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Abstract

Commodity-equity and cross-commodity return co-movements rose dramatically after the 2008 financial crisis. This development took place following what has been dubbed the "financialization" of commodity markets. We first document changes since 2000 in the intensity of speculative activity in grain and livestock futures. We then use a structural VAR model to establish the role of speculative activity in explaining the strength of co-movements between grain, livestock and equity returns. We find that speculative intensity does not in itself affect the extent to which grain markets move in sync with the stock market. Rather, *pre*-crisis, financial speculators' futures positions facilitated the transmission of macroeconomic shocks into grain markets. Strikingly, in the *post*-crisis period, this transmission channel weakened to the point of statistical insignificance. The role of speculative activity is less evident in livestock markets, where only macroeconomic conditions have a statistically significant impact on return co-movements with equities.

JEL classification: Q11, Q13, G12, G13
Bank classification: International topics; Recent economic and financial developments

Résumé

Les corrélations entre les rendements des actions et des contrats sur matières premières agricoles, ainsi qu'entre les rendements de différents contrats sur divers produits agricoles, ont fortement augmenté après la crise financière de 2008. Cette hausse a eu lieu dans la foulée de ce qu'on a appelé la « financiarisation » des marchés des matières premières. Dans la présente étude, nous faisons d'abord le point sur l'évolution, depuis 2000, de l'intensité de l'activité spéculative sur les marchés à terme des grains et du bétail. Ensuite, à l'aide d'un modèle VAR structurel, nous examinons si la spéculation influence le degré de covariation des rendements entre les actions et les contrats sur les grains et le bétail. Nous montrons que l'intensité de cette activité n'a pas, en soi, d'incidence sur le degré avec lequel les marchés des grains et les marchés boursiers évoluent de manière parallèle. Au contraire, *avant* la crise, les positions à terme des spéculateurs financiers ont facilité la transmission des chocs macroéconomiques aux marchés des grains. Fait étonnant, dans l'*après*-crise, ce canal de transmission s'est affaibli au point de devenir négligeable sur le plan statistique. Nous observons que le rôle de l'activité spéculative est moins évident sur les marchés du bétail, où les conditions macroéconomiques sont le seul facteur dont l'influence sur la covariation des rendements des actions et des contrats sur le bétail est statistiquement significative.

Classification JEL : Q11, Q13, G12, G13
Classification de la Banque : Questions internationales; Évolution économique et financière récente

1. Introduction

In the past decade, the magnitude of financial traders' positions in commodity futures (or "paper") markets has grown substantially – both in absolute terms and relative to the positions of traditional market participants such as refineries, slaughterhouses, mills, metal smelters, grain elevators, etc. Since the tripling of food prices in 2007–08, market commentators and policy-makers alike have questioned whether food prices are still driven mainly by physical supply and demand factors, or whether trading by financial institutions (in particular, hedge funds) in commodity paper markets has become a major explanatory factor in agricultural ("ag") price fluctuations.

We approach this question through the lens of cross-market linkages. Historically, food and other commodity markets (energy, industrial and precious metals) have been partly isolated (or "segmented") from one another and from financial markets (Bessembinder, 1992). A key difference between traditional commodity traders and financial institutions, however, is that the latter – but not the former – typically trade in multiple asset markets. As a result, the expansion of financial institutions in commodity markets (i.e., "financialization") may improve risk sharing in good times, lessening the relevance of idiosyncratic commodity shocks to commodity risk premia (Brunetti and Reiffen, 2011; Hamilton and Wu, 2013) and increasing the importance of common shocks. In bad times, the literature on limits to arbitrage (Gromb and Vayanos, 2010) identifies various channels through which financial institutions can in theory transmit shocks across different markets or asset classes. Finally, insofar as trader performance at financial institutions is benchmarked against a commodity index, Başak and Pavlova (2013) demonstrate that "financialization" should raise "correlations amongst commodity futures (as well as) equity-commodity correlations."

In short, the returns in more "financialized" livestock and grain futures can be characterized by increases in the extent to which they co-move with one another and with equity returns. At first blush, the dramatic increase in commodity-equity and cross-commodity co-movements that started in autumn 2008 fits this intuition.

To investigate this hypothesis, we compute indices of speculative intensity for grain and livestock markets. We use data on trader positions published by the U.S. Commodity Futures Trading Commission (CFTC) for grain (corn, soybean, Kansas City and Chicago

wheat) and livestock (live and feeder cattle, lean hogs) futures markets. Büyükşahin and Robe (2013), who give a broad view of commodity market financialization using measures constructed instead from non-public trader-level position data, provide empirical evidence that fluctuations in public speculative intensity indices may proxy for changes in the relative importance of hedge funds and similar cross-market traders during the 2000–10 period.

We use a structural vector autoregression (SVAR) model to examine the role of speculative intensity in grains or livestock markets in explaining the co-movements of these markets with one another or with equities. Precisely, we ask whether dynamic conditional ag/equity and grain/livestock return correlations (DCC) are affected by the makeup of the commodity futures open interest after accounting for key market fundamentals: global macroeconomic conditions, which drive current food demand; precautionary and speculative demand, through changes in grain and meat inventory levels; supply, through indices of crop progress and condition; and idiosyncratic shocks such as agricultural market stress caused by mad cow and swine flu episodes. Because the DCC series all experience structural breaks after the demise of Lehman Brothers and the onset of a massive financial crisis in September 2008, we analyze the *pre*- and *post*-Lehman periods separately.

For 2000–08, we identify a causal relationship from the intensity of speculative activity to the strength of equity-grain linkages. However, we show that speculative intensity does not in itself affect the extent to which grain markets move in sync with the stock market – rather, *pre*-crisis, financial speculators' futures positions simply facilitated the transmission of economic shocks into grain markets. In the *post*-Lehman period, this transmission channel is weaker – to the point of statistical insignificance. The role of speculative activity is even weaker for livestock, where only macroeconomic conditions statistically significantly impact returns' co-movements with equities.

Taken together, our results suggest that, for grains as well as livestock, the intensity of participation by financial speculators (including hedge funds) in paper markets is not the main explanatory factor for ag and equity return co-movements. In that sense, our results cast doubt on the popular claim that the past decade witnessed the "financialization of food."

This paper is organized as follows. Section 2 discusses our contribution to the literature. Section 3 presents evidence on correlations (DCC). Section 4 describes the futures position data and speculative intensity patterns in food futures markets. Section 5 discusses

our SVAR analyses, linking return co-movements to market fundamentals, speculative activity, financial market stress, and the interaction of these factors. Section 6 concludes.

2. Literature

Our paper contributes to a fast-growing literature on the role of financial institutions in commodity futures markets. Closest are two sets of papers.[1]

Büyükşahin and Robe (2013) and Cheng, Kirilenko and Xiong (2012) investigate links between financialization and cross-market linkages. Using non-public CFTC data from 2000–10, Büyükşahin and Robe show that, of all financial institutions, it is the aggregate positions of hedge funds (especially funds active in both equity and commodity markets) that help predict the strength of correlations between equity and commodity futures returns.[2]

Since that paper amalgamates different commodity groups, however, it does not control for grain or livestock supply and demand fundamentals that are known to matter for ag prices. Its econometric approach, furthermore, precludes inferences regarding causality. A key result of the present paper is to show that speculative activity in ag markets in fact does not *drive* co-movements between grain and livestock returns or between ag and equity returns. Instead, speculative activity helps transmit macroeconomic shocks to grain markets – with the result of stronger co-movements between different markets during economic downturns.

Büyükşahin and Robe (2013) find a lower predictive power for aggregate hedge fund positions in the 18 months after Lehman Brothers' 2008 demise.[3] Supporting their finding, we find statistical evidence that financial speculators' net futures positions helped transmit macroeconomic shocks into grain markets before Lehman – but no such evidence thereafter. We do so by using a structural VAR model that parsimoniously accounts for key market

[1] Büyükşahin and Robe (2013) and Fattouh, Kilian and Mahadeva (2013) give fuller reviews of this literature.
[2] In a companion paper, Büyükşahin and Robe (2011) carry out a similar study in the specific case of energy futures, where they can better control for oil market-specific demand and supply fundamentals. They find qualitatively similar results.
[3] The findings of Cheng, Kirilenko and Xiong (2012), who use the same confidential CFTC data, suggest a possible explanation: in years after September 2008 (but not in prior years), financially-constrained commodity index traders and hedge funds reacted to financial stress by cutting their net long positions in commodity futures markets. This behavior is consistent with the findings of Acharya, Lochstoer and Ramadorai (2013) on limits to arbitrage in energy markets, and of Raman, Robe and Yadav (2012) on changes in liquidity provision under stress in the crude oil futures market.

factors all together and thus allows us to discuss *ceteris paribus* effects. An independent contribution is the construction of a hand-collected dataset (described in the appendix) of relevant market drivers.

The SVAR approach links our paper to a set of studies that tease out the role of speculative activity on crude oil prices (Kilian and Murphy, 2013), cotton prices (Janzen, Smith and Carter, 2013) and corn price volatility (McPhail, Du and Muhammad, 2012).

Kilian and Murphy (2013) model speculation as a phenomenon tied to precautionary demand and physical inventories. Closer to our paper are McPhail, Du and Muhammad (2012) and Janzen, Smith and Carter (2013). McPhail, Du and Muhammad capture paper speculation through the same index we employ but, unlike us, do not model corn inventories or supply. Janzen, Smith and Carter consider the incentive to accumulate inventories as a phenomenon distinct from financial speculation and bear further similarity to our approach by viewing financialization through the lens of cross-market linkages. We use a direct measure of speculative activity, however. In contrast, Janzen, Smith and Carter draw on the observation that oil is not a direct substitute in cotton production and consumption, and identify structural shocks due to financial speculation using the co-movements of cotton prices with crude oil. This strategy fits their focus on commodity index traders (CIT), a type of financial traders whose activities might be associated with commodity-to-commodity linkages but not with commodity-equity return co-movements (Aulerich, Irwin and Garcia, 2013; Irwin and Sanders, 2011, 2012; Tang and Xiong, 2012; Büyükşahin and Robe, 2013).

Our findings complement those three papers in that we find no evidence that financial speculation *per se* plays a role in a key moment of the joint distribution of commodity return. Instead, fundamental factors emerge as having the main role in cross-market linkages.

3. Market Linkages

Numerous papers provide evidence on the extent to which various commodities co-move with one another or financial assets – see Büyükşahin and Robe (2013) for a review. In this section, we build on that prior work. We estimate dynamic conditional correlations (Engle, 2002) between the returns on two investable indices (one for grains, the other for livestock) and between the returns on the main U.S. equity index and those two indices.

3.1 Return data

We use weekly returns on benchmark commodity and stock market indices.[4] We obtain daily price data from Bloomberg and we compute Tuesday-to-Tuesday weekly returns. Our sample runs from 3 January 1995 to 8 May 2013.

For ags, we use the unlevered total returns on Standard and Poor's S&P GSCI ("GSCI") Grain (GRTR) and Livestock (LVTR) indices. Each figure is a return on a "fully collateralized commodity futures investment that is rolled forward from the fifth to the ninth business day of each month." The GRTR index covers four grains: corn, soybean, and Kansas City and Chicago wheat. The LVTR index covers live cattle, feeder cattle and lean hogs (live hogs until 1996). For equities, we use returns on Standard and Poor's S&P 500 index.

3.2 Dynamic conditional correlations

To obtain dynamically correct estimates of the intensity of return co-movements, we follow the recent literature and use dynamic conditional correlations or DCC (Engle, 2002). First, we estimate time-varying variances using a GARCH(*1,1*) model, a specification that Büyükşahin, Haigh and Robe (2010) show is appropriate for our sample period. We then estimate a time-varying correlation matrix using standardized residuals from the first-stage estimation.

Figure 1 plots, from January 1995 to May 2013, our estimates of DCCs between the weekly rates of return on the two ag indices (GRTR and LVTR) vs. the unlevered rate of return on the S&P 500 equity index (SP) and vs. one another. As for most commodities (Bhardwaj and Dunsby, 2012; Büyükşahin, Haigh and Robe, 2010), the cross-market linkage strength varies substantially over time for ags; it is usually higher during or just after economic downturns.

Despite the "financialization" of commodity markets in 2004–08, ag-equity and grain-livestock return co-movements were generally *lower* than they had been in prior years. That period witnessed strong world economic growth, though – leaving open the question of whether correlations might have been even lower absent financialization. Strikingly, return

[4] Precisely, we measure the percentage rate of return on the I^{th} investable index in period t as $r^I_t = \text{Log}(P^I_t / P^I_{t-1})$, where P^I_t is the value of index I at time t.

co-movements rose quickly and massively after Lehman Brothers' demise in September 2008. Ag-equity DCCs remained unusually high until late 2011 (livestock) or early 2012 (grains), but have since dropped to pre-crisis levels. These last two observations suggest the possibility of structural breaks in autumn 2008 – a topic to which we will return in section 5.

4. Financial Speculation in Grain and Livestock Markets, 2000–13

Open interest in the ag futures markets included in the S&P GSCI commodity indices has grown substantially in the past decade. In grain markets, open interest has risen several-fold since 2004. In this section, we document changes in the intensity of speculative activity amid this growth. In doing so, we rely on results in Büyükşahin and Robe (2013) suggesting that Working's (1960) T index may be used as a public-data substitute for measures of financialization that they computed with non-public, trader-level futures position data.

4.1 Data

For every futures market boasting a high-enough level of trading activity, the CFTC's weekly Commitments of Traders (COT) reports break down the total open interest between two (until 2009) or four (since 2009) categories of traders. We use this public information to compute weekly measures of financial speculation in ag markets between 2000 and 2013.

COT reports classify large traders as either "commercial" or "non-commercial."[5] A trading entity generally gets all of its futures and options positions in a given commodity classified as "commercial" by filing a statement with the CFTC that it is commercially "engaged in business activities hedged by the use of the futures or option markets" as defined in CFTC regulations.[6] The "non-commercial" group includes various types of mostly financial traders such as hedge funds, mutual funds, floor brokers, etc.[7]

[5] COT reports also provide data on the positions of non-reporting (i.e., small) traders.
[6] To ensure that traders are classified accurately and consistently, the CFTC staff may exercise judgment in re-classifying a trader if it has additional information about the trader's use of the markets.
[7] Since 4 September 2009, COT reports split non-commercials between "managed money traders" (i.e., hedge funds) and "other non-commercial traders" with reportable positions. As of October 2013, however, the CFTC has not communicated any plan to make similarly detailed data available retroactively beyond 2006. We therefore rely on the legacy classification scheme to obtain a sufficiently long time series of position data for the VAR analyses in section 5.

4.2 Measuring the intensity of financial speculation

To measure the extent and growth of speculative activity in ag markets, we rely on Working's (1960) T index, which compares the activities of all "non-commercial" commodity futures traders (typically called "speculators") to the net demand for hedging originating from "commercial" traders (also known as "hedgers").

4.2.1 Measuring "excess" speculation

Working's T index is predicated on the idea that, if long and short hedgers' respective positions in a given futures market were exactly balanced, then their positions would always offset one another and speculators would not be needed in that market. In practice, of course, long and short hedgers do not always wish to trade simultaneously or in the same quantity. Hence, speculators must step in to fill the unmet hedging demand. Working's T measures the extent to which speculation exceeds the level required to offset any unbalanced hedging at the market-clearing price (i.e., to satisfy hedgers' net demand for hedging at that price).

For each commodity market in our sample, we use public COT data to compute Working's T every Tuesday from 2 January 2000 to 10 May 2013. This T index covers all contract maturities. Formally, in the *i*th commodity market in week *t*:

$$Working's\ T_{i,t} \equiv T_{i,t} = \begin{cases} 1 + \dfrac{SS_{i,t}}{HL_{i,t} + HS_{i,t}} & if\ HS_{i,t} \geq HL_{i,t} \\ 1 + \dfrac{SL_{i,t}}{HL_{i,t} + HS_{i,t}} & if\ HL_{i,t} \geq HS_{i,t} \end{cases} \qquad (i = 1, \dots, 7),$$

where $SS_{i,t} \geq 0$ is the (absolute) magnitude of the short positions held in the aggregate by all non-commercial traders ("Speculators Short"); $SL_{i,t} \geq 0$ is the (absolute) value of all non-commercial long positions; $HS_{i,t} \geq 0$ stands for all commercial short positions ("Hedge Short"); and $HL_{i,t} \geq 0$ stands for all long commercial positions.

We then average individual index values in the corn, soybean and wheat (*cattle and hogs*) markets to provide an overall picture of financial activity in grain (*livestock*) markets:

$$T_t = \sum_i w_{i,t}\, T_{i,t},$$

where the weight $w_{i,t}$ for commodity *i* in a given week *t* is based on the weight of the commodity in the S&P GSCI index that year (Source: Standard and Poor's), rescaled to account for the fact that we focus on either four grain or three livestock markets (out of 24 S&P GSCI commodity markets).

4.2.2 Excess speculation in U.S. commodity futures markets, 2000–13

Figure 2 depicts, from 2000 to 2013, weighted-average speculative indices for grains and for livestock. We net out 1 from the T index figures to facilitate the interpretation. The minimum value is 0.12 (*0.19*) for grain (*livestock*); the maximum is 0.42 (*0.69*) for grain (*livestock*). In other words, speculative positions in ag markets were, on average, 12% to 69% greater than what was minimally necessary to meet net commercial hedging needs at the market-clearing prices. Figure 2 identifies a substantial, long-term increase in the livestock T index. The matching figure for grains doubled in 2004–08, yet for 2000–13 as a whole, the grain T index did not experience any secular increase. Notably, both grain and livestock T indices exhibit substantial volatility. Their patterns will be of particular interest in the analysis below.

5. The Structural VAR Model

We propose a 4-variable SVAR model to jointly explain, and quantify empirically, the relative importance of macroeconomic factors (demand), physical food market fundamentals (supply, storage) and financial speculation (T) in explaining cross-market return correlations (DCC).

The last two variables (T, DCC) have been discussed in earlier sections. We include a proxy for the overall strength of consumption-linked demand, in line with evidence that global economic growth is a key driver of commodity prices and that, in the past four decades, "commodity booms were preceded by unusually high world economic growth, especially in middle-income countries" (Carter, Rausser and Smith, 2011; see also Alquist and Coibion, 2013). Specifically, we use the measure of cyclical fluctuations in global real economic activity proposed by Kilian (2009). We denote it SHIP, because Kilian's measure is based on the cost of shipping dry freight (including grains) in bulk. This choice of world demand proxy is similar to those made by, e.g., Kilian and Murphy (2013, oil); Janzen, Smith

and Carter (2013, cotton); and McPhail, Du and Muhammad (2012, corn). The series is monthly; cubic splines yield weekly figures.

Grain supply is affected mostly by planting decisions (which, for most crops, are made once a year) and by U.S. weather conditions (temperature and rain). Livestock supply is indirectly affected by the same variables, in the specific case of corn. We take grain supply into account through weather. Because weather is an exogenous variable, we treat it as such in the SVAR (for this reason, the variable will not appear in the impulse response figures).

Lehecka (2012) shows that the impact of weather in grain markets can be captured by a crop condition index computed from the U.S. Department of Agriculture (USDA) weekly reports on crop progress and condition. We follow a similar approach and proxy each crop's supply situation through a weekly crop condition index. Ours is a cross-crop, mean-centered, asymmetrically weighted average of the percentages of plots in very poor, poor, good or excellent shape for each crop – see the appendix for full details.

We include inventories, in line with prior VAR studies of storable commodities (e.g., Kilian, 2009; Janzen, Smith and Carter, 2013). For grains, we build on work by Adjemian (2012) showing that World Agricultural Supply and Demand Estimates (WASDE) monthly forecasts of future grain storage levels contain new information.[8,9] For livestock, we use beef and pork stock levels taken from monthly USDA cold-storage reports. The appendix explains how we construct each series.

For the data series $\{y_t\}$ consisting of the vector y_t of the variables of interest, we consider the system:

$$A(L)y_t = \varepsilon_t,$$

where $A(L)$ is a matrix of polynomial in the lag operator L, and ε_t is a vector of orthogonalized disturbances. For the four-variable VAR, we impose the Cholesky restrictions by applying the following exclusion restrictions on contemporaneous responses in the matrix *A* to fit a just-identified model:

[8] We also conduct robustness analyses using, instead of WASDE-based figures, year-on-year changes in current storage levels (which we construct from quarterly USDA-National Agricultural Statistics Service (NASS) survey reports – see the appendix).

[9] Depending on the month of the year when they are issued, crop forecasts contain information about expected grain supply and/or demand. We control for information about expected supply by including crop condition reports. Hence, to ensure that the storage series used only reflect grain usage forecasts, we "roll" (in a manner similar to the computation of roll returns) the monthly WASDE series for corn and soybean (*wheat*) from old crop to new crop reports in November (*August*) of each year.

$$A = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}.$$

The ordering of the variables imposed in the recursive form implies that the variable with index 1 is not affected by contemporaneous shocks to the other variables, whereas variable 2 is affected by contemporaneous shocks to variable 1, but not to variables 3 and 4. In general, the recursive form implies that a variable with index *j* is affected by the contemporaneous shocks to variables with index $i < j$, but not by the contemporaneous shocks to variables with index $k > j$. Thus, slower-moving variables (e.g., the state of world demand for commodities) are better candidates to be ordered before fast-moving variables like market prices.

We choose and order the variables by making assumptions that are theoretically and conceptually plausible in our setting. We follow Janzen, Smith and Carter (2013, p.13) and "other studies of commodity price dynamics [in assuming] the precedence of real economic activity shocks." In our case, this assumption implies that shocks to global real economic activity result in instantaneous adjustments in storage capacity, traders' positions and prices.

We posit, in turn, that changes in stock levels will immediately drive changes in trading activity and commodity prices, but will lower global real economic activity with a lag. Ordering the less-frequently observed storage decisions ahead of financial speculation is equivalent to assuming that changes in financial traders' positions generate signals that are not immediately incorporated into physical speculators' choices.

Next, we assume that financial speculation (T) should not have an immediate impact on macroeconomic fundamentals (since they are slower-moving) – but has an instantaneous effect on prices and correlations. The assumption that the extent of commodity market financialization may impact correlations is in line with a theoretical model (Cheng, Kirilenko and Xiong, 2012) showing that greater participation by financial institutions should increase cross-market correlations because such participation improves risk-sharing between commodity market participants in normal times but also introduces a transmission channel for market crashes in periods of financial market stress.

Finally, our ordering of the last two variables (T, DCC) is motivated by recent articles (Büyükşahin and Robe, 2013; Tang and Xiong, 2012) that find predictive power in,

respectively, the positions of hedge fund for equity-commodity linkages and of index traders for cross-commodity linkages.

We select lag lengths using the Akaike information criteria (AIC), and we compute bootstrapped confidence intervals based on 500 replications. Results are reported with 90% confidence intervals.

Estimations are run for two sample periods separately: from 2 January 2000 to 16 September 2008, and from 16 September 2008 until the end of 2011. Zivot-Andrews unit root tests detect a structural break in ag-equity correlations (DCC) in the immediate weeks after the Lehman collapse. Our estimations are therefore for the periods before and after the Lehman crash. We end the second subperiod in December 2011 because the plot of cross-market correlations in Figure 1 suggests the possibility of the start of a second structural break after 2011 (corresponding roughly with the end of the euro crisis).

For grains, we propose that the dynamic conditional grain/equity return correlations (DCC Grains-S&P) are driven by shocks in (i) the macroeconomy (SHIP); (ii) inventories (Grain Storage); and (iii) speculative activity (Grains T). We also use, as an exogenous variable, our weekly weighted-average index of new-crop conditions for soybean, wheat and corn. Pre-crisis estimations are run with eight lags, whilst post-crisis estimations are run with five lags following the AIC.

For livestock, we assume that the dynamic conditional livestock/equity return correlations (DCC Livestock-S&P) are driven by shocks to (i) macroeconomic conditions (SHIP); (ii) storage conditions (Cold Storage); and (iii) speculative activity (Livestock T). We also use two exogenous variables in the livestock model. One is our index of the new corn crop's condition, recognizing corn's role in livestock production. The other is a dummy that we set equal to 1 (and 0 otherwise) for the swine flu epidemic in 2009 (relevant to the post-crisis analysis only) as well as for the first cases of mad cow disease in 2003–04 (relevant to the pre-crisis period only).[10] Both *post*- and *pre*-Lehman estimations are run with four lags, following the AIC.

[10] We include demand dummies to account for exogenous shocks to demand for pork and beef. They cover two periods (23 December 2003 to 30 April 2004, and 18 April to 31 August 2009), to account for the first U.S. episodes of mad cow disease (bovine spongiform encephalopathy, or BSE) and swine flu (H1N1 virus). The time intervals are based on empirical evidence that the market impact lasted approximately four months – see, e.g., Attavanich, McCarl and Bessler (2011) for swine flu and Pozo and Schroeder (2012) for mad cow disease.

An analysis of the dynamic conditional grain/livestock return correlations (DCC Livestock-Grains) is included in the appendix; it follows a similar methodology.

5.1 Results

Figures 3 and 4 (Panels A and B) show the impulse-response functions from our four variable recursive VAR with 90 percent confidence bands for grains and livestock futures markets, respectively. In each figure, Panel A reports the *pre*-Lehman period results and Panel B reports the *post*-Lehman results. Results are organized so that the rows of a matrix indicate the variable whose shock we are following, while the columns of the same matrix indicate the variable whose response we are tracking. Each chart within the panels gives the impulse responses over 20 weeks to a one-standard-deviation shock to the variable identified in the first column.

Figure 3 Panel A shows that an increase in speculative activity (Grains T) leads to an increase in the dynamic conditional grain/equity return correlations (DCC Grains-S&P) in weeks 3, 4, 7 and 8. The other panels reveal the mechanism through which such an effect takes place. Deteriorating macroeconomic conditions (SHIP) lead to an increase in speculative activity (Grains T) after 2 and 3 weeks, with a feedback effect seen in increased food storage (Grain Storage) after 4 and 5 weeks. We interpret those results as evidence that speculative intensity does not *in itself* affect the extent to which grain markets move in sync with the stock market – rather, financial speculators' futures positions simply facilitated the transmission of the inital macroeconomic shock into grain markets.

Panel B of Figure 3 shows that in the *post*-Lehman period, this transmission channel is weakened to the point of statistical insignificance. Macroeconomic conditions affect storage decisions after 10 weeks, with an impact that remains significant until 14 weeks. We do not, however, observe any significant impact on grain/equity return correlations, a result that may be due to the period of high volatility and uncertainty in the financial markets.

Figure 4 reveals an even weaker role for speculative activity in driving livestock/equity return correlations. In the *pre*-crisis Lehman period (Panel A), the effect on DCC (Livestock-S&P) is driven only by macroeconomic conditions (SHIP), with an effect that starts in week 7 and lasts until week 14. The *post*-Lehman period (Panel B) shows a

similar pattern – although, here, macroeconomic conditions have a much faster (if less durable) impact on DCC (Livestock-S&P) return correlations that starts in week 1 and lasts until week 5. Whether *pre*- or *post*-Lehman, we find no evidence of a statistically significant role for speculative activity (Livestock T) on livestock/equity return correlations.

Results from the grain/livestock return correlations (not reported, for space reasons, but available upon request) bear strong similarities to the equity-commodity results. They confirm the important role of macroeconomic fundamentals in driving return co-movements.

Taken together, our results show that, for grain as well as livestock markets, the trading activities in commodity "paper markets" of financial institutions such as hedge funds are not the main explanatory factor of cross-market linkages, thus casting doubts on the claim that food markets have become "financialized."

6. Conclusions

Commodity-equity and cross-commodity return co-movements rose sharply after the 2008 financial crisis. This development took place following what has been dubbed the "financialization" of commodity markets. Using a dataset of trader positions in U.S. futures markets, we first document changes since 2000 in the intensity of financial speculation in grain and livestock futures. We then use a structural VAR model to establish whether speculative activity can help explain the strength of co-movements between grain, livestock and equity returns. Because the correlations all experience a structural break after September 2008, we analyze the *pre*- and *post*-crisis periods separately. In 2000–08, we identify a causal relationship from the intensity of speculative activity to the strength of equity-grain linkages. However, we find that speculative intensity does not in itself affect the extent to which grains move in sync with equities – rather, *pre*-crisis, financial speculators' futures positions helped transmit macroeconomic shocks into grain markets. Strikingly, in the *post*-crisis period, this transmission channel weakened to the point of statistical insignificance. The role of speculative activity is even weaker in livestock markets, where only macroeconomic conditions have an impact on return co-movements with equities.

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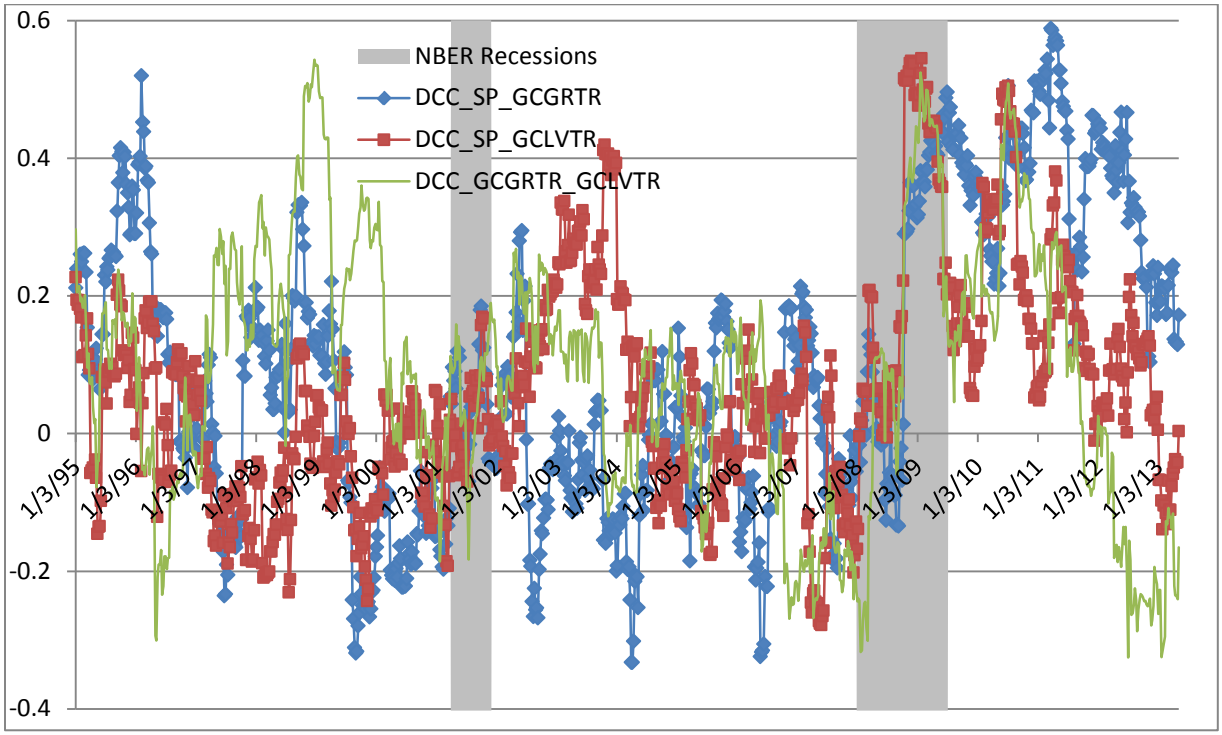
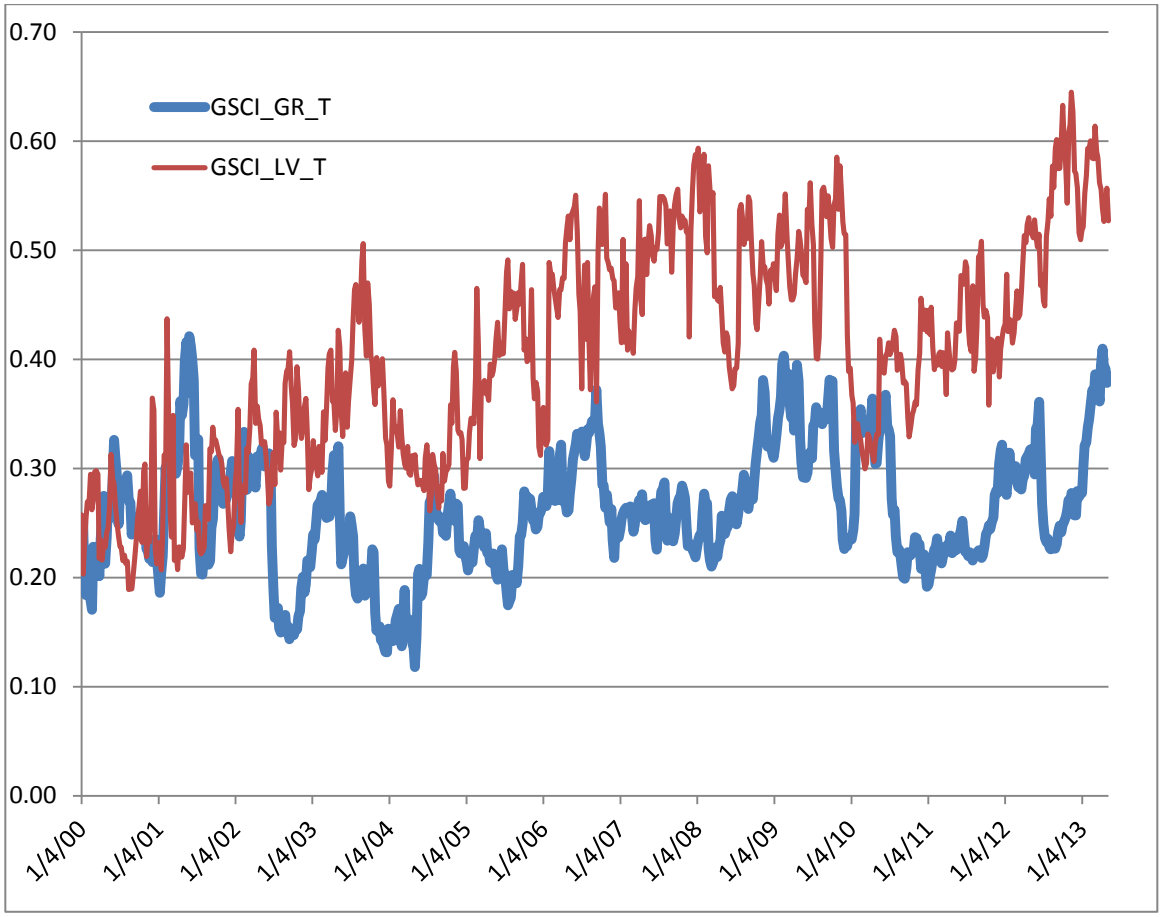
Figure 1: Return Correlations (DCC) between Equity, Grain and Livestock Indices, 1995–2013



Notes: Figure 1 depicts, from 3 January 1995 to 7 May 2013, time-varying correlations between **weekly** unlevered rates of return (precisely, changes in log prices) on the S&P 500 equity index and S&P GSCI total return Grain index (GRTR, **blue**); S&P 500 equity index and S&P GSCI total return Livestock index (LVTR, **red**); or GRTR and LVTR indices (**green**). In each case, we estimate dynamic conditional correlation (DCC) by log-likehood for a mean-reverting model (Engle, 2002) using Tuesday-to-Tuesday returns from 3 January 1995 to 10 May 2013. The shaded bands identify weeks in the periods classified by the U.S. National Bureau of Economic Research as recessions (Source: NBER).

Figure 2: Financial Speculation in Ag Markets, 2010–13



Notes: Figure 2 plots, from January 2000 to May 2013, indices of speculative intensity (Working's T index *minus* 1) in livestock (**red** series) and grain (**blue** series) futures markets. We use data on trader positions published by the U.S. Commodity Futures Trading Commission (CFTC Commitments of Traders Reports) to compute weekly index values for each of the grain markets (corn, soybean, Kansas City wheat, Chicago wheat) and livestock markets (live cattle, feeder cattle, lean hogs) covered by Standard and Poor's GSCI Grains and Livestock total return indices. These commodity-specific index values are then aggregated into two weekly series (one for grain, one for livestock) using a time series of annual GSCI commodity weights (source: Standard and Poor's).

Figure 3A: Recursive VAR for Grain before the Lehman crisis (2000–08)

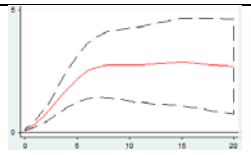
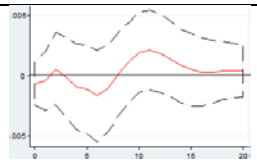
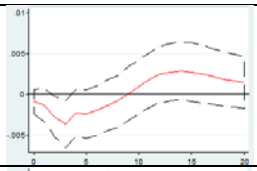
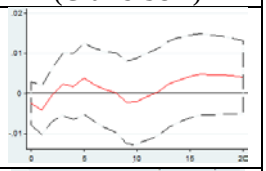
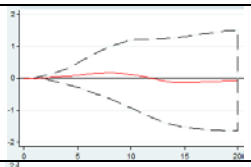
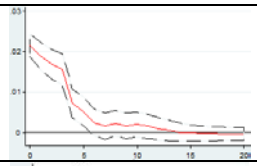
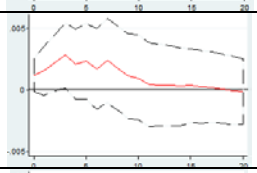
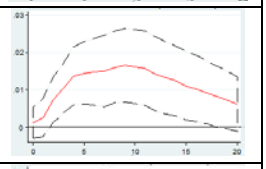
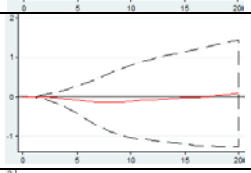
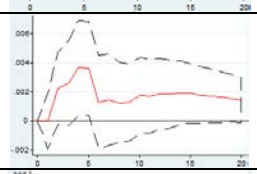
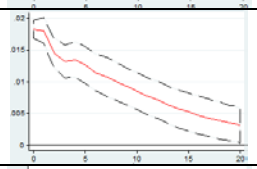
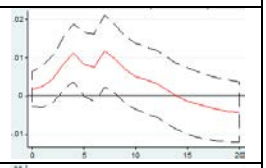
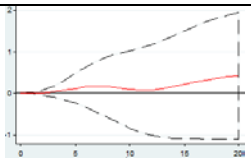
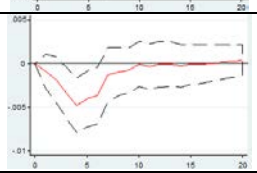
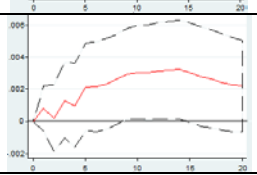
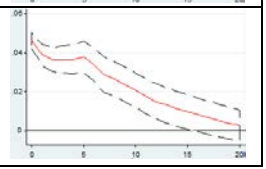
Recursive VAR	Ordering 1	2	3	4
Impact of (↓)	On SHIP	On Grain Storage	On Grains T	On DCC (Grains-S&P)
SHIP				
Grain Storage				
Grains T				
DCC (Grains-S&P)				

Figure 3B: Recursive VAR for Grain after the Lehman crisis (Sept. 2008–Dec. 2011)

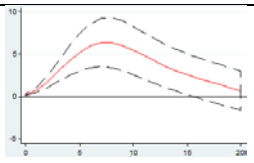
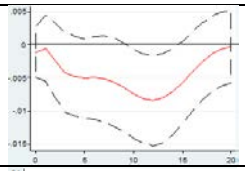
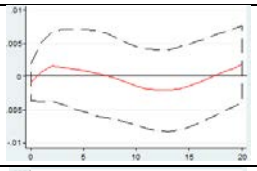
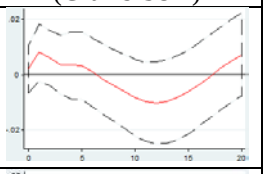
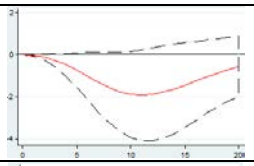
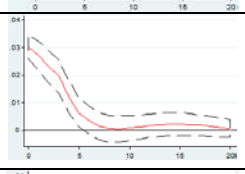
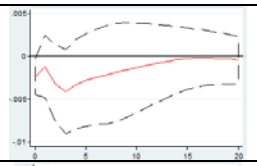
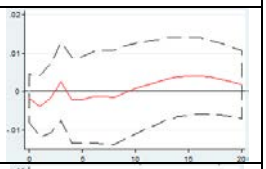
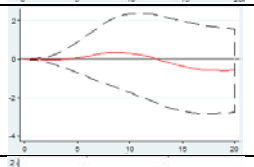
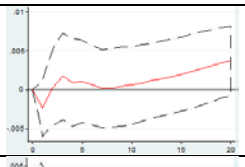
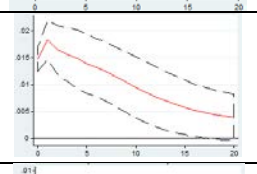
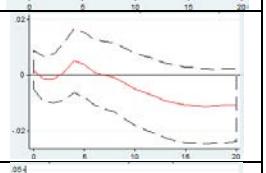
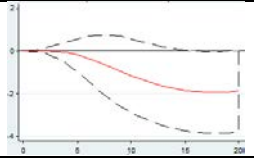
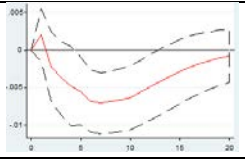
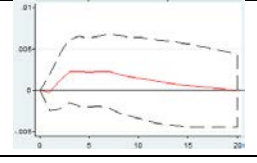
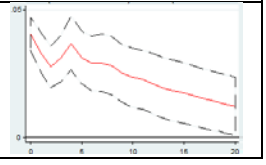
Recursive VAR	Ordering 1	2	3	4
Impact of (↓)	On SHIP	On Grain Storage	On Grains T	On DCC (Grains-S&P)
SHIP				
Grain Storage				
Grains T				
DCC (Grains-S&P)				

Figure 4A: Recursive VAR for Livestock before the Lehman Crisis (2000–08)

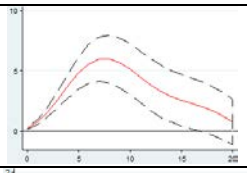
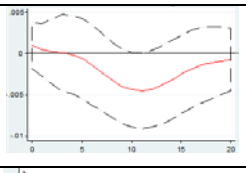
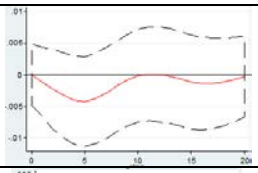
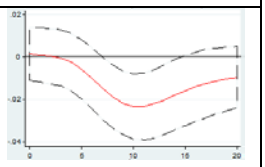
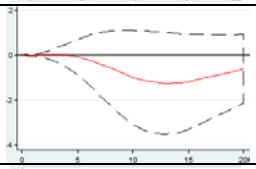
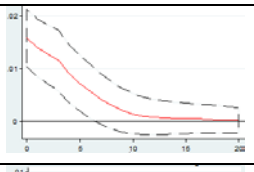
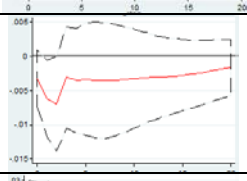
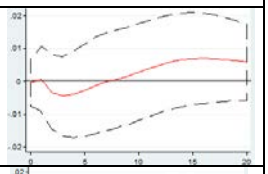
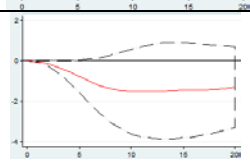
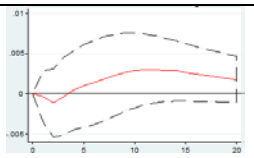
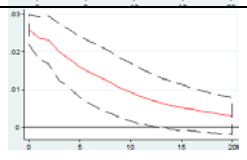
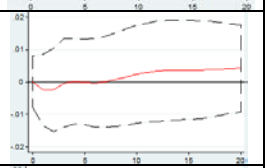
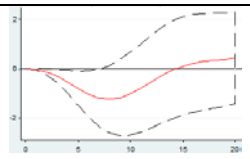
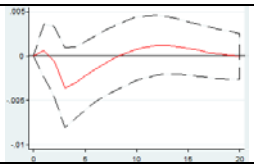
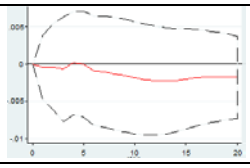
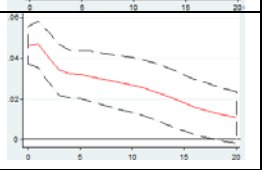
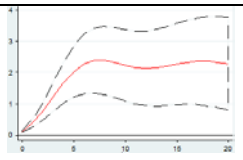
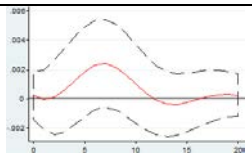
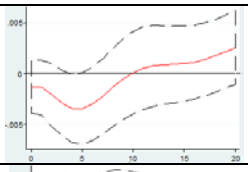
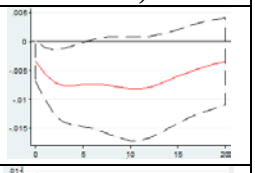
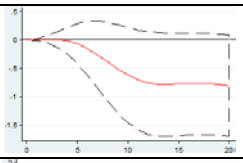
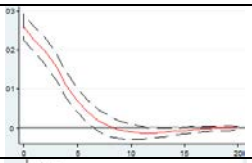
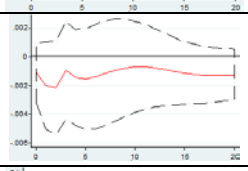
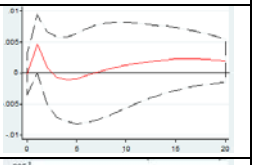
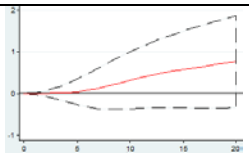
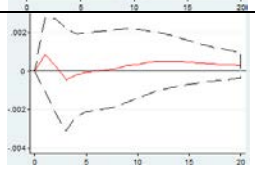
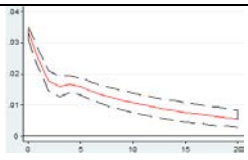
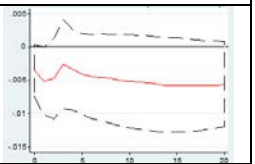
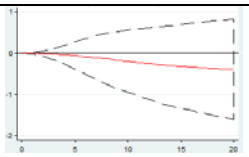
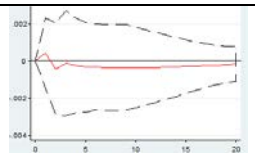
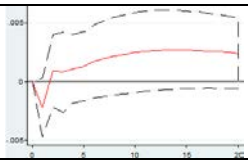
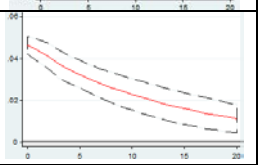
Recursive VAR	Ordering 1	2	3	4
Impact of (↓)	On SHIP	On Cold Storage	On Livestock T	On DCC (Livestock-S&P)
SHIP				
Cold Storage				
Livestock T				
DCC (Livestock -S&P)				

Figure 4B: Recursive VAR for Livestock after the Lehman Crisis (Sept. 2008–Dec. 2011)

Recursive VAR	Ordering 1	2	3	4
Impact of (↓)	On SHIP	On Cold Storage	On Livestock T	On DCC (Livestock-S&P)
SHIP				
Cold Storage				
Livestock T				
DCC (Livestock-S&P)				

Appendix

This appendix consists of three parts. The first discusses how the dataset containing the return series, DCC estimates, and fundamental and financial variables was constructed. The second part provides references to justify our choices of time dummies covering the initial episodes of mad cow disease and swine flu (H1N1). The third part summarizes our analysis of the grain-livestock return co-movements, to which we merely allude in the paper for brevity.

A. Data Construction

The construction of the DCC series is described in the main text. We focus on Tuesday-to-Tuesday returns for two reasons. First, we seek to avoid "Monday" and "end-of-the-week" effects. Second, it is Tuesday end-of-day futures and options positions that the CFTC's weekly Commitments of Traders Reports aggregate. When the Tuesday of a given week is a holiday, we use the Wednesday immediately following the holiday. If the latter is also a holiday, then we select the Monday prior to the Tuesday. For robustness, we also computed Wednesday-to-Wednesday DCC estimates and verified visually that their time patterns are qualitatively similar.

The SHIP variable, which captures world business cycles (Kilian, 2009), is described in the main text. An updated monthly series (M1.1968-M3.2013) was obtained from the website of the variable's inventor, Lutz Kilian. We use cubic splines to obtain weekly values.

The variables that we construct to summarize crop condition reports, grain storage levels, future grain stock forecasts and meat cold-storage levels are all based on USDA data. With the exception of the crop condition reports, which are weekly, all the underlying data are monthly or quarterly. In all cases, we therefore extract from the USDA's website the date and time of the relevant USDA announcements, and then create weekly series such that the value taken by any of our variables on a given Tuesday matches the information that was available to futures traders before futures markets closed that Tuesday.

Lehecka (2012) shows that USDA reports on the progress and condition of selected crops in major producing states (which "represent direct assessments of the overall status of a

crop on a weekly basis throughout the growing season") contain significant price-moving information during "the relevant part of the year (i.e., when the new crop has been planted)." He further shows that the price impact is attributable to the condition reports. Accordingly, we update Georg Lehecka's dataset of **crop condition reports** through May 2013 in order to construct an index that captures, for each crop, its state of progress. On a given week, our index for a crop is a weighted average of the percentages of very poor, poor, good and excellent reports. We consider several linear and non-linear weighing schemes. For the paper, we start with a quadratic weighing scheme that gives more importance to poor reports. We then de-mean the resulting series. Mean-centering is all the more important given that the report value is zero on weeks when there is nothing yet in the ground. Finally, we compute a weighted average of these individual-grain indices using the annual GSCI weights for corn, soybean, and wheat (properly rescaled to sum up to 1).

For meat cold storage, we use the USDA's total figures for beef and pork (excluding frozen hams). The USDA cold-storage reports are released several weeks after the time when the stocks were actually measured. For the VAR analysis, we therefore time-shift (forward) the stock series to ensure synchronicity with our other variables.

For grain storage, we construct two weekly variables for each grain. We also compute weighted averages for all grains, using annual GSCI weights (properly rescaled to sum up to 100%).

1. We use quarterly USDA-NASS grain stock surveys to create weekly series of year-on-year first differences in storage levels. Differencing takes care both (i) of the seasonality in stock levels (we take extra care at quarter ends that comparable figures are being differenced) and (ii) of a non-stationarity due to a secular increase in corn storage figures after 2005 (likely due to the sharp increase in ethanol demand from that year onward).

2. We also use monthly WASDE September-stock forecasts. One difficulty is that the information content of these monthly forecasts varies over the course of a year. Depending on the month of the year when they are issued, crop forecasts contain information about expected grain supply and/or demand. We already control for information about supply *via* crop condition reports. Hence, to ensure that the storage series we use consistently

reflect grain usage forecasts, we "roll" the monthly WASDE series for corn and soybean (*wheat*) from old crop to new crop reports in November (*August*) of each year. We use weekly series of month-on-month differences in our econometric analyses: to that effect, we take care that the change at the beginning of a "roll month" compares the "new crop" figures that month with the "new crop" figures of the previous (pre-roll) month.

The construction of various Working T indices is detailed in the main text. The position data used to construct the T series are published by the CFTC on Fridays based on Tuesday data on the end-of-day positions of individual traders. When Tuesday is a holiday, the CFTC uses the end-of-day positions of the following Wednesday. For the week of 11 September 2001, we used the figures for the prior Tuesday.

B. Shocks in the Livestock Space

We include demand dummies to account for exogenous shocks to demand for pork and beef. They cover two periods (23 December 2003 to 30 April 2004, and 18 April to 31 August 2009) to account for the lasting impacts of the first U.S. episodes of mad cow disease (bovine spongiform encephalopathy, or BSE) and swine flu (H1N1 virus). The time intervals are based on empirical evidence that the market impact of those two events lasted approximately four months in each case. In the main text (see footnote 10), we justify those choices by referring to recent papers by Attavanich, McCarl and Bessler (2011) in the case of swine flu and Pozo and Schroeder (2012) in the case of mad cow disease. We consulted a number of additional papers, all of which also support our choice. Those papers are listed at the end of this appendix.

C. VAR Analysis of Grain-Livestock (cross-commodity) Return DCC

For a cross-commodity analysis, we estimate dynamic conditional correlations (Engle, 2002) between the returns on two investable ag indices: the total return S&P GSCI indices for grains and for livestock. Figure 1 in the main text depicts in green the evolution of that variable. It displays the same sharp rise in autumn 2008 as for the grain-equity and livestock-equity DCC series.

For the structural VAR, we propose that the dynamic conditional grain/equity return correlations (DCC Grains-Livestock) are driven by shocks in (i) macroeconomic conditions (SHIP); (ii) storage capacity (Corn Storage); and (iii) speculative activity (Non-Energy T), with this third variable computed as a weighted average of all non-energy commodities included in the S&P GSCI index (properly rescaled to account for the fact that the weights do not sum up to zero). Mad cow and swine flu dummies are included as exogenous variables, as is the corn crop progress report. Pre-crisis estimations are run with seven lags, whilst post-crisis estimations are run with five lags following the AIC.

Figure 5 (Panels A and B) shows the impulse-response functions from our four variable recursive VAR with 90 percent confidence bands. As with Figures 3 and 4 in the main text, Panel A reports the *pre*-Lehman period results and Panel B reports the *post*-Lehman results. Results are again organized so that the rows of a matrix indicate the variable whose shock we are following, while the columns of the same matrix indicate the variable whose response we are tracking. Each chart within the panels gives the impulse responses over 20 weeks to a one-standard-deviation shock to the variable identified in the first column.

We see from Figure 5 (Panel A) that improvements in macroeconomic conditions (SHIP) lead to a decrease in the dynamic conditional grain/livestock return correlations (DCC Livestock-Grains) in week 2 and in weeks 4 to 12. A positive shock to SHIP also leads to a decrease in financial speculation (Non-Energy T) in week 3, which in turn leads to a persistent decrease in food storage (Corn Storage) starting in week 4, though that persistent decrease carries no significant effect on correlations (DCC Livestock-Grains). Panel B of Figure 5 shows that, in the *post*-Lehman period, a positive shock to SHIP leads to a decrease in the dynamic conditional grain/livestock return correlations (DCC Livestock-Grains) between weeks 7 and 12. We interpret those results as evidence that fundamentals matter the most.

Figure 5A: Recursive VAR for Livestock-Grain before Great Recession

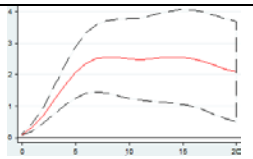
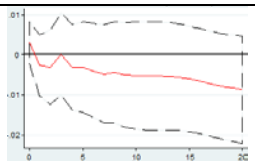
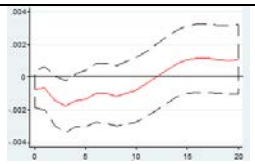
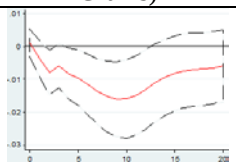
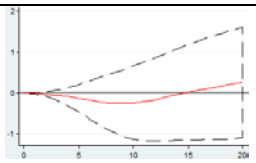
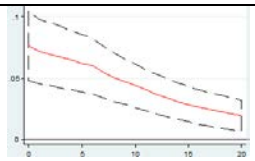
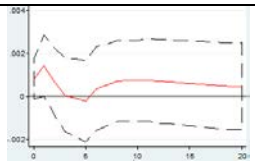
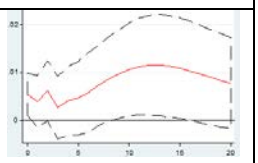
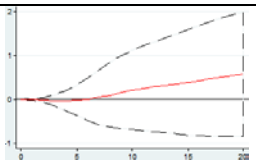
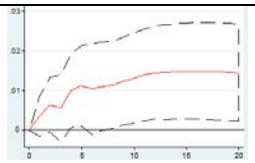
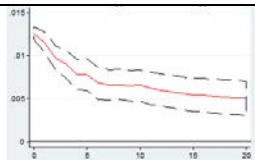
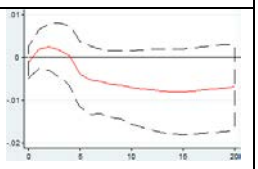
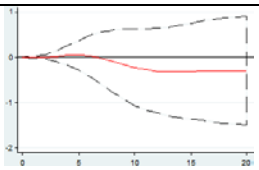
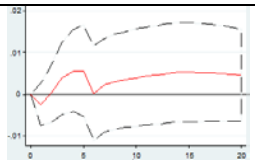
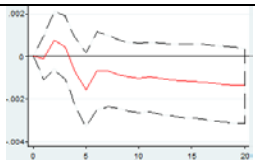
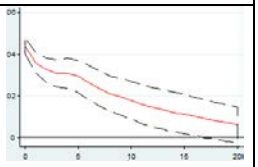
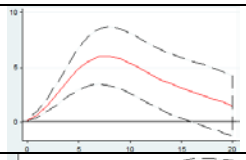
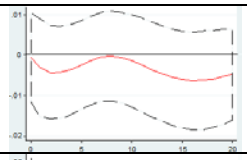
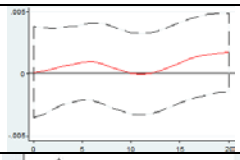
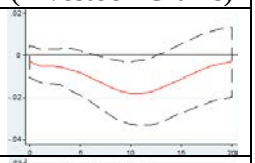
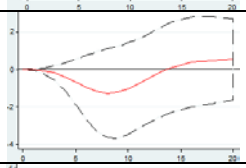
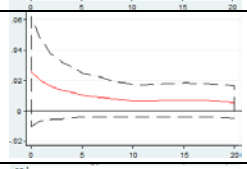
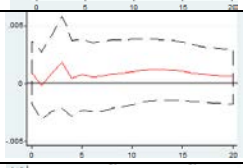
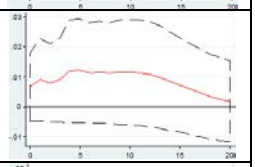
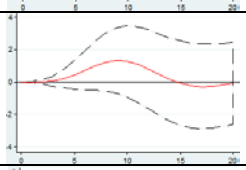
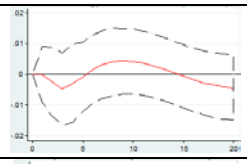
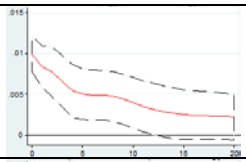
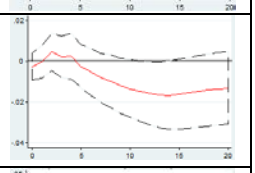
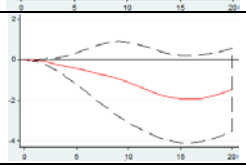
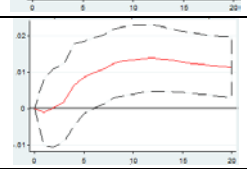
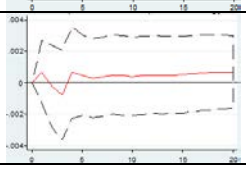
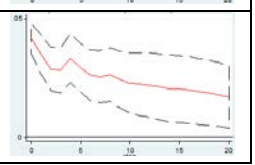
Recursive VAR	Ordering 1	2	3	4
Impact of (↓)	On SHIP	On Corn Storage	On Non-energy T	On DCC (Livestock-Grains)
SHIP				
Corn Storage				
Non-energy T				
DCC (Livestock -Grains)				

Figure 5B: Recursive VAR for Livestock-Grain after Great Recession

Recursive VAR	Ordering 1	2	3	4
Impact of (↓)	On SHIP	On Corn Storage	On Non-energy T	On DCC (Livestock-Grains)
SHIP				
Corn Storage				
Non-energy T				
DCC (Livestock-Grains)				

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