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Abstract

This study examines the effects of the monetary policy of the United States on commodity prices. Using a Bayesian Structural VAR, we identify the interest rate shocks as a measure of the stance of the U.S. monetary policy and evaluate their impacts on different types of commodity prices. The empirical evidence suggests that a U.S. monetary contraction has a negative and significant effect on the aggregate commodity prices, which takes place with a substantial lag (i.e., eight quarters after the shock). However, the aggregate response masks the existence of significant heterogeneity in the responses of the different types of commodities. More specifically, a positive interest rate (contractionary) shock leads to: i) an initial increase in the prices of non-fuel commodities, which later reverts path and becomes negative (as in the case of the prices of agricultural raw materials); ii) a positive and persistent rise in the food prices; iii) a fall in the beverage prices; and iv) a persistent reduction in the prices of metals and the prices of fuel (energy) prices.

Keywords: monetary policy, commodity prices, Bayesian Structural VAR.

\textit{JEL classification}: E37, E52.

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1. Introduction

Periods of changes in global liquidity and dispersions in interest rates have generally coincided with variations in commodity prices. The expansion in global liquidity and the falls in interest rates have been dynamic since 2001 and are a result of increased activity in the carry trade that moved liquidity from the United States to emerging markets and expanded investments in several asset classes including stocks, real estate and commodities (Hammoudeh and Yuan, 2008; Batten et al., 2010; Belke et al., 2010b; Brana et al., 2012; Frankel, 2013; Ratti and Vespignani, 2013a, 2013b; Belke et al., 2014). The impact on commodity prices has however been heterogeneous. For example, Brana et al. (2012) investigate the impact of global excess liquidity on goods and asset prices for a sample of emerging market economies. The authors find that excess liquidity at global level has spillover effects on output and price levels, but the impact on real estate, commodity and share prices is less clear. Similarly, Belke et al. (2010b) show that while monetary aggregates in OECD countries provide leading information on property prices and gold prices, shocks to liquidity do not seem to have impacts on equity prices.

The recent influence of U.S. monetary policy on asset prices dates back to the early years of the last decade. The Federal Reserve opened the liquidity spigot in those years to combat the Dot.com recession and kept interest rates low, which created a bubble in asset prices that burst in 2008. In the period 2001-2008, the Brent oil prices tripled and reached their record level of $147 a barrel. The CRB (Commodity Research Bureau) commodity price index surged by 105 percent, housing prices increased by 40–60 percent in a number of OECD countries and stock prices more than doubled in nearly all major markets (Belke et al., 2010a).

The above discussion shows that the U.S. monetary policy is a major driver of global asset prices. Other drivers that have influenced commodity prices during this period include
economic activity and speculation (Frankel, 2013). Overall, the anecdotal evidence thus points to the importance of the U.S. monetary policy as a common macroeconomic factor that drives the movement of commodity prices, despite its varying and heterogeneous impacts on the dynamics of those prices.

This study adds to the existing literature on the interactions between global excess liquidity and commodity prices by focusing on the effects of the U.S. monetary policy on the commodity prices of different sectors. In particular, it uses a Bayesian Structural VAR (BSVAR) to identify shocks to the Federal funds rate and evaluate their impacts on the all (broad) commodity price index as well as the prices of different types of commodities which include non-fuel commodities, foods, beverage, agricultural raw materials, metals, and fuel (energy) commodities. The BSVAR framework is particularly helpful and advantageous in that it allows one to empirically quantify the responses of a multiple set of commodity prices to shocks affecting the interest rate due to changes in the U.S. monetary policy. Moreover, it accounts for the uncertainty about the probability distribution of the impulse-response functions, thereby making problems such as over-fitting potentially caused by a short data set, weak sample information or a large number of parameters less dramatic. Additionally, it allows for a better identification of the monetary policy shock, as the analysis is not conditional on a set of “true” parameters that can be sensitive to the strength of the identification and the sampling distribution of estimators and test statistics as in the case of the frequentist analysis.

While there is no consensus about whether commodity prices should be included in the formulation of optimal monetary policies - as they may be subject to large and idiosyncratic shocks with no macroeconomic implications (Marquis and Cunningham, 1990; Pindyck and Rotemberg, 1990; Cody and Mills, 1991; Bernanke et al., 1997), the empirical evidence undoubtedly supports the view of a strong and negative impact of monetary contrac-
tions on the aggregate commodity price index (Leeper and Zha, 2003; Christiano et al., 2005; Sims and Zha, 2006a, 2006b; Mallick and Sousa, 2012; Sousa, 2010, 2014a, 2014b).

The main contribution of the study to the existing literature lies in evaluating the effects of the U.S. monetary policy on not only on the aggregate commodity price index but also on different commodity prices, ranging from energy and precious metals to agricultural and food commodities. The study enables one to investigate which types of commodities are the most sensitive to changes in the U.S. interest rate and in which directions. Moreover, the diversified results have implications for policymakers to take into account when setting monetary policy (in particular, because of the impact of changes in different commodity prices on general inflation), for commodity producers to be prudent in designing proper hedging strategies against volatile prices and for investors in terms of selecting the commodities that are indexed to inflation.

Using quarterly data over the period from January 1957 to March 2008 which excludes the recent years where unconventional monetary policy (e.g., quantitative easing) has been implemented, our empirical evidence suggests that a monetary contraction has a significant and negative effect on the aggregate commodity price, which takes place with a substantial lag (i.e., eight quarters after the shock). However, this aggregate response disguises the existence of significant heterogeneity in the responses of the different types of commodities to monetary policy shocks which affect expected future prices, storability of the commodity and demand for commodity inventories. More specifically, a positive interest rate shock leads to: i) an initial increase in the prices of non-fuel commodities, which later reverts and becomes negative (as in the case of the prices of agricultural raw materials); ii) a positive and persistent rise in the food prices; iii) a fall in the beverage prices; and iv) a persistent reduction in the prices of metals and the prices of fuel (energy) prices.
The remainder of this article is organized as follows. Section 2 reviews the related literature. Section 3 describes the empirical methods used to assess the effects of the monetary policy on the commodity prices. Section 4 presents the data and discusses the empirical findings. Section 5 concludes.

2. A brief review of the literature

The short-term interest rate is a crucial tool of monetary policy that aims at promoting economic growth and price stability. The theoretical foundation for the relationship between changes in interest rates and changes in the general price level (inflation) is embedded in the interest rate parity. This relationship is indeed entrenched in the no-arbitrage condition which posits that the expected rate of change in commodity prices (which may include the risk premium) minus storage costs is equal to the short-term interest rate (Frankel, 1986). In this case, the general price level is found to be proportional to commodity prices (Frankel, and Hardouvelis, 1985).

From a theoretical point of view, the mechanisms via which real interest rates are a relevant influence on the real prices of mineral and agricultural commodities are discussed in a detailed manner in Frankel (2008). Notably, high interest rates reduce the demand (or increase the supply) for storable commodities by: (i) increasing the incentive for extraction today rather than tomorrow; (ii) decreasing the firms' desire to carry inventories; and (iii) by encouraging speculators to shift out of spot commodity contracts and into treasury bills.

From an empirical perspective, the general strand of the literature deals with the impact of monetary policy on asset prices. For instance, studies such as Meltzer (1995) and Congdon (2005) find that in the face of strong monetary growth, the central bank may reduce money supply in order to store the balance between long-run money growth and asset values.
Bernanke and Gertler (1999) suggest that asset prices are relevant for monetary policy stances only when they may signal potential inflationary pressure or deflationary forces.

Another line of investigation looks more specifically into the relationship between the movements of commodity prices and the management of monetary policy. The seminal work by Frankel (1984) shows that an increase in the supply of money raises the real prices of commodities because the prices of many other goods display rigidity in the short-term. Bernanke et al. (1997) document that the monetary authority reacts to higher oil prices by tightening monetary policy. Other studies such as Marquis and Cunningham (1990) and Cody and Mills (1991) doubt that commodity prices can help in setting appropriate monetary policy. By contrast, Pindyck and Rotemberg (1990) examine the excess comovement of raw commodity prices and show that the impact of monetary policy on commodity prices cannot be denied. Lastrapes and Selgin (1995) find evidence consistent with the hypothesis that monetary policy has treated metals price movements as signals of inflationary pressures. However, Lastrapes and Selgin (2001) estimate the magnitude of the linkages between monetary policy actions and gold, platinum and silver prices and show that this relationship was weakened after the mid-nineties. Leeper and Zha (2003) and Sims and Zha (2006a, 2006b) rely on Bayesian frameworks to assess the effects of monetary policy shocks in the US and uncover a large and negative effect of monetary contractions on the aggregate commodity price. Using a standard VAR, Christiano et al. (2005) find a similar result and argue that the inclusion of the aggregate commodity price in the system of endogenous variables helps tackling the price puzzle. Barsky and Kilian (2004) maintain that monetary policy influences commodity prices via its impact on expectations of greater economic growth and inflation. Sousa (2010, 2014a) shows that, apart from important effects on households’ wealth composition, monetary policy shocks in the euro area and the U.S. have a substantial impact on the aggregate commodity price. Mallick and Sousa (2012) focus on the real effects of monetary policy in five large
emerging economies (Brazil, Russia, India, China and South Africa). They identify monetary policy shocks using modern Bayesian techniques and show that a contractionary monetary policy produces an immediate reduction in the aggregate commodity price. Similarly, for a small open economy such as Portugal, Sousa (2014b) finds that unexpected variations in the interest rate set by the monetary authority can account for the negative comovement between bonds and stocks and generate a quick fall in the broad commodity price.

A number of recent works focus on the impact of global liquidity on inflation, and commodity and goods prices (Belke et al., 2010b; Belke et al., 2014). This literature has been influenced by the recent expansion in international capital flows among countries, which has been strengthened by the quantitative easing programs followed by major central banks. Indeed, Humphreys (2009, 2010) highlights that two major ingredients have led to the surge in commodity prices from 2003 to 2008. First, an extended economic upswing associated with the massive rise in global liquidity due to the availability of low-cost credit. Second, a structural shift in the global economy characterised by an increase in the trend growth rate of the demand for commodities due to the industrialisation and urbanisation of emerging economies, a huge growth in the availability of low-cost labour and a dramatic reduction of the manufacturing costs. Gilbert (2010) emphasizes the role of demand growth, monetary expansion and exchange rate movements as drivers of the price movements in agricultural commodities. The author suggests that index-based investment in agricultural futures markets was the major transmission channel of macroeconomic and monetary factors to the rise in food prices over the period of 2007-2008.\(^1\) Frankel and Rose (2010) put forward the same key forces, to which they add a speculative bubble (generated by bandwagon expectations, i.e. speculators acting on the basis of forecasts of future commodity prices that extrapolate trends) and risk (most likely associated with geopolitical uncertainties).

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\(^1\) Early works by Bordo (1980) and Chambers and Just (1982) have also shown that monetary expansions can raise the relative price of agricultural commodities.
Examples of studies that investigate the global and financial liquidity include Hammoudeh and Yuan (2008), Batten et al. (2010), Brana et al. (2012), Ratti and Vespignani (2013a, 2013b) and Belke et al. (2014). For example, Hammoudeh and Yuan (2008) analyse the volatility behaviour and the joint effect of oil and interest rate shocks on gold, silver and copper prices. Batten et al. (2010) find evidence suggesting that while gold volatility is explained by monetary variables, while the same does not apply to other precious metal prices. Consequently, the authors point out that precious metals cannot be considered a single asset class. Brana et al. (2012) show that global excess liquidity contributed to strong capital inflows in emerging market economies and may have led to bubbles on the asset markets. Using a structural factor-augmented error correction (SFAVEC) model, Ratti and Vespignani (2013a) show that a positive liquidity shock in the BRIC countries (i.e. Brazil, Russia, India and China) leads to a significant and persistent rise in commodity prices (especially, in the case of mineral and metal prices) that is substantially larger than the effect of an unanticipated increase in liquidity in the G3 countries. Ratti and Vespignani (2013b) corroborate the importance of substantial unanticipated increases in liquidity in recent years as generating significant increases in real oil prices. Belke et al. (2014) employ the cointegrated VAR model to analyse the long-run impact of the official liquidity that is created by the monetary authority on commodity and goods price inflation. Their empirical results support the proposition that the global liquidity aggregate is a key driver of the long-run homogeneity of commodity and goods prices movements.

Overall and as emerges from the abovementioned works, the literature devoted to the assessment of the empirical relationship between monetary policy and commodity prices does not always reach a consensus. Moreover, the majority of pieces of research identify monetary policy shocks and their impacts on commodity prices through a standard VAR model which ignores the uncertainty of the system variables’ probability distri-
bution when doing the impulse-response function analysis. Finally, the use of aggregate measures for commodity prices also masks important price reactions of different subsets of commodities. Our study attempts to address this gap in the literature by considering the case of the US monetary policy over the period 1957-2008, which excludes the use of quantitative easing.

3. Empirical methodology

To identify and assess the effects of the US monetary policy on commodity prices, we estimate the following Structural VAR (SVAR)

$$\Gamma(L)X_t = \Gamma_0 X_t + \Gamma_1 X_{t-1} + ... = \epsilon + \epsilon_t,$$  

(1)

$$\epsilon_t = \Gamma_0^{-1} \epsilon_t,$$  

(2)

where $\epsilon_t \mid X_s, s < t \sim N(0, \Lambda)$. $\Gamma(L)$ is a matrix valued polynomial in the positive powers of the lag operator $L$, $n$ is the number of variables in the system, $\epsilon_t$ is the vector of the economic fundamentals’ shocks that span the space of innovations to $X_t$, and $\epsilon_t$ is the vector of VAR innovations.

Monetary policy can be characterized as

$$i_t = f(\Omega_t) + \epsilon^i_t,$$  

(3)

where $i_t$ is the central bank’s target (policy) interest rate, $f$ is a linear function, $\Omega_t$ is the information set, and $\epsilon^i_t$ is the interest rate shock.

We consider a recursive identification scheme and assume that the variables in $X_t$ can be separated into 3 groups: i) a subset of $n_1$ variables, $X_{1t}$, which do not respond contemporaneously to the monetary policy shock; ii) a subset of $n_2$ variables, $X_{2t}$, that respond contemporaneously to it; and iii) the policy instrument in the form of the central bank rate, $i_t$.

The recursive assumptions can be summarized by $X_t = [X_{1t}, i_t, X_{2t}]$ and
\[
\Gamma_0 = \begin{bmatrix}
\gamma_{11} & 0 & 0 \\
\gamma_{21} & \gamma_{22} & 0 \\
\gamma_{31} & \gamma_{32} & \gamma_{33}
\end{bmatrix}_{n_1 \times n_1 \atop n_1 \times n_2 \atop n_2 \times n_2}.
\]

As in Christiano et al. (2005), we include the growth rate of the monetary aggregate in the set of variables that react contemporaneously to the monetary policy shock \((X_{2t})\). The commodity price index, the GDP, the private consumption, the private investment and the GDP deflator are allowed to react to monetary policy only with a lag. There variables are, therefore, included in \(X_{lt}\).

Finally, the impulse-response function to a one standard-deviation shock under the normalization of \(\Lambda = I\) is given by

\[
B(L)^{-1}\Gamma_0^{-1},
\]

We use a Monte Carlo Markov-Chain (MCMC) algorithm to assess the uncertainty about the distribution of the impulse-response function. We construct probability intervals by drawing from the Normal-Inverse-Wishart posterior distribution of \(B(L)\) and \(\Sigma\)

\[
\beta' | \Sigma \sim \hat{\beta}, \Sigma \otimes (X'X)^{-1}
\]

\[
\Sigma^{-1} \sim \text{Wishart}((T \hat{\Sigma})^{-1}, T - m)
\]

where \(B(L)\) is a matrix valued polynomial in the positive powers of the lag operator \(L\) associated with the regression coefficients, \(\beta\) is the vector of regression coefficients in the VAR system, \(\Sigma\) is the covariance matrix of the residuals, \(\hat{\beta}\) and \(\hat{\Sigma}\) are the corresponding maximum-likelihood posterior estimates at the mean, \(X\) is the matrix of regressors, \(T\) is the sample size and \(m\) is the number of estimated parameters per equation.
4. Data

This section provides a summary description of the quarterly data used in the empirical analysis. All variables are expressed in natural logarithms and measured at constant prices unless stated otherwise. Our study period runs from January 1957 to March 2008.

The variables in $X_{1t}$, which are predetermined with respect to monetary policy innovations, include the broad commodity price index, the GDP, the private consumption, the private investment and the GDP deflator. The broad commodity price index is replaced by the price index of the subsets of commodities when we examine the shock transmission from monetary policy to individual types of commodities.

Data for the commodity price indices are sourced from the International Monetary Fund (IMF). These data cover: 1) the broad commodity price index which includes both Fuel and Non-Fuel Price Indices; 2) the non-fuel commodity price index which includes Food and Beverages and Industrial Inputs Price Indices; 3) the food price index which includes Cereal, Vegetable Oils, Meat, Seafood, Sugar, Bananas, and Orange Price Indices; 4) the beverage price index which includes Coffee, Tea, and Cocoa Price Indices; 5) the agricultural raw materials price index which includes Timber, Cotton, Wool, Rubber, and Hides Price Indices; 6) the metals’ price index which includes Copper, Aluminum, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices; and 7) the fuel (energy) commodity price index which includes Crude Oil (petroleum), Natural Gas, and Coal Price Indices.

The macroeconomic variables GDP, the GDP deflator, the private consumption and the private investment are accessed from the International Financial Statistics of the IMF. Private consumption corresponds to the private final consumption expenditure, while private investment is the gross private investment expenditure.

The variable in $X_{2t}$, which is allowed to react contemporaneously to monetary policy shocks, is the growth rate of the monetary aggregate $M_2$ and is obtained from database of the
Board of Governors of the Federal Reserve System. This variable reflects the official liquidity conditions. Belke et al. (2014) also use it for the US and Japan as well as $M_3$ and $M_4$ for the other countries in order to construct the global liquidity indicator.

We use the federal funds effective rate as the monetary policy instrument. The main source for this variable is the Board of Governors of the Federal Reserve System. The use of this variable in identifying the monetary policy shocks is standard in the literature.

Finally, we include in the set of exogenous variables a constant and a time trend, and the selected optimal lag length is 2. The quarterly sample covers the period 1957:1-2008:3 for which data are available at quarterly frequency for all the variables we consider. As unconventional monetary policy started to be implemented in 2008:4, we do not consider data from that period onwards.

5. Empirical results

5.1. All commodity prices

We identify the monetary policy shocks by imposing the recursive assumptions defined in Equation (4) and estimate the BSVAR represented by Equations (1) and (2). Figure 1 plots the impulse-response functions to a positive shock in the interest rate and when we use an aggregate commodity price index. The solid line corresponds to the point estimate, while the dotted line represents the median response. On the other hand, the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain (MCMC) algorithm based on 10000 draws.

It can be seen that an unexpected increase of 30 basis points in the interest rate (contractionary policy) leads to an immediate fall in the broad commodity price index as a result of the ensuing contraction in economic activity. This is due to an increase in the cost of cred-

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22 For brevity, we do not report the BSVAR estimates. However, they are available upon request.
its to both consumers and producers. Then the response of the commodity price index to the monetary policy shock is positive between the third and the sixth quarters – thereby, displaying some overshooting – before it becomes negative again. The overshooting could be the result of overreaction or speculation. The negative commodity price response is more obvious in about eight quarters after the shock strikes. This change in the response pattern could also be due to an aggregation bias or to counter shocks occurring later in time and causing higher expected inflation.

The results also suggest that following a contractionary monetary policy, both the GDP and its components (private consumption and private investment) fall, but the response comes with a lag. A negative effect occurs between six and 14 quarters after the shock occurs. The trough is reached after eight quarters and the impact is more pronounced in the case of private investment which usually moves with a lag relative to financial asset classes.

In addition, following the contractionary shock, the aggregate price level decreases and the growth rate of M₂ fall, reflecting the drop in liquidity. Interestingly, as the shock to the interest rate erodes and this rate even moves lower, the growth rate of the monetary aggregate starts to rise and becomes positive after about two quarters. This finding is in accordance with the works of Friedman (1968), Cagan (1972) and Sousa (2010), who describe this shape of the path of the short-term nominal interest rate following a monetary contraction as a short-lived liquidity effect that is followed by expected inflation and income effects.

[Insert Figure 1 about here]

The strategy for estimating the parameters of the model focuses on the portion of fluctuations in the data that is caused by a monetary policy shock. It is, therefore, natural to ask how large that component is. With this question in mind, Table 1 summarizes the percentage of the variance of the k-step-ahead forecast error due to an interest rate shock. Notice that the policy shocks account for a reasonable fraction of the variations in the commodity price index
(5% of the variations 20 quarters ahead, which is similar to the variations in the aggregate price level). Moreover, these shocks are responsible for 6.4% of the variations in private investment and 9.7% of the variations in the growth rate of the monetary aggregate 20 quarters ahead.

[Insert Table 1 about here]

5.2. Non-fuel commodity prices

We now replace the aggregate commodity price index with the non-fuel commodity price index in the BSVAR. Figure 2 displays the impulse-responses to the monetary contraction shock. The empirical findings suggest that a 30 basis points shock to the federal funds rate lead to an initial increase in the prices of non-fuel commodities. However, this effect later reverts path and becomes negative after eight quarters. One possible explanation of this swinging behaviour is that the interested rate shock is first initiated to deal with a heating economy with rising prices due to a prevailing strong demand, which later reverses course because of the subsequent deepening of the contractionary effect. This may also have to do with the swing behaviour of interest rate after a shock to itself which exhibits a temporary liquidity effect.

We also find that the positive interest rate shock has a contractionary effect on both the level and the composition of the real output, being particularly large in the case of private investment, which falls by 0.5% in eight quarters after the occurrence of the shock. As before, the shrink in liquidity is temporary, as the interest rate falls in a persistent manner in six quarters after the shock and the growth rate of M₂ becomes positive after four quarters, probably of consequent corrective measures.

[Insert Figure 2 about here]

Table 2 provides a summary of the forecast-error variance decomposition due to the interest rate shock. While the policy shock explains 5% of the variations of non-fuel prices in
the four-quarter and the eight-quarter horizons, that fraction falls to 3.8% in the 20-quarter horizon. As in the case of the aggregate commodity price index, the interest rate shock is responsible for relatively large variations in the private investment (6.5%) and the growth rate of the monetary aggregate (8.6%) 20 quarters ahead.

[Insert Table 2 about here]

In order to have a deeper assessment of the impact of monetary policy on non-fuel commodity prices, we replace the non-fuel commodity price index in the BSVAR model with (i) food prices, (ii) beverage prices, (iii) prices of agricultural raw materials, and (iv) prices of metals. More specifically, the BSVAR is re-estimated each time a specific item of the non-fuel commodity price index is included in the system. For brevity, we only plot the response of the various prices of non-fuel commodities to the positive interest rate shock (Figure 3).³

It can be seen that the volatile food prices rise on the impact and the largest effect (about 1.5%) occurs four quarters after the monetary contraction. The effect is also persistent, as food prices remain higher than their initial level for almost 12 quarters. This behaviour may have to do with the reason for initiating the monetary shock which could be high inflation expectations coupled with very low supply elasticity for food in the short-run which makes food prices very volatile.

Our results also show that an unexpected increase of 30 basis points in the Federal funds rate has a negative impact on beverage prices, which occurs between four and eight quarters after the shock hits. This suggests that beverages have more elastic price demand elasticity than food. Moreover, the swinging behaviour of the interest rate may have something to do with it.

In the case of the prices of agricultural raw materials, we find that after an initial and brief increase in the response to the monetary policy shock, they fall below their initial level

³ The impulse-response functions for all the variables included in the system are available upon request.
at the horizon of eight quarters then they start to turn up. This behaviour mirrors the response of the interest rate to its own shock but these prices turn up faster than the interest rate. This may show that the drop in the interest rate persists, which leads to a turnaround in those prices.

We also show that an unexpected increase in the federal funds rate has a persistent and negative effect on the metal prices, suggesting that the policy action is motivated by higher inflation expectations. The increases in interest rates have impacts on cyclical metals through the business cycles. After a lag of about four quarters, these prices start to fall in reaction to the monetary tightening. They achieve a trough of a nearly -3% in about 10 quarters after the shock, and they remain lower than their initial level in the 20-quarter horizon. The metals prices are cyclical in nature and react to changes in structures which are sensitive to interest rates.

[Insert Figure 3 about here]

In Table 3, we report the forecast-error variance decomposition due to the monetary contraction. As before, we only present the portion of fluctuations in the non-fuel commodity prices that are caused by a monetary policy shock. At the eight-quarter horizon, the policy shock accounts for 10.8% of the variation in food prices. The monetary policy explains 4.7% of the variation in the beverage prices, 4% of the variation in the prices of agricultural raw materials, and 7.8% in the variation in the metal prices at the 20-quarter horizon.

[Insert Table 3 about here]

5.3. Fuel (energy) commodity prices

As a final assessment, we investigate the impact of a positive shock to the federal funds rate on fuel (energy) commodity prices. Figure 4 plots the impulse-response functions. Similar to the prices of metals, we find that a monetary contraction leads to a persistent fall in fuel (energy) commodity prices. This result can be explained by the income elasticity and en-
ergy intensity of energy in the economy. Consumption of energy is considered a discretionary expense.

Moreover, while we do not find a significant impact of the monetary policy shock on the real GDP and the private consumption, the private investment falls by about 0.5% in the eight-quarter horizon. This implies energy conservation is a possible energy policy.

In addition, the positive interest rate shock has a negative and persistent effect on the aggregate price level, albeit small in magnitude: the aggregate price is 0.1% below its initial level 12 quarters after the shock.

Finally, and in accordance with the previous estimations, the empirical findings suggest that the impact of monetary policy on liquidity conditions is temporary and the Fed funds rate falls below its initial level about six quarters after the shock.

[Insert Figure 4 about here]

In Table 4, we present the forecast-error variance decomposition due to the interest rate shock. At the 20-quarter horizon, the policy shock accounts for 5.8% of the variation in the fuel (energy) commodity prices; 10.3% of the variance of the forecast-error of the growth rate of M₂; 6.2% of the variation of the aggregate price deflator; and 6% of the variation of the private investment.

[Insert Table 4 about here]

5. Conclusion

Understanding the relationship between monetary policy and asset price dynamics is of paramount importance to decision-making process for many economic agents. Changes in monetary policy should influence asset prices and may cause and burst bubbles. Indeed, changes in the policy interest rate directly affects the liquidity conditions and commodity prices in the economy as well as other macroeconomic aggregate such as production and con-
sumption. In particular, Bernanke and Gertler (1999) argue that an effective monetary policy should consider price stability and financial stability as complementary and mutually consistent objectives because it can help not only to promote economic growth and but also to avoid harmful effects from asset price booms and bursts.

This article attempts to assess the effects of the monetary policy in the United States on commodity prices by means of a Bayesian SVAR model, instead of a standard VAR model used in previous studies. Commodity price developments are represented not only by an all commodity price index, but also by price indices of different subsets of commodities. Our empirical framework first allows us to identify the structural shocks to monetary policy, captured by unexpected variations in the federal fund rate, and then to quantify the effects of these shocks on the various commodity prices we consider. This is helpful since we can account for uncertainty about the probability distributions of the variables in the system when it comes to estimating the impulse-response functions.

Our main empirical findings over the study period from January 1957 to March 2008 indicate that a contractionary shock to the US monetary policy affects significantly and negatively the aggregate commodity prices and that the effect of this shock clearly takes place with a substantial lag that comes to eight quarters. This negative relationship between the policy interest rate and the all-commodity price index is consistent with the results of previous studies (e.g., Frankel and Hardouvelis, 1985; Belke et al., 2014).

Furthermore, we show that a monetary policy shock leads to heterogeneous responses from different types of commodities, which should depend on the characteristics of the particular commodity market such as future prices expectations, storability of the commodity and demand for commodity inventories. Thus, an increase in policy interest rate leads to a positive and persistent rise in the highly volatile food prices which could be caused by higher costs of credit for a necessity good with lower demand elasticity. On the other hand, it causes a fall in
the prices of beverage which are part of discretionary spending and have more elastic demand. It also leads to a persistent reduction in the prices of metals which are highly cyclical and the prices of fuel (energy) prices which are affected by the demand for energy that follows economic activity. The changes in the prices of non-fuel commodities following a positive shock to the US monetary policy have a more complex impact as they first increase and then revert path and turn back negative. The same pattern is found for the prices of agricultural raw materials which are affected by the weather conditions and the states of the business cycle.

Our analysis corroborates the importance of the US monetary policy as a key driver of international commodity prices. In particular, it suggests that the surge in commodity prices that one observed before the financial turmoil of 2008-2009 may be attributed to a relatively abnormal period of excess liquidity (as proxied by low real interest rates). Moreover, shocks to the US policy rates can be a valuable indicator of the variations in commodity prices.

From a policy perspective, our work shows that when designing and implementing its policy, the monetary authority should take into account the diverse nature of the response of the prices of the various types of commodities. For instance, an interest rate hike aimed at counterbalancing the effects of a rise in the beverage prices or in the prices of metals and fuel (energy) commodities can have destabilizing effects on the food prices.
References


### Table 1. The percentage variance due to a positive interest rate shock: aggregate commodity price.

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<tr>
<th></th>
<th>1 Quarter ahead</th>
<th>4 Quarters ahead</th>
<th>8 Quarters ahead</th>
<th>20 Quarters ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity price</td>
<td>0.0</td>
<td>2.2</td>
<td>4.0</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[1.3; 3.6]</td>
<td>[2.6; 6.0]</td>
<td>[2.9; 7.7]</td>
</tr>
<tr>
<td>GDP</td>
<td>0.0</td>
<td>1.7</td>
<td>3.1</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.9; 3.1]</td>
<td>[1.8; 4.7]</td>
<td>[2.6; 7.0]</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.0</td>
<td>1.5</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.8; 2.8]</td>
<td>[1.4; 4.0]</td>
<td>[2.0; 6.1]</td>
</tr>
<tr>
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<td>1.5</td>
<td>4.7</td>
<td>6.4</td>
</tr>
<tr>
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<td>[0.8; 2.7]</td>
<td>[2.7; 7.6]</td>
<td>[3.9; 9.6]</td>
</tr>
<tr>
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<td>0.0</td>
<td>1.1</td>
<td>3.0</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.6; 2.1]</td>
<td>[1.4; 5.7]</td>
<td>[2.6; 9.1]</td>
</tr>
<tr>
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<td>23.0</td>
<td>14.5</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>[56.8; 66.6]</td>
<td>[19.1; 28.1]</td>
<td>[11.6; 18.4]</td>
<td>[9.6; 18.4]</td>
</tr>
<tr>
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<td>5.9</td>
<td>8.6</td>
<td>10.5</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>[3.9; 8.3]</td>
<td>[6.1; 11.8]</td>
<td>[8.0; 13.9]</td>
<td>[7.1; 12.9]</td>
</tr>
</tbody>
</table>

Notes: The median and the 68% probability bands (in square brackets) are computed using a Markov-Chain Monte Carlo (MCMC) algorithm.

### Table 2. The percentage variance due to a positive interest rate shock: non-fuel commodity prices.

<table>
<thead>
<tr>
<th></th>
<th>1 Quarter ahead</th>
<th>4 Quarters ahead</th>
<th>8 Quarters ahead</th>
<th>20 Quarters ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity price</td>
<td>0.0</td>
<td>5.0</td>
<td>5.0</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[2.5; 8.2]</td>
<td>[3.3; 7.3]</td>
<td>[2.5; 6.1]</td>
</tr>
<tr>
<td>GDP</td>
<td>0.0</td>
<td>1.9</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.9; 3.4]</td>
<td>[2.5; 6.1]</td>
<td>[2.5; 6.8]</td>
</tr>
<tr>
<td>Consumption</td>
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<td>2.3</td>
<td>3.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[1.3; 4.2]</td>
<td>[2.1; 5.3]</td>
<td>[1.8; 5.5]</td>
</tr>
<tr>
<td>Investment</td>
<td>0.0</td>
<td>1.2</td>
<td>5.8</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.6; 2.3]</td>
<td>[3.4; 9.3]</td>
<td>[4.1; 9.3]</td>
</tr>
<tr>
<td>Deflator</td>
<td>0.0</td>
<td>0.9</td>
<td>1.9</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.4; 1.7]</td>
<td>[1.0; 3.5]</td>
<td>[2.0; 6.3]</td>
</tr>
<tr>
<td>Interest rate</td>
<td>67.8</td>
<td>22.4</td>
<td>14.0</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>[62.7; 72.4]</td>
<td>[18.3; 27.2]</td>
<td>[11.0; 17.1]</td>
<td>[10.5; 17.8]</td>
</tr>
<tr>
<td>$M_2$</td>
<td>7.3</td>
<td>6.4</td>
<td>8.3</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>[5.0; 10.1]</td>
<td>[4.7; 8.5]</td>
<td>[6.3; 10.9]</td>
<td>[6.3; 11.0]</td>
</tr>
</tbody>
</table>

Notes: The median and the 68% probability bands (in square brackets) are computed using a Markov-Chain Monte Carlo (MCMC) algorithm.

### Table 3. Percentage variance due to a positive interest rate shock: The food prices, beverage prices, agricultural raw materials and metals prices.

<table>
<thead>
<tr>
<th></th>
<th>1 Quarter ahead</th>
<th>4 Quarters ahead</th>
<th>8 Quarters ahead</th>
<th>20 Quarters ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food prices</td>
<td>0.0</td>
<td>8.4</td>
<td>10.8</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[5.2; 11.9]</td>
<td>[7.2; 14.9]</td>
<td>[4.0; 10.1]</td>
</tr>
<tr>
<td>Beverage prices</td>
<td>0.0</td>
<td>2.3</td>
<td>4.6</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[1.4; 3.6]</td>
<td>[2.9; 7.1]</td>
<td>[3.1; 6.8]</td>
</tr>
<tr>
<td>Agricultural raw materials</td>
<td>0.0</td>
<td>1.8</td>
<td>3.1</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[1.0; 3.2]</td>
<td>[2.0; 4.5]</td>
<td>[2.5; 5.8]</td>
</tr>
<tr>
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<td>0.0</td>
<td>2.0</td>
<td>6.5</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[1.3; 3.4]</td>
<td>[4.3; 9.4]</td>
<td>[4.9; 11.8]</td>
</tr>
</tbody>
</table>

Notes: The median and the 68% probability bands (in square brackets) are computed using a Markov-Chain Monte Carlo (MCMC) algorithm.
Table 4. The percentage variance due to a positive interest rate shock: fuel (energy) commodity prices.

<table>
<thead>
<tr>
<th></th>
<th>1 Quarter ahead</th>
<th>4 Quarters ahead</th>
<th>8 Quarters ahead</th>
<th>20 Quarters ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity price</td>
<td>0.0</td>
<td>2.4</td>
<td>4.4</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[1.5; 4.0]</td>
<td>[2.7; 6.9]</td>
<td>[3.6; 8.9]</td>
</tr>
<tr>
<td>GDP</td>
<td>0.0</td>
<td>1.7</td>
<td>2.8</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.9; 3.0]</td>
<td>[1.6; 4.5]</td>
<td>[2.4; 7.3]</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.0</td>
<td>1.6</td>
<td>2.8</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.9; 2.8]</td>
<td>[1.5; 4.4]</td>
<td>[2.3; 7.2]</td>
</tr>
<tr>
<td>Investment</td>
<td>0.0</td>
<td>1.5</td>
<td>4.1</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>[0.0; 0.0]</td>
<td>[0.8; 2.7]</td>
<td>[2.3; 6.6]</td>
<td>[3.7; 9.0]</td>
</tr>
<tr>
<td>Deflator</td>
<td>0.0</td>
<td>1.1</td>
<td>3.6</td>
<td>6.2</td>
</tr>
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<td></td>
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<td>[0.6; 2.2]</td>
<td>[1.7; 7.1]</td>
<td>[3.2; 10.5]</td>
</tr>
<tr>
<td>Interest rate</td>
<td>57.0</td>
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<td>15.7</td>
<td>13.8</td>
</tr>
<tr>
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<tr>
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<td>9.1</td>
<td>11.9</td>
<td>10.3</td>
</tr>
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<td>[3.2; 7.4]</td>
<td>[6.6; 11.8]</td>
<td>[8.9; 15.4]</td>
<td>[7.7; 13.3]</td>
</tr>
</tbody>
</table>

Notes: The median and the 68% probability bands (in square brackets) are computed using a Markov-Chain Monte Carlo (MCMC) algorithm.
Figure 1. Impulse-response functions to a positive interest rate shock: aggregate commodity price.

Figure 2. Impulse-responses functions to a positive interest rate shock: non-fuel commodity prices.
Figure 3. Impulse-response functions to a positive interest rate shock: The food prices, beverage prices, prices of agricultural raw materials and metals prices.

Figure 4. Impulse-responses function to a positive interest rate shock: fuel (energy) commodity prices.