Macroeconomics and the Nexus between Energy and Agricultural Commodities Prices

R.D. WEAVER AND JIACHUAN TIAN

JANUARY 2015

PRESENTATION AT
9th Intern. European Forum on System Dynamics and Innovation in Food Networks,
Igls/Innsbruck, Austria, February 09-13, 2015

ABSTRACT

The variation of energy prices has been a traditional source of shocks to the real economy. In many cases, this variation has manifested in jumps in energy prices that were characterized by some persistence. From another perspective, energy price volatility has historically been noted and its effects on real economy debated. Historically, the importance of the shocks to the real economy has led them to be labeled as energy crises, as they were argued to have resulted in substantial changes in real prices that induced changes in behavior on the demand and supply sides of the many markets. However, empirical studies of transmission of energy prices into the real economy have been challenged by a number of significant specification issues that have resulted in substantial variation in inference drawn from results. Among these issues is the question of completeness of model specification. This paper examines the question of whether such models need to incorporate macroeconomic indicators. Clearly, macroeconomic factors such as interest rates and exchange rates play a role in the determination of energy and commodity prices, however, considerable specification uncertainty characterizes the question of which macro metrics to incorporate. This paper examines this issue from the perspective of weak exogeneity and finds evidence that the parameter estimates associated with time series models that exclude consideration of macro indicators are not compromised by their exclusion. We examine this issue using Italian, U.S. grain, and Brent crude oil prices.

INTRODUCTION

Over the past decades, the nexus of food and energy systems has received periodic though persistent attention as unanticipated events have resulted in short-lived jumps or persistent shifts in levels, trends, or volatility. The prices of agricultural commodities have increased dramatically from 2005 to 2008 (Gilbert, 2008; Headey and Fan, 2008). The prices of a wide range of agricultural commodities more than doubled in this period (Gilbert, 2008). The 2005-2008 food crisis has received large attention and a wide of range of explanation including demand growth, monetary expansion, exchange rate and energy price transmission. Yet the causation of these prices increases remains controversial. Several streams of literature has considered food price dynamics. More recently, energy prices have plummeted joined by substantial decreases in most commodity prices. Piesse and Thirtle (2009) argues that low stock to utilization ratio is "the key variable" to explain food price increases. Trostle (2010) confirms Thirtle's argument as well as reviews other factors on agricultural commodities demand and supply. Another stream has argued energy price shocks are transmitted into the real economy and have induced response in other commodity prices including food prices. Mitchell (2008) notes that food production costs increase due to higher energy prices. He also concludes that the large increase in biofuel production has reduced field crop production directed toward food. Headey and Fan (2008) conclude that high oil prices and the use of biofuel are crucial factors. Other literature has considered the causal effects of macroeconomy performance and policy on commodity prices such as food and energy. Gilbert (2008) confirms the effect of GDP growth on the rising demand of food commodities. Trostle (2010) also mention that rapid global economic growth continues to put upward pressure on food commodity prices through increases in food demand. Piesse and Thirtle (2009) argues that policy changes to reduce supply and stocks (decreasing subsidies, cutting agricultural R&D investments)and to increase demand (promoting use of biofuels in US and EU) are factors resulting the price increase. Frankel (2006) examines the effect of monetary policy on real commodity prices and concludes that low real interest rates lead to high real commodity prices.

On the one hand, the importance of the energy price shocks to the real economy has led them to be labeled as energy crises, as they were argued to have resulted in substantial changes in real effects on productivity, output, employment, and prices that induced changes in behavior on the demand and supply sides of the many markets. Thus, these arguments focus on the causal role of energy price shocks on the macro economy. Indeed, Hamilton's (1983) suggestion that oil price shocks were the predominant cause of recessions in the post-War period continues to be examined and debated. For several decades, the sheer magnitude of oil price shocks has understandably peaked interest in establishing their real effects. Most notable among these crises were those in 1973 following an OPEC embargo, those following political and social disruptions and war include those 1979 following the Iranian revolution, the global oil excess supply that followed as energy demand responded to high prices, the 1990 oil price shock coincident with the Iraqi invasion of Kuwait, a decade long crisis at the start of new millennium associated with a series of unanticipated events that led to a nearly five-fold increase in oil prices. Most recent experience include the rapid decline in crude oil prices as alternative sources of petroleum fuels were developed since the start of the new millennium. However, these crude oil price changes were accompanied by a rapid decrease in Asian economic growth that resulted in a general decrease in demand for energy and other commodities.

To explain changes in food prices that may have been induced by energy prices, just looking at their empirical evidence of price transmission may not be adequate. There are a wide range of factors (including macroeconomic factors) that could affect food and energy prices. In the food price literature, Serra and Zilberman (2013) pointed out that macroeconomic conditions are very important because of their impact on agricultural commodity price levels and volatility. Headey and Fan (2008) conclude that export restrictions, depreciation of USD, weather shocks and low interest rates are important factors of food prices showing evidence of causality as well as oil prices and biofuels. Gilbert (2010) investigates exchange rates, monetary factors, future markets and oil prices as potential causes of food prices. He concludes that world GDP growth, monetary expansion and exchanges rate are significant determinants of changes in world agricultural prices over a 38-year period. On the energy prices side, Hamilton (2009) argue that exchange rate, real income and GDP significantly affect crude oil prices. Anzuini et al. (2012) estimate a VAR to explore the the effects of US monetary policy on commodity prices and find a strong positive relationship. Roache (2010) finds evidence of transmission from US inflation and the US dollar exchange rate into food commodity prices. Doenmez and Magrini (2013) estimate the link between macroeconomic variables and commodity price volatility and find inclusion of macroeconomic variables improves explanation of price volatility. Within the context of the nexus between energy and food prices, the necessity of considering the role of macroeconomic indicators has also been noted by Harri et al. (2009), Cooke (2009), Balcombe (2011), Gohin (2010), and Wright (2011).

Despite these past studies, the question must be raised whether the nexus between energy and food commodity prices can be explored independent of consideration of macroeconomic factors. This paper focuses on the cointegration of energy and food prices and within this context takes on this question by reconsidering the weak exogeneity of macroeconomic indicators. The paper is organized as follows. In the next section, we briefly summarize key literature relevant to our research question. We highlight three specification issues that have varied substantially across the literature: 1) inclusion of variables, 2) nonlinearity in functional form, and 3) frequency of data employed. We next present our approach, followed by our results and conclusions.

PREVIOUS LITERATURE

Hamilton (2009) summarized previous studies of the role of macroeconomic factors and oil prices and concludes that income and price elasticity of the demand of petroleum are both below unity at least in developed, industrialized countries. Such price inelasticity suggests oil price changes can be readily transmitted into real economy including commodity prices. As oil prices increase, if consumption does not respond, the cost effects will be transmitted throughout the vertical chains in which petroleum products are critical inputs. Estimates of the income inelasticity of petroleum demand suggest insensitivity of oil prices to macroeconomic. Hamilton further notes that U.S. data suggests that as GDP per capita increases, the income elasticity declines. Nontheless, Hamilton notes that a large range of macro-economic factors and conditions could affect crude oil price including commodity price speculation, strong world demand, time delays or geological limitation on increasing production, OPEC monopoly pricing and scarcity rent. However, he concludes the three most important factors to explain the high price of oil in 2008 are low price elasticity of demand in industrialized countries, the strong growth of demand for oil in newly industrialized economies where income elasticity of demand is positive, and an absence of global supply response to price increases. Gohin and Chantret (2009) employ a world Computable General Equilibrium (CGE) model to investigate macro-economic linkages in the long-run impart of energy prices on world agricultural markets. They conclude that the introduction of the real income may imply a negative relationship between world food and energy prices. They also conclude that both supply and demand factors are important in the long-run evolution of energy prices. As for the effect of economic growth on food commodity prices, Gilbert (2008) presents evidence of a strong effect of GDP growth on the rising demand of food commodities. Trostle (2010) also mention that rapid global economic growth continues to put upward pressure on food commodity prices through increases in food demand.

Many studies have investigated the role of exchange rate dynamics and oil prices. Chen and Chen (2007) investigate the long-run relationship between real oil prices and real exchange rates using panel data. They test the cointegration of real exchange rates and oil prices using monthly data on the G7 countries from 1972:1 to 2005:10. They show that the real oil prices may have been the dominant cause of real exchange rate movements during that period. They also conclude real oil prices have significant forecasting power for exchange rates. In contrast, Ferro et al. (2012) investigate whether oil prices have a reliable and stable out-of-sample relationship with the Canadian/U.S dollar nominal exchange rate. They find little systematic relation between oil prices and this exchange rate at the monthly and quarterly frequencies. However, they find the existence of such relationship at daily frequency. Beckman and Czudaj(2012) employ a multivariate Markov-Switching vector error correction model (MS-VECM) and test for bidirectional causality between oil prices and exchanges rates. They contribute to literature in two aspects. First, they investigate the relation between oil prices and nominal exchange rates. Secondly, they are able to discriminate between long-run and short-run dynamics by using MS-VECM. They conclude different and also time-varying causalities results across different countries. In general, their results support the existence of a bidirectional dynamic relation between oil price and exchange rates.

On the other hand, only a very limited literature has investigated the role of exchange rates in the energy-food price transmission. Baek and Koo (2009) investigated the short- and long-run effects of market factors (prices of energy, agricultural commodities and exchange rate) on U.S. food commodity prices using a cointegration analysis. They conclude that agricultural commodity prices play a key role in affecting the short- and long-run behavior of U.S. food prices. They also conclude that energy prices and exchange rate have been significant factor influencing U.S. food prices in recent years in both the short- and long-run. Harri et al. (2009) investigate the relationship between oil price, exchange rates and commodity prices including agricultural commodities. Using time series VECM model, they conclude that oil price, corn price and exchange rates are interrelated. They also identified long-run relationships (cointegrations) between oil prices and all agricultural prices except wheat. Nazlioglu and Soytas (2011) use panel cointegration method to model exchange rate, energy and commodity prices. They conclude that considering the exchange rate there is strong evidence of transmission from world oil prices to several agricultural commodity prices. They also conclude that the exchange rate has an impact on agricultural prices. Serra and Zilberman (2013) noted that a spectrum of macroeconomic conditions may impact on agricultural commodity price levels and volatility. The need to consider multiple macroeconomic indicators when investigating the nexus energy-food price levels and volatility transmission was also highlighted by Harri et al. (2009), Cooke (2009), Balcombe (2011), Nazilouglu (2011) and Wright (2011). Summarizing, evidence of roles of multiple macroeconomic indicators in affecting the nexus between energy and food prices has been reported including real and nominal exchange rates (Chen and Chen, 2007; Baek and Koo, 2009; Harri et al. 2009; Hamilton, 2009; Beckman and Czudaj, 2012), real income (Gohin and Chantret, 2009; Hamilton, 2009) and GDP (Hamilton, 2009).

Another stream of literature has considered existence of a direct effect of exchange rates on agricultural commodity prices. Almost all international commodities are traded in US dollars. It follows that dollar depreciation results in an increase in commodities prices dominated in US dollars. Over 2005- 2008, the dollar depreciated by around 25% against the euro but much less against other currencies. The likely dollar depreciation effect was therefore small but should be evident (Gilbert, 2008). Rilder and Yandle (1972) investigate the impact of exchange rates on commodity prices and develop a model: $dlnp = -(1 - v_1)\theta$ where θ is dollar depreciation rate and v_1 is the price elasticity of the agricultural commodity. Thus, they conclude that dollar price rise in proportion to the dollar depreciation by one minus elasticity. Gilbert later (1989) shows this result to be robust in general cases and concludes dollar depreciation increases commodity prices with an elasticity of between 0.5 and 1.0. Mitchell (2008) suggested that the depreciation of the dollar has increased food prices by around 20%, assuming an elasticity of 0.75. Abbott et al. (2008) also show that in the current crisis the divergence between the dollar and many other currencies is quite stark compared to previous increases in nominal dollar denominated food price increases. He also shows that agricultural commodity exports (particular grain and oilseeds) increase when dollar depreciates.

Monetary explanations of changes in price levels and relative prices have received wide support in 1970-1980s (Gilbert, 2008). Bordo (1980) consider the impact of monetary growth on agricultural prices and concludes that monetary expansion could raise agricultural prices relative to a more general price deflator. Chambers and Just (1982) confirm Bordo's finding. However, Gilbert (2008) notes that 2005-2008 boom in agricultural prices took place contemporaneous with booms in other commodities prices as well as with equity and real estate price booms. He concludes that monetary growth may spill over into asset prices as well as commodity prices. Browne and Cronin (2010) also investigate the relationship between commodity prices, money and inflation. Using a cointegating VAR approach and US data, they conclude that both commodity and consumer prices rise proportionally to the money supply growth in the long run.

Literature has also considered the possible effects of both nominal and real interest rates on commodity prices. Some literature argues that low real interest rates have an effect on the commodities prices. Frankel (2006) argues that low real interest rate caused a general price increase in a wide range of commodities during the period of 1950-2005. He indicates that low interest rates reduce storage cost thereby increasing the demand for storable commodities, and encourage speculators to shift out of treasury bills and into commodity contracts. Each results in an increase in commodities prices. Frankel (2006) also investigates such relationships and concludes that low real interest rates lead to high real commodity prices. However, Headey and Fan (2008) argue that low interest rates may be a less convincing factor than the depreciation of USD. Akram (2009) investigate the recent (2005-2008) fluctuations in commodity prices based on structural VAR models estimated on quarterly data over 1990q1-2007q4. They show that commodity prices increase significantly in response to reduction in real interest rates.

With respect to methods, three issues have been addressed with respect to examination of the nexus between energy and food prices. First, a multivariate approach would seem to be motivated by evidence of a relationship between macroeconomic indicators and the agricultural commodities and energy price nexus. However, considerable specification uncertainty exists with respect which macro indicators should be considered. Second, the functional form of any relationships is not resolved by theory and introduces further specification uncertainty. Given the results from Phillips curve studies (see Hamilton (2010) for a summary), it is not surprising that functional form might constitute an important specification for study of energy price transmission to other prices. Our past research also shows that functional form is a critical specification that conditions inference. Using weekly agriculture commodity prices and weekly UK Brent Blend spot price from January 2000 through December 2010, we found very different causality inferences using linear and nonlinear causality tests. Thus, in considering the macroeconomic conditions in the nexus of food and energy prices, one has to investigate the problem of nonlinearity (this is also noted by Beckman and Czujaj (2012)). In our case, this includes testing for structural breaks using a series of nonparametric tests (CUSUM, MOSUM, sup-F, and exp-F) as well as testing nonlinear causilty using TY test (Toda and Yamaoto, 1995) and DP test (Diks and Panchenko, 2006). Third, the frequency of data used would seem a critical specification issue that will condition inference. Most past studies in this area use low frequency data (daily, weekly, monthly). This is mainly because of the relative stability of macroeconomic conditions in short run as well as the availability of data.

APPROACH

Fundamentally, a key area of uncertainty in modeling transmission across prices is the specification of the determinants of the impacted price. That is, in a vertical chain, the downstream price can be related to the upstream price, however, other factors must also be considered, at least theoretically. In the current context, to explore the nexus between energy and food commodity prices would seem to demand a full specification of the determinants of food commodity prices. Economic systems often include substantial numbers of variables and motivate interest in specification and estimation of parts of such systems. Indeed, where specification of the overall system is uncertain, or where interest focuses only on a subsystem such partial systems are both of interest and may allow explicit consideration of the scope of an uncertain system. This opens the question of under what conditions estimation of a subsystem provides useful information (consistency and efficiency) concerning parts of a larger system. Johansen (1992) introduced the concept of weak exogeneity to respond to this question. Our approach is based on exploiting this concept of weak exogeneity to examine existence of conditions which would obviate the need to consider macro indicators while exploring the nexus between energy and food commodity prices.

Consider a full linear system representing the transmission of cointegrated prices. We can write such a system in the form of a vector error correction model (VECM):

$$\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \alpha\beta' X_{t-k} + \phi D_t + \mu + \varepsilon_t, t = 1, .., T$$

where $X_{-k+1}, .., X_0$ are fixed and $\varepsilon_1, \dots, \varepsilon_T$ are independent p-dimensional Gaussian variable with mean zero and variance matrix Λ. The vector D_t denotes seasonal dummies centered at zero. The parameters in the model are short-run effects $\Gamma_1, \dots, \Gamma_{k-1}$, the seasonal coefficients ϕ, the constant term μ, the covariance matrix Λ, the $p\times r$ matrices α (the adjustment coefficients) and β (the cointegrating relations). It is often the case that the econometrician is unable to specify or measure all elements of the full system represented by the VECM. Such model uncertainty leads to estimation of what we could call a "partial system" and implicitly defines a "residual system" that is left out of consideration. Granger's definition of weak exogeneity allows us to consider implications of estimation of the partial system when the partial system excludes variables in the residual system.

Let a be a $p\times m$ full rank selection matrix that we can use to define the partial system given the full system. Let $b = a_\perp$ be a $p\times(p-m)$ full rank matrix of vectors orthogonal to a that we use to define the residual system. To investigate the weak exogeneity of the residual system $b'\Delta X_t$, relative to the partial system, we need to consider the conditional expectation of the partial system outcomes $a'\Delta X_t$ conditional on those of the residual system $b'\Delta X_t$. To derive this, by pre-multiplication of the full VECM, we have the conditional expectation $a'\Delta X_t$:

$$E(a'\Delta X_t | b'\Delta X_t, \Delta X_{t-1}, \dots, \Delta X_{t-k+1}, \Delta X_{t-k})$$
$$= (a - b\Lambda_{bb}^{-1}\Lambda_{ba})'(\sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \alpha'\beta X_{t-k} + \phi D_t + \mu) + \Lambda_{ab}\,\Lambda_{bb}^{-1} b'\Delta X_t$$

and

$$var(a'\Delta X_t | b'\Delta X_t, \Delta X_{t-1}, \dots, \Delta X_{t-k+1}, \Delta X_{t-k}) = \Lambda_{aa} - \Lambda_{ab}\Lambda_{bb}^{-1}\Lambda_{ba} = \Lambda_{aa.b}$$

where $\Lambda_{aa} = a'\Lambda a, \Lambda_{ab} = a'\Lambda b, etc.$

Thus, by adding a random error, we can write such an error in terms of that of the partial and residual system parameters, i.e.

$$a'\Delta X_t = (a - b\Lambda_{bb}^{-1}\Lambda_{ba})'(\sum_{i=1}^{k-1}\Gamma_i\Delta X_{t-i} + \alpha'\beta X_{t-k} + \phi D_t + \mu) + \Lambda_{ab}\,\Lambda_{bb}^{-1}b'\Delta X_t + u_t, t = 1, \dots T$$

where $u_t = (a - b\Lambda_{bb}^{-1}\Lambda_{ba})'\varepsilon_t$ are independent Gaussian variables with zero mean and variance matrix $\Lambda_{aa.b}$. Granger called such model a partial VAR model or a conditional model for $a'\Delta X_t$ given $b'\Delta X_t$ and past information. Using this notation, Johansen defines weak exogeneity of $b'\Delta X_t$ for α and β as the parameters of the distribution of $a'\Delta X_t$ given $b'\Delta X_t$ and the past information $\Delta X_{t-1}, \dots, \Delta X_{t-k+1}, \Delta X_{t-k}$ are variation independent of parameters of the distribution of $\Delta X_{t-1}, \dots, \Delta X_{t-k+1}, \Delta X_{t-k}$(Johansen, 1992). In particular, note we can write $b'\Delta X_t$ as

$$b'\Delta X_t = \sum_{i=1}^{k-1} b'\Gamma_i\Delta X_{t-i} + b'\alpha\beta' X_{t-k} + b'\phi D_t + b'\mu + b'\varepsilon_t, t = 1, .., T$$

If $b'\alpha = 0$, then $b\,'\Delta X_t = \sum_{i=1}^{k-1} b'\Gamma_i\Delta X_{t-i} + b'\phi D_t + b'\mu + b'\varepsilon_t, t = 1, .., T$. This means $b'\Delta X_t$ does not contain information on the cointegration relations (vector β). Following the definition by Engle et.al (1983) and Johansen (1992), this indicates $b'\Delta X_t$ is weakly exogenous for the parameter vector (α, β). It has been shown that weak exogeneity of $b'\Delta X_t$ means the conditional distribution of ΔX_t given $b'\Delta X_t$ and $\Delta X_{t-1}, \dots, \Delta X_{t-k+1}, \Delta X_{t-k}$ contains parameters α and β, whereas the (un)distribution of $b'\Delta X_t$ given $\Delta X_{t-1}, \dots, \Delta X_{t-k+1}, \Delta X_{t-k}$ does not contain α and β (Johansen and Juselius, 1992). Intuitively, this property provides a basis for a nested parameter test of weak exogeneity.

Indeed, Johansen (1992) provides a parameter restriction that is implied by the condition of weak exogeneity. He shows that if $b'\alpha = 0$, then $b'\Delta X_t$ is weakly exogenous for the parameter (α, β). Hence the maximum likelihood estimator for (α, β) in the full model is the same as that in partial model. Equivalently, Johansen (1992) shows that the hypothesis of weak exogeneity of $Z_t = b'X_t$ for α and β can be formlateed as

$$H: \alpha_z = 0$$

From above, it is clear that Z may be of smaller dimension than X. We define α_z as composed of the rows of α corresponding to Z_t. Then, under the null hypothesis H, the maximum likelihood estimation of the parameters could be performed by reduced rank regression, and the rest of H in H_r: ($\Pi = \alpha'\beta$ where α and β are $p{\times}r$ matrices) consists in comparing the eigenvalues $\widehat{\lambda_\iota}$ and $\widetilde{\lambda_\iota}$, where $\widehat{\lambda_\iota}$ is eigenvalue without the restriction and $\widetilde{\lambda_\iota}$ is eigenvalue with the restriction respectively. The test statistic is

$$T\sum_{i=1}^{r}\ln\left\{\frac{(1-\widetilde{\lambda_\iota})}{(1-\widehat{\lambda_\iota})}\right\} \xrightarrow{d} \chi^2(rp_z)$$

where p_z is the dimension of Z_t.

RESULTS

We suspect macroeconomic factors may play a role in each bivariate VECM. To motivate the choice of the macroeconomic factors, we restrict our interest on those macroeconomic factors that can be directly adjusted by policies (e.g. interest rate, money supply, etc.) rather than macro performance indicators such as GDP growth or unemployment rates. We begin by consideration of money supply, exchange rate and interest rate to be our macroeconomic factors to consider.

TABLE-1 Bivariate Pair and Macro Factors (M2, 10 year maturity rate and US/EU exchange rate) Cointegration Weak Exogeneity Test Table

As Table 1 shows, money supply (M2) is not weakly exogenous in every pair of commodity and energy pair. In addition, the US/Euro exchange rate is found to be not exogenous in most pairs. These results imply that the money supply and exchange rate are endogenous within the system defined as commodity and energy prices and hence cannot be omitted models considering the cointegration of energy and commodity prices. The significant role of M2 plays in the price systems is consistent with monetary theories (Bordo 1980) and evidence from the agricultural commodity markets literature, e.g. Chambers and Just (1982), Gilbert (2008). Further, the result of exchange rate being endogenous is also consistent with findings reported in previous literature (Baek and Koo 2009, Gilbert 2008, Harri et al. 2009, Nazioglu and Soytas 2011).

Given the results in Table 1, we examine robustness of these results with respect to the set of macroeconomic variables included and reconsider weak exogeneity of exchange rate and interest rate play in the price transmission in a model that excludes M2. The logic for this exclusion follows from the intuition that M2 is key policy control target that may directly impact exchange and interest rates. Thus, if we restrict our interest to exchange and interest rates, the role of M2 may already be considered by variation of exchange and interest rates. In addition, we also reconsider the maturity length for interest rates following the intuition that short-run rates may be central to inventory decisions. From this perspective, we consider the role of short-run interest rates using a 3 month maturity.

TABLE-2 Cointegration Rank Table each bivariate pair with Macro-factors

TABLE-3 Cointegration Rank Table of each bivariate pair without Macro-factors

Table 3 reports cointegration ranks of bivariate VECM consisting of two price variables, while table 2 reports cointegration ranks of multivariate VECM consisting of the exact two price variables together with two macro factors (3 month maturity rate and exchange rate). Comparing cointegration ranks reported in two tables, we find the cointegration rank is not increasing as we add in macro-factors. This impies that the maro-factors are not significant in the bivariate VECM system and hence we may exclude them from estimation of bivariate VECMs consisting price variables only. To verify this inference, we conduct weak exogeneity test in the VECM.

TABLE-4 Bivariate Pair and Macro Factors (3-month Maturity Rate and US/EU exchange rate) Weak Exogeneity Test

For those VECMs with strictly positive cointegration rank as reported in Table 3, we test weak exogeneity of each variable in the four-variable VECMs. The results are reported in Table 4. As shown in Table 4, the short-run interest rate is not (weakly) exogenous in four of the bivariate pairs, while interest rate is (weakly) exogenous in every pair. This result basically agrees with the previous conclusion that we drew from the comparison of Table 2 and Table 3, that is we can exclude macroeconomic factors in bivariate VECM for further analysis.

CONCLUSIONS

This paper examines the question of whether empirical conditions exist that would suggest exclusion of key macroeconomic factors from models of price transmission will not compromise estimates based on simple models that restrict consideration of price transmission models to include prices only. The relevance of this issue is motivated by a now vast literature in both the agricultural economics literature and in the economics literature that examines price transmission using time series models that exclude other key determinants of prices. Clearly, structural modeling approaches could be used with the inclusion of all variables hypothesized by researchers as both exogenous as well as those endogenous variables that causally determine prices of interest. However, such approaches suffer ultimately from the specification uncertainty encompassing which variables to include, as well as functional form, etc. In this paper, we show that key macro economic variables such as interest rates and exchange rates appear to be weakly exogenous to crude and food commodity prices. Following Granger's work, this condition allows their exclusion from linear price transmission models without compromising desirable properties of the resulting estimators.

REFERENCES

Abbott, P. C., Hurt, C., & Tyner, W. E. (2009). *What's driving food prices? March 2009 Update* (No. 48495). Farm Foundation.

Akram, Q. F. (2009). Commodity prices, interest rates and the dollar. *Energy Economics*, *31*(6), 838-851.

Alessio Anzuini, Marco J. Lombardi and Patrizio Pagano (2012)The impact of monetary policy shocks on commodity prices. Working Paper. Banca d'Italia

Balcombe, K. (2009). The nature and determinants of volatility in agricultural prices.

Baek, J., & Koo, W. W. (2010). Analyzing factors affecting US food price inflation. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, *58*(3), 303-320.

Beckmann, J., & Czudaj, R. (2013). Oil prices and effective dollar exchange rates. *International Review of Economics & Finance*, *27*, 621-636.

Borensztein, E., & Reinhart, C. M. (1994). The macroeconomic determinants of commodity prices. *Staff Papers-International Monetary Fund*, 236-261.

Browne, F., & Cronin, D. (2010). Commodity prices, money and inflation.*Journal of Economics and Business*, *62*(4), 331-345.

Chen, S. S., & Chen, H. C. (2007). Oil prices and real exchange rates. *Energy Economics*, *29*(3), 390-404.

Cooke, B. (2009). *Recent food prices movements: A time series analysis* (Vol. 942). Intl Food Policy Res Inst.

Diks, C., & Panchenko, V. (2006). A new statistic and practical guidelines for nonparametric Granger causality testing. *Journal of Economic Dynamics and Control*, *30*(9), 1647-1669.

Doenmez, A. and E. Magrini (2013) Agricultural Commodity Price Volatility and its Macroeconomic Determinants. JRC Technical Report. European Commission Joint Research Centre Institute for Prospective Technological Studies

Engle, R. F., Hendry, D. F., & Richard, J. F. (1983). Exogeneity. *Econometrica: Journal of the Econometric Society*, 277-304.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.
Ferraro, D., Rogoff, K. S., & Rossi, B. (2012). *Can oil prices forecast exchange rates?* (No. w17998).
Frankel, J. A. (2006). *The effect of monetary policy on real commodity prices*(No. w12713). National Bureau of Economic Research.National Bureau of Economic Research.
Gohin, A., & Chantret, F. (2010). The long-run impact of energy prices on world agricultural markets: the role of macro-economic linkages. *Energy Policy*, *38*(1), 333-339.
Gilbert, C. L. (2010). How to understand high food prices. *Journal of Agricultural Economics*, *61*(2), 398-425.
Gilbert, C. L. (2010, March). Speculative influences on commodity futures prices 2006-2008. United Nations Conference on Trade and Development.
Hamilton, J. D. (2008). *Understanding crude oil prices* (No. w14492). National Bureau of Economic Research.
Hamilton, J. D., & Wu, J. C. (2014). Risk premia in crude oil futures prices.*Journal of International Money and Finance*, *42*, 9-37.
Harri, A., Nalley, L., & Hudson, D. (2009). The relationship between oil, exchange rates, and commodity prices. *Journal of Agricultural and Applied Economics*, *41*(2), 501-510.
Headey, D., & Fan, S. (2008). Anatomy of a crisis: the causes and consequences of surging food prices. *Agricultural Economics*, *39*(s1), 375-391.
Johansen, S., & Juselius, K. (1992). Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK. *Journal of econometrics*, *53*(1), 211-244.
Johansen, S. (1992). Testing weak exogeneity and the order of cointegration in UK money demand data. *Journal of Policy Modeling*, *14*(3), 313-334.
Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of Econometrics*, *52*(3), 389-402.
Long, J. B., Shleifer, A., Summers, L. H., & Waldmann, R. J. (1990). Positive feedback investment strategies and destabilizing rational speculation. *the Journal of Finance*, *45*(2), 379-395.
Mitchell, D. (2008). A note on rising food prices.
Pfaff, B. (2008). *Analysis of integrated and cointegrated time series with* R. Springer.
Roache, S. (2010) What explains the rise of food price volatility? IMF Working paper. WP/10/129. International Monetary Fund.
Serra, T., & Zilberman, D. (2013). Biofuel-related price transmission literature: A review. *Energy Economics*, *37*, 141-151.
Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of econometrics*,*66*(1), 225-250.
Trostle, R. (2010). *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices (rev*. DIANE Publishing.
Nazlioglu, S., & Soytas, U. (2012). Oil price, agricultural commodity prices, and the dollar: A panel cointegration and causality analysis. *Energy Economics*,*34*(4), 1098-1104.
Wright, B. D. (2011). The economics of grain price volatility. *Applied Economic Perspectives and Policy*, *33*(1), 32-58.

Appendix

Table-1 Bivariate Pair and Macro Factors (M2, 10-year Maturity Rate and US/EU exchange rate) Weak Exogeneity Test

	Stat	P		Stat	P		Stat	P		Stat	P		Stat	P		Stat	P
It_corn	15.1	0.001	It_corn	0.6	0.731	It_corn	0.9	0.340	It_corn	17.1	0.000	It_corn	0.9	0.628	It_corn	0.4	0.541
It_wheat	6.5	0.039	Itsyb	32.0	0.000	US_corn	0.0	0.992	USwheat	8.8	0.012	US_syb	36.8	0.000	Brent	1.2	0.267
M2	86.7	0.000	M2	92.6	0.000	M2	90.6	0.000	M2	91.1	0.000	M2	80.6	0.000	M2	74.2	0.000
X10.year	8.9	0.012	X10.year	14.4	0.001	X10.year	2.1	0.145	X10.year	4.4	0.108	X10.year	17.9	0.000	X10.year	0.2	0.621
US.Euro	5.2	0.076	US.Euro	5.2	0.075	US.Euro	5.8	0.016	US.Euro	8.6	0.013	US.Euro	5.0	0.081	US.Euro	5.0	0.025
It_wheat			It_wheat	2.5	0.280	It_wheat	3.5	0.062	It_wheat	18.2	0.000	It_wheat	3.4	0.184	It_wheat	1.8	0.175
It_wheat			It_syb	25.7	0.000	US_corn	0.2	0.698	USwheat	8.5	0.014	US_syb	31.2	0.000	Brent	0.8	0.382
M2			M2	94.0	0.000	M2	97.1	0.000	M2	92.7	0.000	M2	86.4	0.000	M2	83.7	0.000
X10.year			X10.year	7.3	0.026	X10.year	2.0	0.154	X10.year	0.6	0.727	X10.year	7.9	0.019	X10.year	0.0	0.884
US.Euro			US.Euro	5.3	0.071	US.Euro	5.7	0.017	US.Euro	8.5	0.014	US.Euro	5.2	0.074	US.Euro	5.1	0.024
It_syb			It_syb			It_syb	0.0	0.830	It_syb	12.0	0.002	It_syb	14.0	0.001	It_syb	1.1	0.292
It_wheat			It_syb			US_corn	0.0	0.947	USwheat	1.3	0.510	US_syb	5.1	0.077	Brent	0.9	0.333
M2			M2			M2	105	0.000	M2	99.4	0.000	M2	98.6	0.000	M2	93.0	0.000
X10.year			X10.year			X10.year	3.1	0.079	X10.year	3.2	0.198	X10.year	2.0	0.370	X10.year	1.3	0.248
US.Euro			US.Euro			US.Euro	5.2	0.023	US.Euro	4.3	0.117	US.Euro	4.5	0.106	US.Euro	4.2	0.040
US_corn			US_corn			US_corn			US_corn	0.2	0.625	US_corn	0.0	0.862	US_corn	0.1	0.716
It_wheat			It_syb			US_corn			USwheat	0.7	0.387	US_syb	0.1	0.729	Brent	0.4	0.519
M2			M2			M2			M2	94.6	0.000	M2	94.6	0.000	M2	91.9	0.000
X10.year			X10.year			X10.year			X10.year	1.7	0.195	X10.year	2.4	0.124	X10.year	1.6	0.206
US.Euro			US.Euro			US.Euro			US.Euro	4.2	0.041	US.Euro	5.7	0.017	US.Euro	6.0	0.014
USwheat			USwheat			USwheat			USwheat			USwheat	1.2	0.553	USwheat	0.2	0.651
It_wheat			It_syb			US_corn			USwheat			US_syb	7.8	0.020	Brent	0.9	0.350
M2			M2			M2			M2			M2	89.7	0.000	M2	85.7	0.000
X10.year			X10.year			X10.year			X10.year			X10.year	4.0	0.133	X10.year	0.0	0.914
US.Euro			US.Euro			US.Euro			US.Euro			US.Euro	3.0	0.221	US.Euro	2.4	0.124
US_syb			US_syb			US_syb			US_syb			US_syb			US_syb	1.0	0.318
It_wheat			It_syb			US_corn			USwheat			US_syb			Brent	1.0	0.307
M2			M2			M2			M2			M2			M2	75.7	0.000
X10.year			X10.year			X10.year			X10.year			X10.year			X10.year	0.9	0.342
US.Euro			US.Euro			US.Euro			US.Euro			US.Euro			US.Euro	4.0	0.045

Note: The weak exogeneity test is conducted in R using function 'alrtest'. The 5% significance test statistic is marked by red color, which means the variable is not (weakly) exogenous in the five variable (VECM) system.

Table-2 Cointegration Rank of each bivariate pair with Macro-factors (3 month Maturity Rate and Exchange Rate)

	EU_corn	EU_wheat	EU_soybean	US_corn	US_wheat	US_soybean	Brent Blend
EU_corn		1	1	0	0	1	0
EU_wheat	1		1	0	0	1	0
EU_soybean	1	1		0	0	1	0
US_corn	0	0	0		0	0	0
US_wheat	0	0	0	0		0	0
US_soybean	1	1	1	0	0		0
Brent Blend	0	0	0	0	0	0	

Note: The cointegration rank test is conducted in R using function 'ca.jo'. The test results is based on 10% significance level. The number in ij-th slot (i-th row and j-th column) reports the cointegration rank of the VECM system consisting of i-th row variable, j-th column variable, 3 month maturity rate and exchange rate.

Table-3 Cointegration Rank of each bivariate pair without Macro-factors

	EU_corn	EU_wheat	EU_soybean	US_corn	US_wheat	US_soybean	Brent Blend
EU_corn		1	1	0	1	1	0
EU_wheat	1		1	0	1	0	0
EU_soybean	1	1		0	1	1	0
US_corn	0	0	0		0	0	0
US_wheat	1	1	1	0		0	0
US_soybean	1	0	1	0	0		0
Brent Blend	0	0	0	0	0	0	

Note: The cointegration rank test is conducted in R using function 'ca.jo'. The test results is based on 10% significance level. The number in ij-th slot (i-th row and j-th column) reports the cointegration rank of the VECM system consisting of i-th row variable, j-th column variable (without Macro-factors).

Table-4 Bivariate Pair and Macro Factors (3-month Maturity Rate and US/EU exchange rate) Weak Exogeneity Test

	Stat	P		Stat	P		Stat	P		Stat	P		Stat	P		Stat	P
It_corn	6.938	0.008	It_corn	0.062	0.803	It_corn			It_corn			It_corn	0.191	0.662	It_corn		
It_wheat	9.062	0.003	Itsyb	29.616	0.000	US_corn			USwheat			US_syb	38.034	0.000	Brent		
3 month	4.066	0.044	3 month	8.469	0.004	3 month			3 month			3 month	9.191	0.002	3 month		
US.Euro	1.568	0.211	US.Euro	0.644	0.422	US.Euro			US.Euro			US.Euro	2.422	0.120	US.Euro		
It_wheat			It_wheat	0.139	0.709	It_wheat			It_wheat			It_wheat	1.924	0.165	It_wheat		
It_wheat			It_syb	26.797	0.000	US_corn			USwheat			US_syb	31.184	0.000	Brent		
3 month			3 month	5.522	0.019	3 month			3 month			3 month	3.777	0.052	3 month		
US.Euro			US.Euro	0.134	0.714	US.Euro			US.Euro			US.Euro	0.907	0.341	US.Euro		
It_syb			It_syb			It_syb			It_syb			It_syb	15.907	0.000	It_syb		
It_wheat			It_syb			US_corn			USwheat			US_syb	4.734	0.030	Brent		
3 month			3 month			3 month			3 month			3 month	0.019	0.890	3 month		
US.Euro			US.Euro			US.Euro			US.Euro			US.Euro	0.574	0.449	US.Euro		
US_corn			US_corn			US_corn			US_corn			US_corn			US_corn		
It_wheat			It_syb			US_corn			USwheat			US_syb			Brent		
3 month			3 month			3 month			3 month			3 month			3 month		
US.Euro			US.Euro			US.Euro			US.Euro			US.Euro			US.Euro		
USwheat			USwheat			USwheat			USwheat			USwheat			USwheat		
It_wheat			It_syb			US_corn			USwheat			US_syb			Brent		
3 month			3 month			3 month			3 month			3 month			3 month		
US.Euro			US.Euro			US.Euro			US.Euro			US.Euro			US.Euro		
US_syb			US_syb			US_syb			US_syb			US_syb			US_syb		
It_wheat			It_syb			US_corn			USwheat			US_syb			Brent		
3 month			3 month			3 month			3 month			3 month			3 month		
US.Euro			US.Euro			US.Euro			US.Euro			US.Euro			US.Euro		

Note: The weak exogeneity test is conducted in R using function 'alrtest'. The 5% significance test statistic is marked by red color, which means the variable is not (weakly) exogenous in the four variable (VECM) system.