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Do agricultural prices respond to interest on reserves?

Debdatta Pal

Indian Institute of Management Lucknow, India.
Email: debdatta@iiml.ac.in

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ABSTRACT

This paper elucidates the responsiveness of agricultural commodity prices to changes in interest on reserves, an unconventional monetary policy. It uses a vector autoregression model on monthly data for the United States, from October 2008 to July 2019. The empirical findings show that an increase in the interest rate on reserves leads to a drop in the price of corn, sorghum, and cotton. An increase in the interest on reserves declines the money supply, which increases the real interest rate and makes bonds lucrative over alternative investments such as agricultural commodities. This depresses the farm commodity prices, and the effect reaches its maximum after nearly four months. However, the impact on wheat prices is relatively weak. The estimations are robust to alternate specifications. The results of this study confirm the strong linkage between money supply and the prices of agricultural commodities. Food security for those nations that are heavily dependent on imported food grain from the U.S. market are dependent on the U.S. monetary policy.

Contribution/Originality: This is the first investigation that explores the fluctuations in agricultural commodity prices in response to changes in interest on reserves, which is an unconventional policy.

1. INTRODUCTION

Frequent fluctuations in agricultural commodity prices have drawn the attention of policymakers, as price rises in response to external shocks lead to economic instability and increased poverty (Dessus, Herrera, & De Hoyos, 2008). In recent times, substantial effort has been devoted to assessing the sensitivity of agricultural prices to monetary policy shocks. The overshooting model (Dornbusch, 1976; Frankel, 1986) suggests that, as agricultural prices are more flexible relative to the prices of industrial goods, a drop in the interest rate, stemming from the increased money supply, causes agricultural prices to rise and overshoot their long-run equilibrium. From a monetarist perspective, with the increase in money supply, consumers hold more money than they want, and thus invest more in commodity markets to restrict the excess money available to them. The rising demand for commodities raises their prices (Mishkin, 2001). Alternatively, the Keynesian view suggests that a drop in interest rate due to augmented money supply makes bonds less lucrative compared to commodities, thus boosting the price of agricultural commodities (Mishkin, 2001; Scrimgeour, 2015).

Conventionally, to change the money supply, the Federal Reserve engages in open market operations to achieve the targeted federal funds rate. *All else equal*, a drop in the federal funds rate reflects an expansionary monetary policy that would raise the money supply in the economy. Alternatively, the Federal Reserve could influence the reserve ratio by changing the reserve requirement of banks or by paying interest on reserves. Until 2008, the U.S. banks did not earn any interest on reserves. However, post-financial crisis, the Federal Reserve not only lent to banks to ensure liquidity since October 2008, but it also started paying interest on reserves – an unconventional way of influencing the money supply (Bernanke & Kohn, 2016). Higher interest on reserves encourages banks to hold more reserves with the Federal Reserve, raises the reserve ratio, and lowers the money supply in the economy (Mankiw, 2012).

The impact of the Federal Reserve's participation in open market operations on agricultural prices has been widely examined; however, little is known regarding the plausible fluctuations in agricultural commodity prices in response to changes in interest on reserves initiated by the central bank in 2008. Therefore, the novelty of this study is in elucidating the responsiveness of agricultural commodity prices to changes in interest on reserves. To the best of my knowledge, this is the first scholarly investigation exploring the relationship between the price of agricultural commodities and interest on reserves. Due to the rapid financialization of agricultural commodities (Cheng & Xiong, 2014) since the crisis, the results are likely to be of interest to investors and policymakers.

2. REVIEW OF LITERATURE

Schuh (1974) shows that the Federal Reserve's monetary policy is expected to affect the value of the U.S. currency, which is likely to impact the price and the U.S. agricultural commodities' competitiveness in the international market. However, the exchange rate is unlikely the sole factor that would channelize the monetary policy to impact agricultural prices. The overshooting hypothesis by Dornbusch (1976) suggests that agricultural prices would experience a real short-run impact from monetary policy changes. It specifies that due to the policy variation, agricultural prices might experience a temporary rise past their long-run equilibrium.

In one of the pioneering works, Bordo (1980) found that the prices of U.S. commodities adjusted rapidly in response to a change in policy. Similar findings also surfaced in the contributions by Barnett, Bessler, and Thompson (1983) and Devadoss and Meyers (1987), who argued that agricultural prices change quickly to monetary policy fluctuations. Consistent with the overshooting hypothesis, Orden and Fackler (1989) suggested that increased money supply boosts agricultural prices that overshoot the price equilibrium by more than a year. Similarly, Robertson and Orden (1990) indicated that prices of agricultural commodities adjusted relatively quickly compared to industrial goods in response to monetary policy change. Lai, Hu, and Wang (1996) suggested an increase in agricultural prices responding to unanticipated monetary shocks. Saghaian, Reed, and Marchant (2002) also found corroborative proof in the sustenance of the overshooting model and showed that agricultural prices react faster to monetary policy blows than industrial prices. Similarly, Kwon and Koo (2009) found that farm prices increase more quickly than non-farm prices due to unexpected monetary policy changes. However, Dorfman and Lastrapes (1996) argued that, in the short run, livestock prices change quicker than crop prices in response to money supply changes.

Among recent investigations, Alam and Gilbert (2017) showed that monetary policy significantly impacts agricultural prices. Loizou, Mattas, and Pagoulatos (1997) suggested that the agrarian economy of Greece is majorly affected by the money supply. Anzuini, Lombardi, and Paganoa (2013) confirmed a boosting effect of expansionary monetary policy on food prices. Scrimgeour (2015) also estimated a 0.67% fall in agricultural commodity prices in response to an unexpected rise by 10 basis points in the federal funds rate. However, Kim and Kim (2021) suggested a delayed increase in agriculture prices due to monetary policy surprises. The review of the literature suggests that scholarly investigations primarily explore the fluctuations in agriculture prices due to changes in conventional monetary policy. Therefore, it is timely and relevant to study the plausible responsiveness of agricultural commodity prices to unconventional changes in interest on reserves.

3. EMPIRICAL SETUP

Following Sims (1980), a vector autoregression (VAR) model using U.S. monthly data from October 2008 to July 2019 is proposed as follows: $\boldsymbol{y}_t = (\Delta iorr_t, \Delta M_t, \Delta r_t, \Delta ap_t)'$, where $iorr_t$ represents interest on required reserves, M_t is the M2 money supply, r_t denotes the real interest rate, ap_t refers to the price of agricultural commodity, and Δ is the first order difference operator. This paper covers four agricultural commodities – corn, wheat, sorghum, and cotton. The M_t and ap_t series are expressed in logs. The real interest rate is constructed by adjusting the federal funds rate with the CPI inflation rate. As the augmented Dickey–Fuller test suggests that all the underlying series are integrated of order one, this paper uses first-order difference series. Data on macroeconomic variables and commodity prices were retrieved from the Federal Reserve Economic Data and the International Monetary Fund, respectively. Table 1 contains the summary statistics of the underlying variables.

Table1. Descriptive statistics.

Variable	Mean	Standard deviation	Kurtosis	Skewness	Minimum	Maximum
Interest rate on required reserves (i)	0.634	0.663	1.283	1.63	0.25	2.4
Money supply (M2) in billions of USD (M)	11215.74	2093.777	-1.325	0.081	7911.8	14837.9
Real interest rate I	0.123	0.372	6.911	-1.559	-1.915	0.975
Price of corn in USD per metric ton (p)	201.77	56.684	-0.478	1.038	147.315	332.998
Price of wheat in USD per metric ton (p)	208.686	4.708	-0.902	0.384	122.549	319.460
Price of sorghum in US cents per pound (p)	9.028	0.209	-0.378	0.881	5.94	16.49
Price of cotton in US cents per pound (p)	89.109	2.591	8.798	2.731	51.50	229.667

The VAR representation is as follows:

$$B_0 y_t = \lambda + \sum_{i=1}^{p} B_i\, y_{t-i} + u_t$$

Where u_t refers to the vector of serially and mutually uncorrelated structural innovations, and p is the lag length. It is postulated that B_0^{-1} possesses a recursive structure so that the reduced form error ε_t could be decomposed in accordance with $\varepsilon_t = B_0^{-1} u_t$:

$$\boldsymbol{\varepsilon}_t \equiv \begin{pmatrix} \varepsilon_t^{iorr} \\ \varepsilon_t^{M} \\ \varepsilon_t^{r} \\ \varepsilon_t^{ap} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} u_t^{iorr} \\ u_t^{M} \\ u_t^{r} \\ u_t^{ap} \end{pmatrix}$$

The model imposes restrictions only on short-run contemporaneous relations without any restriction over the long run. Decomposition of ε_t is based on the following assumptions. First, the innovations made to the interest on the required reserve do not contemporaneously respond to the money supply shock, real interest rate changes and price fluctuations of agricultural commodities.

This leaves the last three elements of the first row of B_0^{-1} as zero. The second assumption is that the money supply responds contemporaneously to the interest rate on the required reserve. However, the money supply would take longer to respond to the real interest rate. This implies that the last two elements of the second row of B_0^{-1} are zero. Next, it is assumed that the real interest rate does not respond to the short-run agriculture price changes (i.e., the element $a_{34} = 0$). Finally, it is assumed that agriculture prices contemporaneously react to changes in interest on required reserves, money supply shock, and fluctuations in real interest rates.

4. RESULTS

The Akaike information criterion and final prediction error are followed to identify the appropriate lag length. Both criteria suggest a lag of eight months. As the underlying variables are $I(1)$, the cointegration of each agricultural commodity price with the interest rate on required reserve, money supply, and real interest rate is tested. With $p = 8$, the Johansen cointegration test (see Table 2) rejects the null hypothesis of no cointegration. Having specified the reduced-form model, the vector error correction model (VECM) is estimated on the $VAR(8)$ under the rank restriction $r = 1$. The resulting estimates are used to compute the impulse response of agricultural prices to monetary policy shocks. The diagnostic test indicates that the VECM is just-identified.

Table 2. Johansen cointegration test results for each agricultural commodity price series with the interest rate on required reserve, money supply and real interest rate.

H_0	Trace statistics (p = 8)				Critical values		
Rank	Corn	Wheat	Sorghum	Cotton	90%	95%	99%
$r = 0$	158.24	163.23	161.46	154.48	59.14	62.99	70.05
$r = 1$	80.74	89.93	81.98	77.40	39.06	42.44	48.45
$r = 2$	47.75	54.99	49.18	43.97	22.76	25.32	30.45
$r = 3$	22.51	24.15	23.05	13.30	10.49	12.25	16.26

4.1. Response of Agricultural Commodity Prices to Monetary Policy Shocks

Figure 1 shows the responses of the prices of the underlying agricultural commodities to the interest rate on required reserves ($iorr$), money supply, and real interest rate with a 95% confidence interval. The point estimates suggest that a positive shock in the interest rate on required reserves, i.e., an increase in the $iorr$, leads to a drop in the price of corn, reaching the maximum impact after four months. However, the result of any innovation in the $iorr$ on corn price eases after two quarters. A similar effect in the $iorr$ was found on the prices of both sorghum and cotton, showing a drop in the prices of both commodities with a maximum effect after around four months. For sorghum and cotton, the impact of the $iorr$ disappears after about eight months. However, estimates show that an increase in the $iorr$ drives down the price of wheat, but the effect is not apparent.

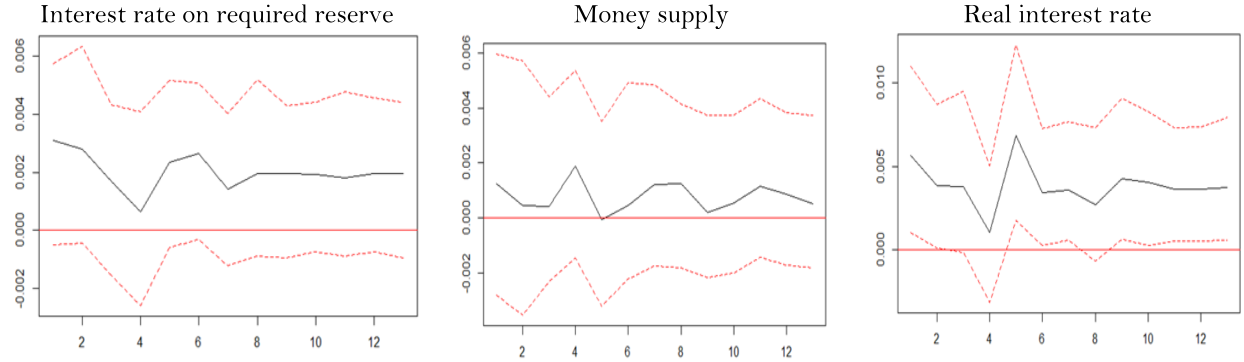
A money supply shock positively impacted the prices of both corn and cotton, though with a delay of three months. The effect reached a maximum after four months; however, it disappeared after five months. Similarly, sorghum prices increased in reaction to money supply shock with a lag of three months, reaching the maximum after seven months. However, the response of wheat prices to the money supply shock was relatively weak.

A positive shock in the real interest rate led to a fall in the corn price, and the effect reached the maximum after four months. The dampening effect of r is evident until the eighth month after the shock. In response to a positive surprise in r, similar sharp declines in wheat, sorghum, and cotton prices are evident within four months of the shock.

Overall, the impulse responses of the prices of the underlying commodities are in line with economic theory. Consistent with the theory of monetary economics, our results show that, by driving down the money multiplier, an increase in interest on reserves has dampened the money supply in the economy. A fall in the money supply has pushed up the real interest rate, leading to a drop in the prices of agricultural commodities.

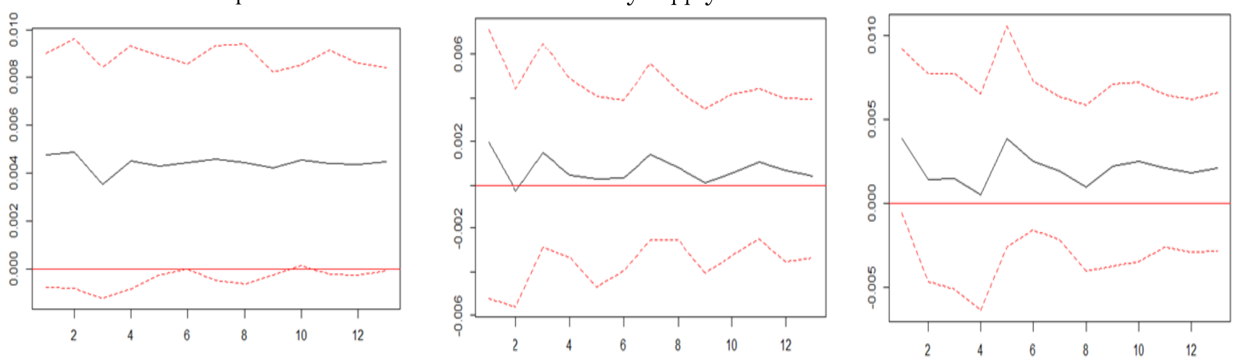
Panel 1.a. Response of corn price to:

Interest rate on required reserve | Money supply | Real interest rate



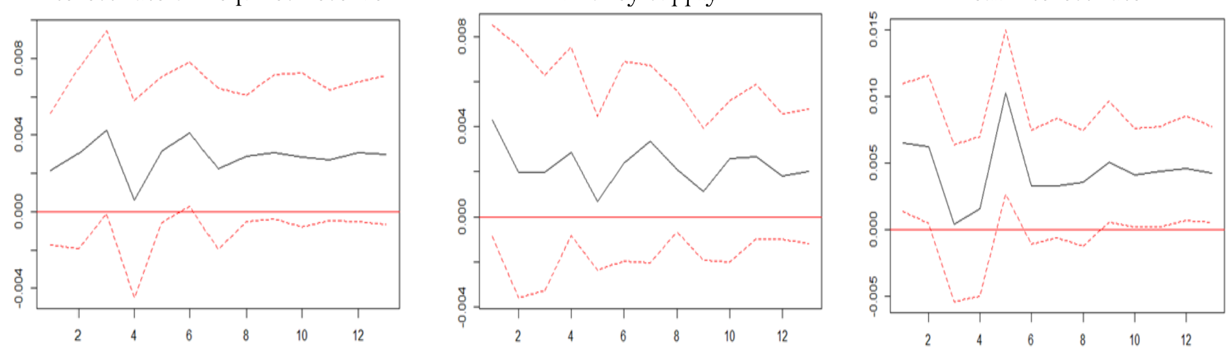
Panel 1.b. Response of wheat price to:

Interest rate on required reserve | Money supply | Real interest rate



Panel 1.c. Response of sorghum price to:

Interest rate on required reserve | Money supply | Real interest rate



Panel 1.d. Response of cotton price to:

Interest rate on required reserve | Money supply | Real interest rate

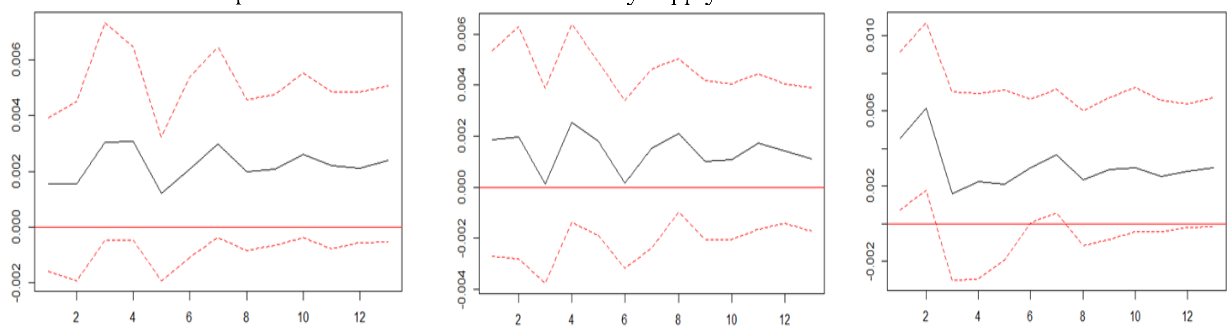


Figure 1. Responses of agricultural commodity prices to monetary policy shocks with a 95% confidence interval.

Note: The dotted lines are the 95% confidence interval. The horizontal axis represents the number of months after the shock.

4.2. Importance of Monetary Policy to Agricultural Commodity Price Changes

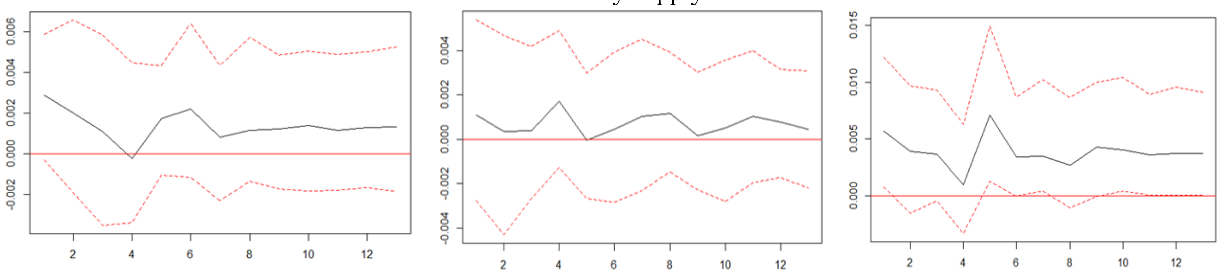
To identify the relative importance of the macroeconomic shocks for various horizons, the forecast error variance decomposition of the underlying agricultural commodities was calculated (see Table 3). According to the estimate, the prices of the respective agricultural commodities contributed the maximum to the variations in agricultural prices. This is consistent with the findings of Gilbert (2010), who attributed agricultural price changes primarily to demand growth. Though macroeconomic innovations are not essential in explaining corn's price variability immediately after shocks, they are relatively more critical within three to six months after the shock. For example, after six months of the shock, the interest rate on the required reserve explains a fraction of 2.77% of the variance in corn price. Similarly, the $iorr$ explains 6.89% and 3.24% of the variance in wheat and cotton prices, respectively, after six months of the shock. After six months, money supply shocks explain 4.64% and 6.18% of the variance in corn and cotton prices, respectively. The real interest rate also gains importance in explaining variance in the agricultural prices over a relatively long time horizon.

Table 3. Forecast error variance decomposition of agricultural commodities over different time horizons.

Percentage contributions to corn price variations				
Period (In months)	u_t^{iorr}	u_t^M	u_t^r	u_t^{ap}
1	0.36	0.12	0.62	98.90
3	0.49	4.54	1.81	93.16
6	2.77	4.64	3.04	89.55
Percentage contributions to wheat price variations				
Period (In months)	u_t^{iorr}	u_t^M	u_t^r	u_t^{ap}
1	2.83	0.01	0.07	97.09
3	6.45	1.89	2.05	89.61
6	6.89	2.43	2.40	88.28
Percentage contributions to sorghum price variations				
Period (In months)	u_t^{iorr}	u_t^M	u_t^r	u_t^{ap}
1	0.01	0.14	0.10	99.75
3	0.04	1.10	1.93	96.93
6	1.39	1.04	4.37	93.20
Percentage contributions to cotton price variations				
Period (In months)	u_t^{iorr}	u_t^M	u_t^r	u_t^{ap}
1	0.18	0.43	2.10	97.29
3	1.10	2.60	2.06	94.24
6	3.24	6.18	4.11	86.47

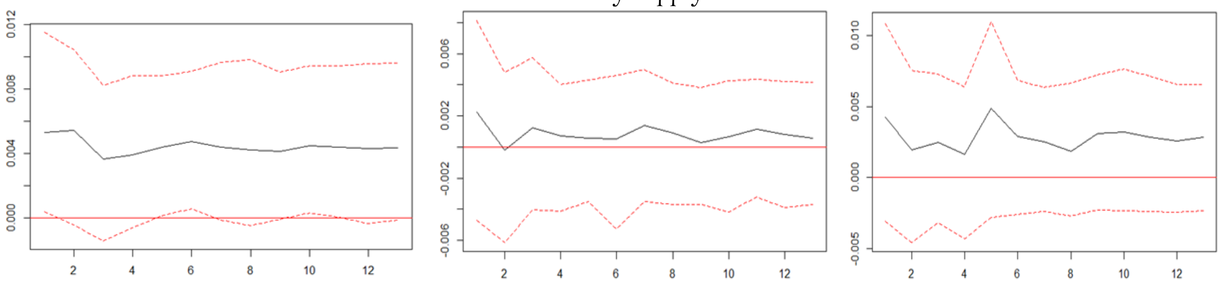
Panel 2.a. Response of corn price to:

Interest rate on excess reserve | Money supply | Real interest rate



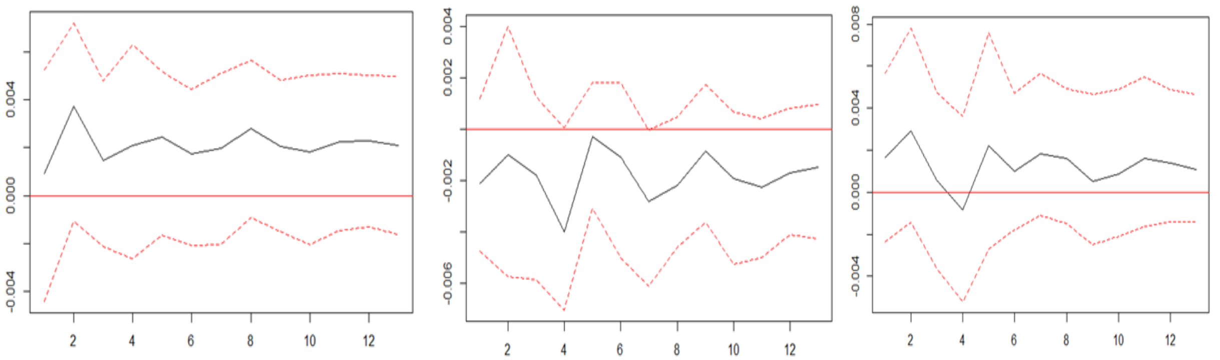
Panel 2.b. Response of wheat price to:

Interest rate on excess reserve | Money supply | Real interest rate



Panel 2.c. Response of sorghum price to:

Interest rate on excess reserve | Money supply | Real interest rate



Panel 2.d. Response of cotton price to:

Figure 2. Responses of agricultural commodity prices to the shocks in interest rate on excess reserve, money supply and real interest rate with a 95% confidence interval.

Note: The dotted lines are at 95% confidence intervals. The horizontal axis represents the number of months after the shock.

4.3. Robustness

Robustness to the estimates is offered by proposing an alternate specification. Instead of assessing the response of agricultural prices to the shocks in interest on required reserve, the sensitivity of farm prices to the changes in interest on excess reserves ($ioer$) is tested. While banks are expected to meet the required reserve set by the Federal Reserve, holding reserves over the requirement is at the sole discretion of the banks and is purely motivated by profit. Here, it is assumed that an increase in the $ioer$ encourages banks to hold more reserves with the Federal Reserve, raises the reserve ratio, pulls the money multiplier down, and reduces the money supply. A drop in the money supply would boost the real interest rate and dampen agricultural prices. Figure 2 suggests that the estimations in Figure 1 are robust to this alternate specification.

5. CONCLUSION AND POLICY IMPLICATIONS

Since October 2008, the Federal Reserve unconventionally started paying interest on the reserves to influence the money supply in the economy. Up to that point, the Federal Reserve influenced the money supply by adjusting the federal funds rate through open market operations. The findings of this study suggest that the traditional interest rate channel should be followed, and that higher interest on reserves dampens the money supply in the economy, raises the real interest rate, and depresses agricultural prices. Shocks in interest on reserves take around four months to have maximum impact. The results also show that agricultural prices are primarily affected by demand growth with a relatively small impact of macroeconomic shocks.

The results of this study confirm the strong linkage between money supply and the prices of agricultural commodities. Conventionally, agricultural prices were believed to be determined by the interaction between demand and supply. However, since the financialization of commodities, prices of agricultural commodities are more closely linked with macroeconomic variables, and agricultural commodity prices are significantly influenced by money supply. This has multi-facet implications not only for the survival of producer farmers but also in terms of food security for those nations that are heavily dependent on imported food grain from the U.S.

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