (DXY) from the Federal Reserve Economic Data of the St. Louis Federal Reserve Bank tracks relative strength of the dollar versus 16 major currencies and is included in the model in order to capture the impact of exchange rates. To account for global demand of commodities, the OECD industrial production index is used as an indicator of the health of the world economy. Ten year Treasury note yield to maturity is the interest rate used to reflect both inflation expectations and financial liquidity. It generally has greater movements in rate than the federal funds rate that researchers were conventionally using before the financial crisis of 2007-2009. Moreover, the federal funds rate has been kept at zero to twenty five basis points to stimulate interbank loans since the liquidity crisis. The IMF GDP deflator of 110 advanced economies is included to account for inflation. In the model for agricultural commodities prices, we include the United Nations food production index which serves as an indicator of agricultural supply.

Descriptive statistics of all variables are shown in table 1.

Empirical Results

To estimate the quantitative effect of the recent extraordinary monetary policy, a vector error correction model with five additional variables (US dollar index, Fed balance sheet, 10 year Treasury note yield, either OECD industrial production or a food production index, and the IMF GDP deflator) is used to explain variations in all commodity and agricultural commodity price indices. To check robustness and to compare how these variables affected prices before the crisis, we run similar models using data from January 1992 to December 2007 before the recession started.

Lag order selection criteria based on AIC, HQIC, and SBIC all suggest that we include four lags but six lags are included in the final models because overspecification is better than underspecification when parameter hypothesis tests are important and because the models with six lags do better at passing the model diagnostic tests. In particular, the coefficients and residuals of the estimated vector error correction model passed a Lagrange multiplier autocorrelation test as well as Jarque-Bera, kurtosis, roots of companion matrix, and skewness standard error normality tests, therefore we believe the model is well-specified. The Johansen test for cointegration suggests that there are two cointegrating equations for this model.

Based on a wide literature review, theory predicts that expansionary monetary shocks should have a positive effect on commodities prices through the liquidity effect (Dorfman and Lastrapes, 1996; Schuh, 1974; Frankel, 1986; Scrimgeour, 2010). The results of our VECM show significant positive relationships between the commodity price index, Federal Reserve expansionary policy, GDP deflator and OECD industrial production. The Federal Reserve expanded its balance sheet over the entire 1992-2014 period; however it grew slowly until 2008 and then more than quadrupled in the short period of 2008-2014. According to our empirical results, a one percent increase in the Fed balance sheet leads to a 2.2% increase in the general commodity index and a 2.0% increase in the agricultural commodity price index (see Table 3). Most researchers in the past have used M1 money supply as their monetary measure and have found that its expansion leads to increases in commodity prices, but generally earlier studies have found smaller impacts than we find here. Saghaian, Reed and Marchant (2002), for example, found that for an 1% increase in money supply, agricultural prices increase by 0.43% and industrial prices by 0.773%.

To compare the current unconventional monetary policy with the pre-crisis period, we run a similar VEC model from 1992 to 2007. The main focus of this model is to quantify the effect of increasing the Federal Reserve balance sheet at a more sedate rate which averaged 0.5% a month over this period. In this timeframe, a one percent increase leads to an expected 0.28% increase in the all commodity price index and a 0.41% increase in the agricultural commodity price index (Table 3). This suggests that earlier results in the literature from before the Fed began its recent extraordinary policies may no longer be relevant.

As the VECM established a long run relationship between the variables in the model, the estimated parameters can be used to determine the adjustment period to a new equilibrium following a displacement. The coefficient of the error correction term represents the speed of adjustment to the new long-term equilibrium. The adjustment coefficients suggest that in order to fully adjust to the equilibrium it takes about $1/|-0.1225| \approx 8$ months for the all commodity price index and $1/|-0.0785| \approx 13$ months for the agricultural price index to adjust to a new long run equilibrium. Contrary to Frankel (1986) and Saghaian et al. (2002) the agricultural commodities take longer to adjust to the equilibrium in the new environment. Frankel (1986) estimated an adjustment period for a 1 percent interest rate hike of approximately six months. The long-run adjustment and short-run coefficients on various lags are shown in Table 4.

The impulse response functions in Figure 4 show the adjustment of the all commodity price index to a new long-term equilibrium following shocks to the 10 Year Treasury yield and the Federal Reserve balance sheet. Both responses are positive, but far from monotonic, with overshooting and even opposite responses visible in early periods. The initial negative response to an expanded Fed balance sheet can be explained by negative sentiment on the economy formed when the Fed announces a quantitative easing program (Glick and Leduc, 2012). Negative response to an increase in the interest rates indicates higher cost of storage of agricultural commodities which leads to a bigger supply in the markets, driving the prices lower. However the positive relationship between the Federal Reserve balance sheet and agricultural commodities is similar to the all commodity index.

Conclusion

This paper estimates the effects on commodity prices of the recent extraordinary monetary policy implemented by the Federal Reserve. We used a VECM with five macroeconomic variables and discovered a long-term relationship between the Federal Reserve balance sheet and both a broad and an agricultural commodity price index. According to our findings, each percent increase in the asset base of the Federal Reserve leads to a 2.2 percent increase of the all commodity price index and a 2 percent increase in the agricultural commodity price index with adjustment periods of 8 and 13 months, respectively.

Expansionary monetary policies create additional liquidity and lower interest rates through various channels (Dorfman and Lastrapes 1996, Frankel 2008). There are many factors affecting commodity prices such as supply, demand, and macroeconomic indicators; however, little attention has been paid to the role of monetary policy. Using the Federal Reserve balance sheet expansion and ten year Treasury note yield as the main indicators of monetary policy we found positive significant relationships between monetary policy and commodity price indices.

This topic is particularly important because the unconventional Federal Reserve monetary policy has been bringing the value of the dollar down, affecting the prices of commodities. Such monetary policies are expected to remain in the future and the long-term effects and risks are unclear. This paper sheds some light on the effect of increasing the money supply as extension of Federal Reserve balance sheet that is likely inflating values of many different asset classes, including commodities. The empirical results show that both all commodity and agricultural commodity price indices react positively to lower interest rates and expansionary monetary policy. The results are consistent with most of the prior research on the long run impact of monetary policy on price levels. However our results also show that the agricultural price index has a longer adjustment period than the all commodity price index which differs from most previous literature.

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Figure 1. All Commodity Index and Federal Reserve Balance Sheet.

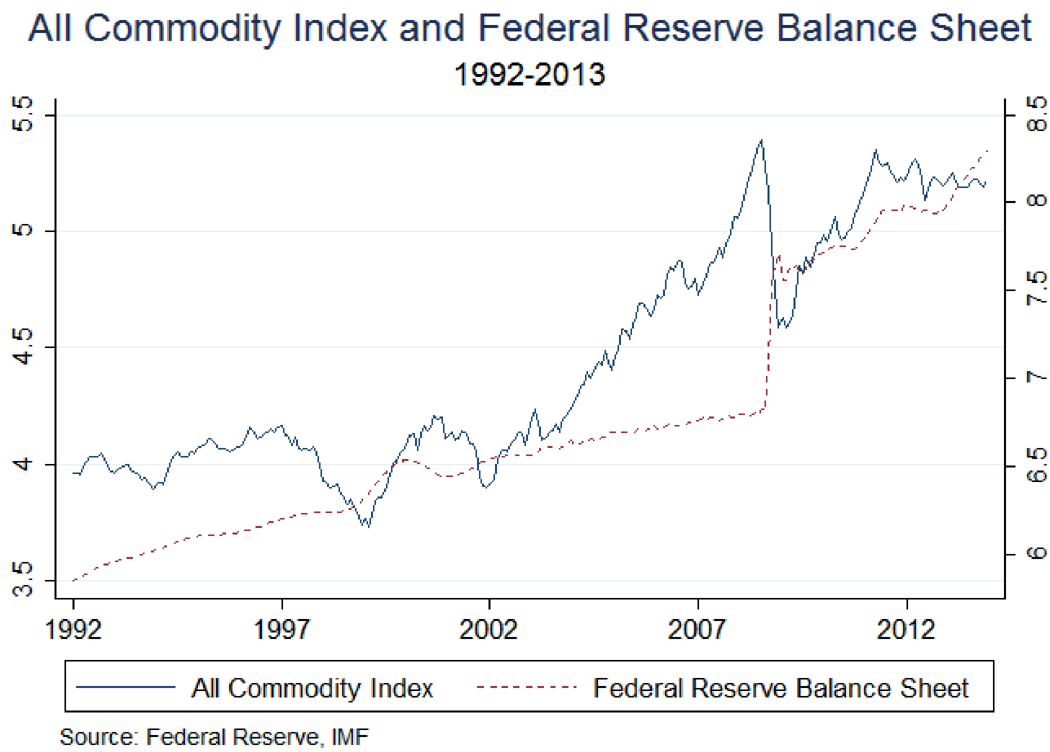

Figure 2. All Commodity Index and OECD Industrial Production Index

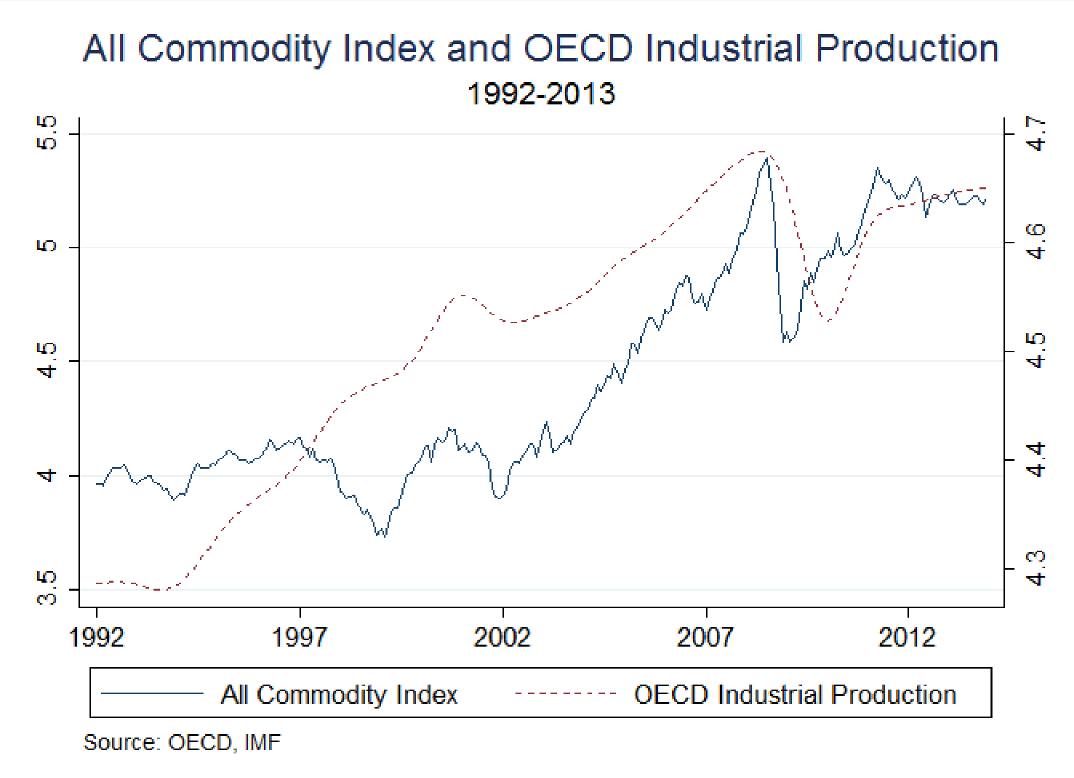

Figure 3. All Commodity Index and 10 Year Treasury Note Yield

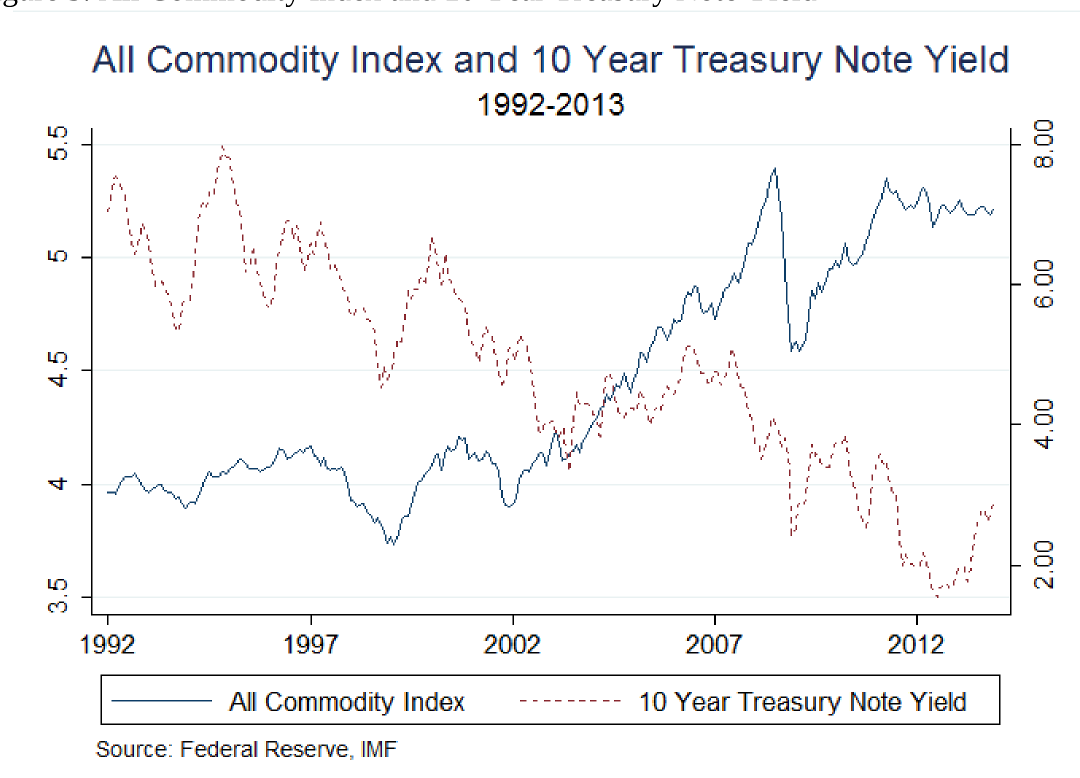

Table 1. Descriptive Statistics

Variable	**Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
All Commodity Price Index	264	96.72	51.37	41.91	219.74
Agricultural Price Index	264	114.99	33.12	75.83	194.72
Dollar Index	264	90.40	11.31	72.17	120.59
10 Year Treasury Note Yield	264	4.77	1.54	1.53	7.96
Federal Reserve Balance Sheet	264	1119.53	924.06	347.47	4032.58
OECD Industrial Production	264	91.92	10.95	72.29	108.11
GDP Deflator	264	106.11	11.00	86.76	124.74
Food Production Index	264	94.01	14.84	71.78	119.44

Table 2. Johansen Test for Cointegration

Maximum rank	Parameters	Log likelihood	Eigenvalue	Trace statistic	5% Critical value
0	186	7085.65	-	126.62	94.15
1	197	7109.43	0.17	79.06	68.52
2	206	7125.65	0.12	46.62*	47.21
3	213	7134.96	0.07	28.00	29.68

Table 3. Parameter Estimates of Normalized Cointegrating Vector

	Variable	All Commodity Index	Agricultural commodity index
1992-2013	Federal Reserve Balance Sheet	2.158*** (0.466)	2.005*** (0.52)
1992-2007	Federal Reserve Balance Sheet	0.284*** (0.041)	0.409*** (0.047)

*** 1% significance level

Table 4. All Commodity Price Index Vector Error Correction Model Parameter Estimates

Variable	Parameter	Std. error	p-value
All Commodity Price Index Adjustment coefficient	-0.1225	0.0320	0.000
Δ Commodity Price Index$_{t-1}$	0.158	0.073	0.031
Δ Commodity Price Index$_{t-2}$	0.065	0.073	0.377
Δ Commodity Price Index$_{t-3}$	0.023	0.073	0.758
Δ Commodity Price Index$_{t-4}$	-0.019	0.074	0.802
Δ Commodity Price Index$_{t-5}$	0.063	0.071	0.376
Δ US Dollar Index$_{t-1}$	-0.249	0.116	0.032
Δ US Dollar Index$_{t-2}$	0.106	0.115	0.355
Δ US Dollar Index$_{t-3}$	0.024	0.113	0.835
Δ US Dollar Index$_{t-4}$	0.102	0.115	0.377
Δ US Dollar Index$_{t-5}$	-0.111	0.114	0.333
Δ Fed Balance Sheet$_{t-1}$	-0.233	0.082	0.005
Δ Fed Balance Sheet$_{t-2}$	-0.209	0.087	0.017
Δ Fed Balance Sheet$_{t-3}$	0.104	0.089	0.241
Δ Fed Balance Sheet$_{t-4}$	-0.064	0.089	0.469
Δ Fed Balance Sheet$_{t-5}$	-0.036	0.088	0.682
Δ OECD Industrial Production$_{t-1}$	-69.479	71.025	0.328
Δ OECD Industrial Production$_{t-2}$	273.964	227.053	0.228
Δ OECD Industrial Production$_{t-3}$	-430.177	308.821	0.164
Δ OECD Industrial Production$_{t-4}$	314.359	220.549	0.154
Δ OECD Industrial Production$_{t-5}$	-89.200	67.540	0.187
Δ GDP Deflator$_{t-1}$	196.969	1204.081	0.87
Δ GDP Deflator$_{t-2}$	-1962.381	3681.869	0.594
Δ GDP Deflator$_{t-3}$	3814.286	4861.574	0.433
Δ GDP Deflator$_{t-4}$	-2799.026	3726.192	0.453
Δ GDP Deflator$_{t-5}$	769.3761	1273.951	0.546
Δ 10Y Treasury Yield$_{t-1}$	0.022	0.012	0.073
Δ 10Y Treasury Yield$_{t-2}$	0.001	0.012	0.936
Δ 10Y Treasury Yield$_{t-3}$	0.003	0.013	0.803
Δ 10Y Treasury Yield$_{t-4}$	0.006	0.012	0.637
Δ 10Y Treasury Yield$_{t-5}$	-0.013	0.012	0.265

Table 5. Agricultural Commodity Price Index Vector Error Correction Model Parameter Estimates

Variable	Parameter	Std. error	p-value
Agricultural Commodity Index Adjustment coefficient	-0.0785	0.0264	0.003
Δ CommodityIndex$_{t-1}$	0.158	0.073	0.031
Δ CommodityIndex$_{t-2}$	0.065	0.073	0.377
Δ CommodityIndex$_{t-3}$	0.023	0.073	0.758
Δ CommodityIndex$_{t-4}$	-0.019	0.074	0.802
Δ CommodityIndex$_{t-5}$	0.063	0.071	0.376
Δ DXY$_{t-1}$	-0.249	0.116	0.032
Δ DXY$_{t-2}$	0.106	0.115	0.355
Δ DXY$_{t-3}$	0.024	0.113	0.835
Δ DXY$_{t-4}$	0.102	0.115	0.377
Δ DXY$_{t-5}$	-0.111	0.114	0.333
Δ Fed Balance Sheet$_{t-1}$	-0.233	0.082	0.005
Δ Fed Balance Sheet$_{t-2}$	-0.209	0.087	0.017
Δ Fed Balance Sheet$_{t-3}$	0.104	0.089	0.241
Δ Fed Balance Sheet$_{t-4}$	-0.064	0.089	0.469
Δ Fed Balance Sheet$_{t-5}$	-0.036	0.088	0.682
Δ Food Production Index$_{t-1}$	-0.023	0.014	-1.650
Δ Food Production Index$_{t-2}$	0.045	0.045	1.000
Δ Food Production Index$_{t-3}$	-0.034	0.060	-0.570
Δ Food Production Index$_{t-4}$	0.022	0.043	0.510
Δ Food Production Index$_{t-5}$	-0.010	0.013	-0.780
Δ GDP Deflator$_{t-1}$	-43.87861	782.9248	0.955
Δ GDP Deflator$_{t-2}$	-2116.896	2377.292	0.373
Δ GDP Deflator$_{t-3}$	5195.208	3114.57	0.095
Δ GDP Deflator$_{t-4}$	-4126.488	2359.807	0.08
Δ GDP Deflator$_{t-5}$	1084.474	794.4788	0.172
Δ 10Y Treasury Yield$_{t-1}$	0.022	0.012	0.073
Δ 10Y Treasury Yield$_{t-2}$	0.001	0.012	0.936
Δ 10Y Treasury Yield$_{t-3}$	0.003	0.013	0.803
Δ 10Y Treasury Yield$_{t-4}$	0.006	0.012	0.637
Δ 10Y Treasury Yield$_{t-5}$	-0.013	0.012	0.265

Figure 4. All Commodity Index Impulse Response Functions

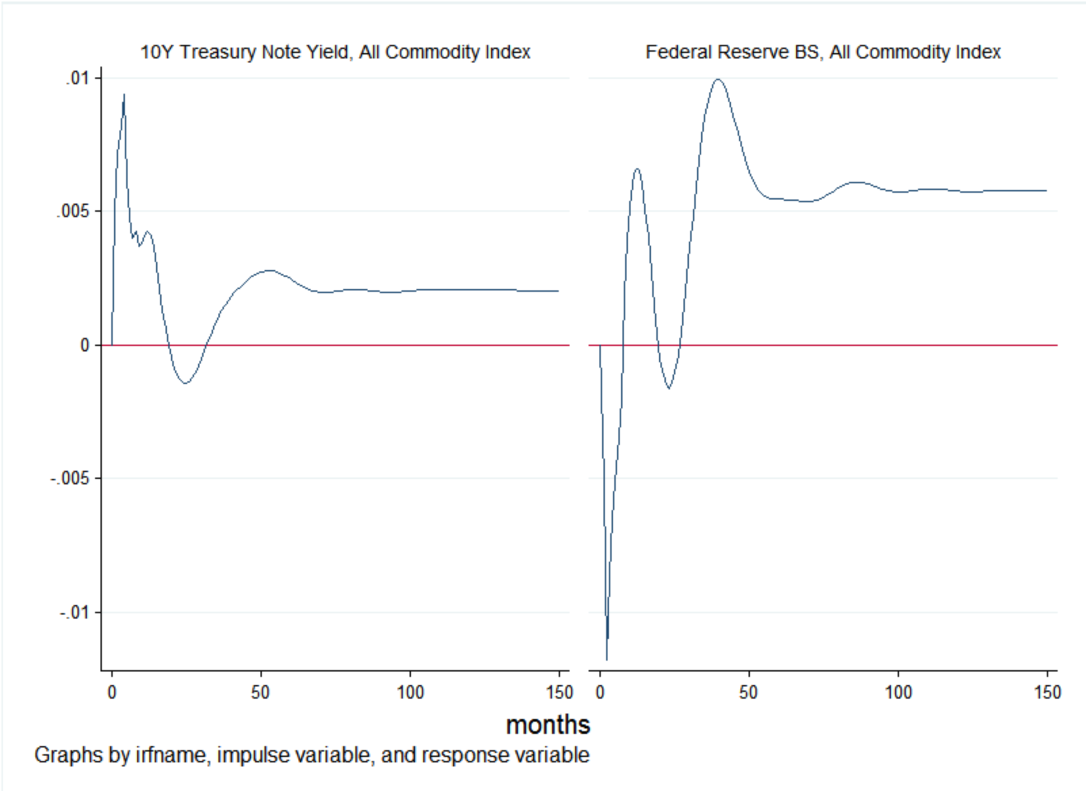

Figure 5. Agricultural Commodity Index Impulse Response Functions