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The Effects of Hedging and Speculation on Cash-Futures Basis: Results from U.S. Wheat Markets

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Abstract: This study examines impacts of hedging and speculation shocks on cash-futures basis for three types of wheat produced in the Northwest U.S. Volatility transfers are measured using a Bayesian vector autoregression (BVAR) procedure to capture the contemporaneous effects of cash-futures basis and open interest positions. By applying a BVAR model and inducing stationarity with the Baxter-King filter this study observes aggregate position sizes relative to actual basis levels within an endogenous structural framework. The results demonstrate a pattern of significant impulse responses to basis from shocks to hedging and speculative total open interest for each market. Positive shocks to open interest create contemporaneous positive impacts on the basis and an increased convenience yield. This implies the risk premium nested within the basis also varies with shocks to hedging and speculative positions. Historical decompositions indicate that hedger and speculator total open interest explains short-run basis volatility for Chicago and Kansas City markets, but not for the Minneapolis market. Evidence is provided that the difference is due to lower liquidity levels in Minneapolis. The results imply that speculator provided liquidity benefits hedgers across the supply chain. This information is valuable to hedgers and liquidity providers, as well as producers, distributors, and exporters.

Keywords: Bayesian estimation; Structural VAR; Agricultural commodities; Hedging; Speculation; Cash-futures basis

JEL Classification: C32, G13, Q13

1. Introduction

The behavior of cash prices, futures prices, and the corresponding cash-futures basis in commodity markets is an important issue for a range of market participants, and it has received much attention in the academic literature. The primary questions of interest relate to either hedging strategies or the mechanics of price discovery in these markets. The two issues are closely related as the process of price discovery informs the decision models employed by hedgers (Hong and Yogo, 2012; Siaplay *et al*., 2012; Acharya *et al*., 2013), and investors (Gorton and Rouwenhorst, 2006; Erb and Harvey, 2006; Gilbert and Pfuderer, 2014), while the demand for hedging and speculation affects both prices and conditional volatility for commodity markets (Frank and Garcia, 2009; Liu and Tang, 2011; Yang, 2013).

This study extends the literature by examining contemporaneous effects of aggregate hedging and speculative positions on cash-futures basis and by using a Bayesian VAR approach with sign restriction identification schemes to measure structural shifts. Earlier work either focuses on futures data only, does not consider the effects of both hedger and speculator positions, or examines price behavior in reduced-form equations without considering contemporaneous effects in an endogeneity -based structural framework. The BVAR approach captures contemporaneous systemic effects underlying the evolution of cash-futures basis as well as the effect of hedging and speculative open interest positions. In addition, by inducing stationarity with a Baxter-King filter this study observes aggregate open interest positions for hedgers and speculators and views their effect on the actual basis level rather than basis returns. Accordingly, this study provides a direct, robust examination of basis behavior in the face of liquidity shocks by both hedgers and speculators.

Section 2 provides an overview of relevant literature to provide context for our study. Sections 3 and 4 present the data and methodology. The test results are discussed in Section 5. Conclusions are summarized in Section 6.

2. Literature Review

The interaction of hedgers and speculators is an important element in price discovery for commodity prices and the corresponding basis. A comprehensive review of Keynes's theory of normal backwardation provided by Bryant *et al*. (2006) suggests that hedging pressure creates a risk premium embedded in the cash-futures basis, and that speculators can profit from this pricing effect.

A speculative bubble in commodity market prices from 2006-2008 raised the question of speculators affecting futures prices in a manner that was harmful to producers and other hedgers. This became the subject of a Senate subcommittee investigation on excessive speculation in wheat markets, which was published in 2009 (see U.S. Senate Report, 2009). This was examined in a series of studies by Sanders and Irwin (2010) and Irwin and Sanders (2011). Despite capital flows from commodity index traders of more than $100 billion from 2004-2008 they do not find evidence that long-only index funds impact futures returns. In contrast, Gutierrez (2013), finds that a common macro-economic factor was not the cause of the bubble, thus suggesting the presence of trading effects.

There is evidence that convenience yield is a determining factor in both risk premium (Yang, 2013) and risk premium volatility (Liu and Tang, 2011) for futures returns. Szymanowska *et al*. (2014) argue that futures returns contain both spot price risk premia and term risk premia. They note that term premium effects are closely related to changes in basis, and reflect risk created by convenience yields. Sorting on basis allows them to demonstrate a negative spot premium and positive term premium, the latter being consistent with hedging pressure effects.

The behavior of commodity spot prices was examined by Ai *et al.* (2006), who found that fundamental factors on the supply side largely explained pricing and correlations, and that speculation was not a significant driver in the markets. The effect on spot prices by commodity index traders such as exchange traded funds was examined by Bohl and Stephan (2013). They find that the financialization of commodity cash markets does not affect cash price volatility and that speculators do not drive conditional variance in these markets.

From the perspective of hedgers, one would expect the demand for hedging to be greater when markets become more volatile. Siaplay *et al*. (2012) provide evidence that producers primarily look to basis as a market signal for the impulse to store at harvest. Hong and Yogo (2012) find that total position size in the market has both correlation and predictive value for futures prices. Their results imply that convenience yield is driven by the demand for hedging in futures markets and they argue that this is due to the informational component of open interest levels relative to future economic activity.

Sanjuán-López and Dawson (2017) consider hedgers from multiple perspectives within the supply chain. They argue that decreased volatility is beneficial to all firms in the supply chain, but increases in futures price create hedging benefits to farmers while processors and input supply firms receive hedging benefits when futures prices decrease. They find a positive impact between net long index trader positions and grains futures prices and also show that index trading reduces volatility. These results are consistent with Gilbert and Pfuderer (2014) who provide evidence that liquidity provided by speculators helps improve market conditions for hedgers. Likewise, Acharya, *et al*. (2013) examine the effect of capital constraints to speculators and provide evidence that such constraints result in limits to hedging and corresponding adverse price effects for producers using futures for price risk management.

3. Data

Weekly data is observed from June 2010 to May 2016 for cash-futures basis and for corresponding open interest positions for hedgers, speculators, and other traders. Consistent with the inventory data used by Gorton *et al*. (2013), cash market data is observed for three different wheat types out of Portland: white wheat, hard red spring wheat, and hard red winter wheat. Table 1 provides summary statistics for the cash-futures basis and open interest positions for each of the three markets.

Table 1. Summary statistics by market

Chicago (Observations N=313)				
	Basis	Hedging OI	Speculation OI	Other OI
Mean	0.5550	414,801.3	225,789.6	152,990.9
Median	0.5925	387,768.0	227,129.0	149,579.0
Maximum	1.7875	643,248.0	306,780.0	23,1903.0
Minimum	-0.9925	273,767.0	149,306.0	85,836.0
Kansas City (Observations N=313)				
	Basis	Hedging OI	Speculation OI	Other OI
Mean	0.8474	165,210.7	72,361.2	38,289.4
Median	0.9350	158,621.0	68,892.0	35,697.0
Maximum	1.7500	243,122.0	123,495.0	76,880.0
Minimum	-0.5500	121,866.0	49,552.0	19,497.0
Minneapolis (Observations N=313)				
	Basis	Hedging OI	Speculation OI	Other OI
Mean	1.6056	61,082.6	12,010.4	11,113.4
Median	1.4025	63,012.0	11,904.0	11,099.0
Maximum	3.8550	98,655.0	22,838.0	21,055.0
Minimum	0.3000	30,797.0	3,952.0	1,508.0

The cash-futures basis corresponding to each of these spot prices is found using futures prices that correspond to the typical hedging instrument for each of the three wheat varieties. White wheat is paired with the nearby Chicago wheat futures contract, hard red winter is matched with the nearby Kansas City futures, and hard red spring is matched with the nearby Minneapolis futures. The basis is estimated by subtracting futures from spot prices. Weekly prices for rolling front month futures contracts were collected from Bloomberg. Data for each type of wheat in the cash market were provided by the Pacific Northwest Farmer's Cooperative. Weekly Commitment of Trader (COT) data provided by the CFTC is used to capture open interest levels for hedging, speculation, and other positions for each market. The COT open interest levels are aggregated across long, short, and spread positions in each market and across each category.

Among these markets, Chicago futures exhibit the highest liquidity and the lowest cash-futures basis, while Minneapolis futures have the lowest liquidity and highest basis. The mean basis level is positive for all markets. Hedging positions represent the majority of total open interest across the three markets. The level of speculative positions relative to hedging positions decreases with overall market liquidity, with speculative open interest levels at about 54% of hedging levels for Chicago contracts, 44% for Kansas City contracts, and 20% for Minneapolis contracts.

4. Methodology

In the US wheat markets, hedgers and speculators are major participants and their behaviors are decided by many exogenous factors, including the weather conditions, macroeconomic situations, the current state of wheat demand and supply, and short-run forecast indicators. From a policy perspective, trading pressure by hedgers and speculators is also an important exogenous factor. At any given time, exogenous independent shocks, such as changes in the level of open interest positions held by hedgers or speculators, contemporaneously appear and create impacts on the cash and futures contract prices, implying the cash-futures basis will be continuously adjusted.

Since the goal of this study is to address the contemporaneous impacts of exogenous independent shocks in the markets, structural VAR models are employed to investigate how independent shocks on hedging and speculative positions propagate through the basis and the risk premium nested in the basis. The dynamic time series model can be specified as:

$$A_0 Y_t = A_1 + \sum_{s=1}^{\infty} A_s Y_{t-s} + u_t \tag{1}$$

where Y_t is a vector containing the cash-futures basis and the open interest levels for hedgers, speculators, and other positions. The term $A_0^{-1}u_t$ is presented in equation (2) after moving the matrix A_0 to the right hand side of equation (1), and represents a residual vector, ε_t, which is estimated from the reduced-form unrestricted VAR, where $A_0^{-1}u_t = \varepsilon_t$.

$$Y_t = A_0^{-1}A_1 + \sum_{s=1}^{\infty} A_0^{-1}A_s Y_{t-s} + A_0^{-1}u_t \tag{2}$$

Equation (2) represents the reduced-form of the structural VAR (SVAR) model, and it can be consistently estimated by Ordinary Least Squares (OLS) estimation as there is no endogeneity in the right hand side variables in the reduced-form VAR model. The error terms from the reduced-form VAR are correlated as each of them is a linear combination of the common independent structural shock, u_t, from equation (1) (Lutkepohl, 2005). Structural VAR model (1) can be transformed into a vector moving average (VMA) representation, which can be analyzed using impulse response functions (Sims, 1980). The VMA representation of vector Y_t is shown in equation (3):

$$Y_t = \mu + \sum_{s=0}^{\infty} \phi_s u_{t-s} \tag{3}$$

Therefore, basis, hedger positions and speculator positions, which are considered to be endogenous variables in this study, are treated as functions of current and past values of independent structural shocks, u_t, showing the impact over time of shocks on each other. To identify the structural shock u_t, the matrix A_0 must be specified such that restrictions on the errors can be imposed to identify the structural shocks (Lutkepohl, 2005).

This study employs an agnostic sign restriction identification procedure for structural shocks as used by Uhlig (2005) and Fry (2011). The matrix A_0 must satisfy $E(u_t u_t') = I$ where $u_t = A_0 \epsilon_t$. Therefore, $(A_0 \epsilon_t \epsilon_t' A_0') = I$. A Cholesky decomposition is used to obtain the matrix $P = Chol(\Sigma)$, which is the Cholesky decomposition of $\Sigma = E(\epsilon_t \epsilon_t')$. Suppose H is a 'given matrix', in which $HH' = I$. It is possible to create a matrix $A_0 = Q'$ where $Q = PH$, and matrix A_0 could satisfy the condition, $\mathrm{E}(u_t u_t') = I$. Within this framework it is possible to construct an infinite number of given matrices H.

Initially, the Cholesky identification procedure is used to get the matrix P. This is followed by the generation of 10,000 rotation matrices H, and from them, the same number of matrices $A_0 = Q^{-1}$ is obtained. In order to allow the data to speak, an agnostic sign restriction is used which applies no predetermined sign pattern for the Q matrices. The Mean-Target methodology suggested by Fry and Pagan (2011) is used to find the model with impulses closest to the mean of the impulses from all models.

VAR models have been widely used to study the interdependency between time series, but they are not parsimonious and can require large numbers of parameters to be estimated. An alternative to the traditional OLS estimation is the Bayesian VAR (BVAR) approach, which is growing in popularity given the more efficient estimates obtained due to the inclusion of out-of-sample information through prior distributions (Koop, 2003; Koop and Korobilis, 2009). The priors are adjusted to get the posterior distributions when data are available, and inferences about the true parameters of the model are based on them.

This study uses the Minnesota priors developed by Litterman (1986) as they have been demonstrated to fit well with the nature of VAR models. They accommodate the use of out-of-sample information thus improving the efficiency of estimations. The resulting BVAR estimations using Minnesota priors are more efficient and the impulse responses are more accurate (Doan, *et al*., 1984).

Previous studies have demonstrated that many economic time series are persistent with a nonlinear trend (Uhlig, 2005; Christiano *et al*., 2005; Canova, 2007; and Kilian, 2009). These studies include trend and cyclical components and can be classified as nonlinear trend stationary. This stands in contrast to other studies that classified the series as non-stationary, such as Kilian and Lutkepohl (2017). The data observed for this study is de-trended using the Baxter-King (BK) procedure which is a band-pass filter that shuts down all fluctuations outside a chosen frequency band (DeJong and Dave, 2011). The BK filter eliminates cycles with frequencies that are too fast or too slow and removes non-linear trends in the data series. The de-trended series contains only cycles that create dynamic impacts between the variables. Although the Hodrick-Prescott (HP) filter is commonly used for this de-trending procedure, there is some evidence that the HP filter may create spurious dynamic relations between variables. The BK filter is an alternative de-trending procedure that addresses this issue and reliably produces cycles within the series.

Spurious regression problems can arise when non-stationary series are regressed (Granger and Newbold, 1974), therefore, unit root tests are run to determine if the original and de-trended series are stationary. Augmented Dickey-Fuller unit root test results are reported in Table 2 on the next page. Consistent test results are obtained using the Elliott, *et al*. (1996), and Ng and Perron (2001) test procedures. After the trend was removed using the BK filter, the hypothesis of a unit root is strongly rejected at 1% alpha level. Accordingly, the de-trended series in levels is used in the estimation of the BVAR model.

Table 2. Augmented Dickey-Fuller test statistics

Level Series				
	Basis	Hedging	Speculation	Other
Chicago	-2.885	-2.828	-2.868	-2.211
Kansas	-2.42	-2.263	-2.265	-1.198
Minneapolis	-2.404	-2.657	-3.192	-1.625
Detrended Series Using Baxter-King Filter				
	Basis	Hedging	Speculation	Other
Chicago	-10.08***	-9.85***	-8.73***	-9.31***
Kansas	-7.68***	-10.21***	-9.33***	-10.16***
Minneapolis	-9.29***	-10.30***	-9.19***	-10.56***

*** *implies statistical significance at the 1% alpha level.*

Previous studies have addressed the stationarity issue by observing futures returns data and the net-long change in open interest data. By applying a Bayesian VAR model and inducing stationarity with the BK filter this study examines aggregate position sizes for hedgers and speculators relative to cash-futures basis levels and examines the shock responses in an endogenous structural framework. This methodology represents a new approach to measuring the effects of price and liquidity shocks on the cash-futures basis.

5. Empirical Results

The focus of this study is on tracking the influence of independent shocks to open interest levels for hedging and speculative positions on the cash-futures basis. The signs of these shocks are constrained to be positive. Other variable signs in the model are unrestricted because of uncertainty about how they react to shocks in hedger and speculator positions. This allows the data to speak on the interdependence of variables.

The sign of matrix A_0^{-1} is as follows:

$$A_0^{-1} = \begin{bmatrix} + & \times & \times & \times \\ \times & + & \times & \times \\ \times & \times & + & \times \\ \times & \times & \times & + \end{bmatrix} \quad (4)$$

where × indicates an unrestricted sign. The study generated ten thousand iterations for the H matrix. Among the ten thousand iterations, roughly 200 produce impulse responses that match the sign restrictions of the matrix A_0^{-1}.

5.1 Responses of basis to hedging and speculative open interest shocks

Figure 1 reports the responses of the Chicago basis (i.e., soft white spot prices minus Chicago wheat futures) to positive shocks on hedger and speculator positions. The figure presents the 90%

confidence intervals and mean-target impulse response functions for a horizon up to 20 weeks after the shocks. Table 3 on page 8 reports the impulse response values for the basis across the three different markets.

The impacts are normalized on basis to an increase of 50 cents. The graph indicates that an independent positive exogenous shock of 40,000 contracts in hedging open interest would create a 50 cent increase in the cash-future basis during the same week, and the spillover effects from hedge trading to basis remain significant for about two weeks before fully decaying. In comparison, an independent positive exogenous shock of 50,000 contracts in speculator open interest results in the same 50 cent increase in the cash-futures basis. The spillover effects remain significant for about four weeks.

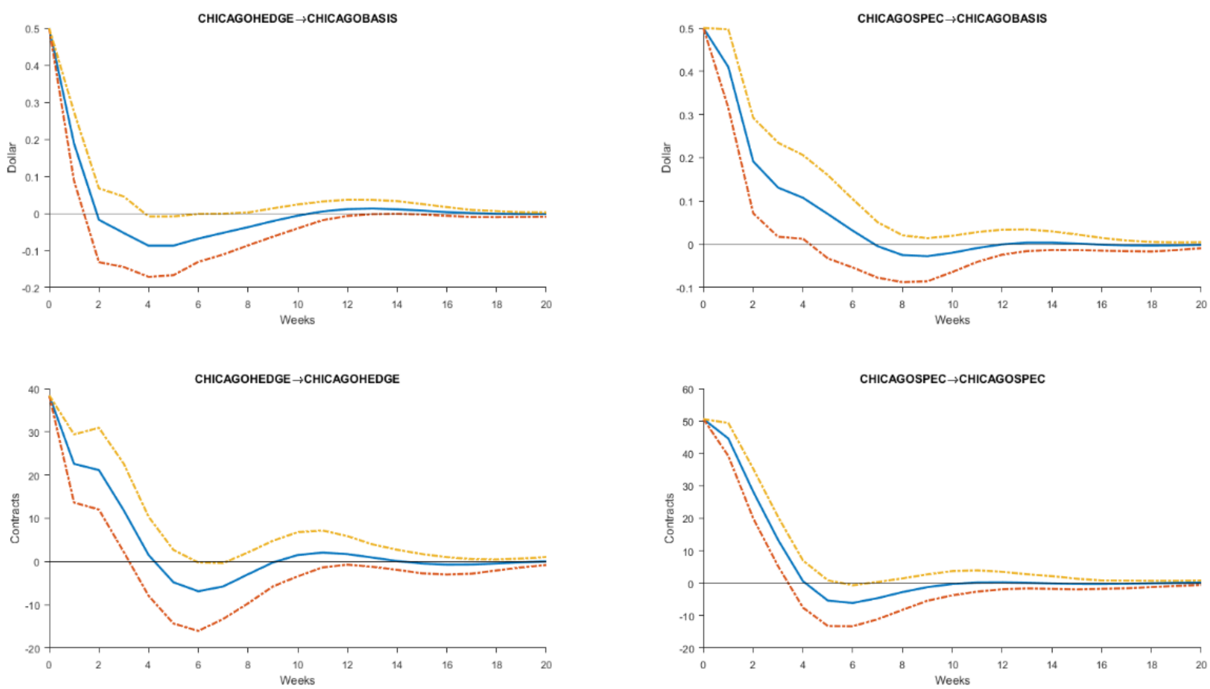

Figure 1. Impulse responses of Chicago basis to shocks in hedger and speculator open interest

The results for the Chicago basis indicate that positive shocks in open interest result in a strengthening of the cash-futures basis and therefore alter the market clearing basis relative to the full-carry price of the futures contract. A corresponding implication is that open interest shocks will affect the term risk premium embedded in the basis, which is consistent with Hong and Yogo (2012), Liu and Tang (2011), and Szymanowska, *et al*. (2014).

To provide some context to these results, the relative size of the open interest shock needed to create a 50 cent move in the basis is compared for hedgers (40,000 contracts, or 9.73% of the average open interest for the sample period) vs. speculators (50,000 contracts, or 21.88% of the average open interest for the sample period). The implication is that the Chicago basis is sensitive to shocks in the levels of both hedger and speculator open interest, and that the level of sensitivity is mostly symmetrical between the two types of traders. This result is consistent with Acharya, *et al.* (2013) and Sanders and Irwin (2010) in its support for the argument that capital investment by speculators tends to benefit hedgers.

Table 3. Impulse responses to shocks on hedging and speculation open interest

Week	Chicago Basis		Kansas City Basis		Minneapolis Basis	
	Hedging	Speculation	Hedging	Speculation	Hedging	Speculation
0	0.50**	0.50**	0.50**	0.50**	0.50**	0.50**
1	0.1885**	0.4098**	0.2387**	0.3881**	0.4118**	0.2955**
2	-0.0172	0.1916**	0.0583	0.2709**	0.0521	0.2354**
3	-0.0527	0.1310**	0.0631	0.2294**	-0.0825	0.1723**
4	-0.0870	0.1076**	-0.0422	0.1319**	-0.3899	0.0278
5	-0.0869	0.0699	-0.0807	0.0664	-0.531**	-0.0400
6	-0.0681	0.0314	-0.0701	0.0077	-0.4378	-0.0761
7	-0.0524	-0.0044	-0.0619	-0.0437	-0.2939	-0.0954
8	-0.0371	-0.0250	-0.0390	-0.0692	-0.1177	-0.0856
9	-0.0208	-0.0275	-0.0189	-0.0769**	0.03427	-0.0634
10	-0.0061	-0.0195	-0.0053	-0.0675	0.1215	-0.0367
11	0.0053	-0.0086	0.0052	-0.0460	0.1520	-0.0093
12	0.0117	-0.0001	0.0106	-0.0220	0.1400	0.0128
13	0.0132	0.0038	0.0123	-0.0009	0.1045	0.0267
14	0.0112	0.0038	0.0118	0.0136	0.0619	0.0316
15	0.0075	0.0017	0.0094	0.0203	0.0225	0.0285
16	0.0036	-0.0007	0.0062	0.0205	-0.0081	0.0199
17	0.0006	-0.0023	0.0029	0.0164	-0.0281	0.0091
18	-0.0012	-0.0028	0.0001	0.0103	-0.0376	-0.0008
19	-0.0018	-0.0023	-0.0019	0.0041	-0.0378	-0.0077
20	-0.0017	-0.0012	-0.0028	-0.0008	-0.0310	-0.0108

*** Significant at the 5% alpha level.*

The pattern of responses to positive shocks in hedger and speculator open interest is consistent across the Kansas City and Minneapolis futures markets as shown in Figures 2 and 3.

For Kansas City basis the magnitude of hedging shock required to create a 50 cent strengthening is the same 40,000 contracts, but it is only 25,000 contracts for speculator positions. In percentage terms, however, the 40,000 contract shock represents 23.98% of the average open interest for hedgers on the Kansas City market, and the 25,000 contract shock represents 33.16% of the average open interest for speculators. The Minneapolis basis shows a similar result. A 50 cent basis move is created by a 25,000 contract shock for hedgers, and a 4,500 contract shock for speculators. While these numbers are lower in absolute terms they represent 40.63% and 37.89% of average open interest for hedgers and speculators, respectively. The results for Kansas City and Minneapolis, when compared as a percent of open interest, are even more symmetrical between hedgers and speculators compared to the Chicago basis, and the implications relative to risk premia and the role of speculative capital are consistent with the results for the Chicago market.

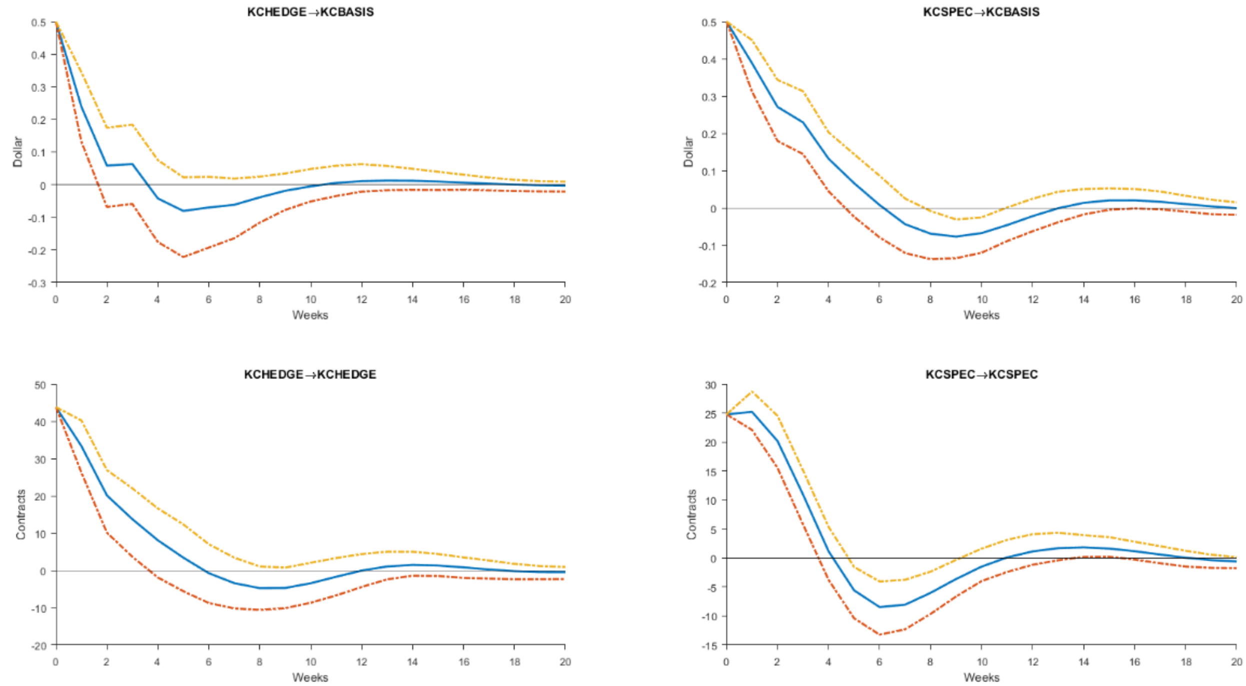

Figure 2. Impulse responses of Kansas City basis to shocks in hedger and speculator open interest

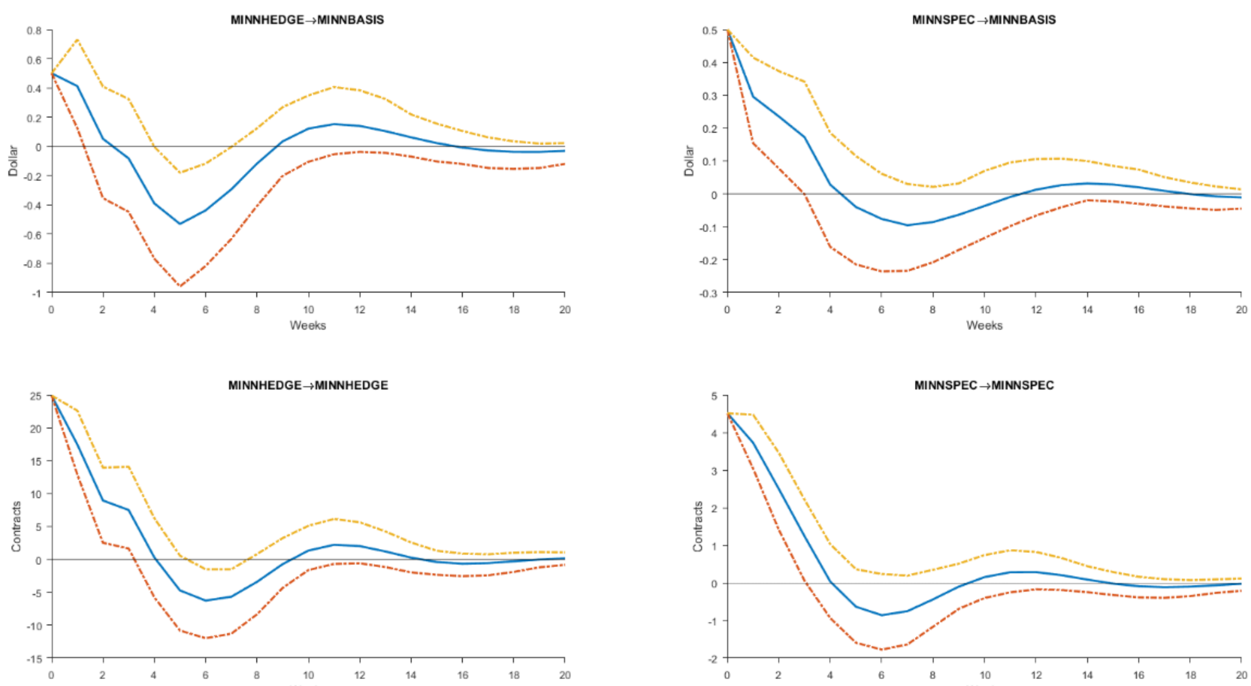

Figure 3. Impulse responses of Minneapolis basis to shocks in hedger and speculator open interest

The impulse responses indicate that both hedging and speculative activity have similar contemporaneous impacts on the basis fluctuations. The data analysis implies that increases in hedging and speculative activity create pressure on the futures contract price and force it to reduce relative to the spot price. It is worthwhile to note that hedger and speculator activity creates pressures on futures contract prices as opposed to spot prices. From the response analysis we find that market participants could expect that a large positive exogenous shock in overall hedging and/or speculation activities would reduce futures contract prices relative to spot prices, thus strengthening the basis with a corresponding increase in the term risk premium. Likewise, a negative shock in hedging and/or speculation will weaken the basis with a corresponding decrease in the term risk premium.

The general symmetry in the shocks for hedgers vs. speculators – in terms of open interest levels for the Chicago market, and in terms of percent of average open interest in the Kansas City and Minneapolis markets – indicate a tendency towards stability in basis and risk premia when they act as counter-parties (e.g., short hedger and long speculator or vice versa). Moreover, even when open interest shocks are one-sided (i.e., caused primarily by hedgers or speculators) the data suggest that the shock must be relatively large to create changes in risk premia that would create excessive adverse effects for market participants. In addition, the effect on basis itself is relatively short lived, lasting only a few weeks.

5.2 Historical decomposition of wheat basis fluctuations

Figure 4 provides historical basis volatility for Chicago basis relative to hedging and speculation open interest shocks. The graph demonstrates the de-trended actual basis compared to what the basis would have been with only hedging and speculative shocks.

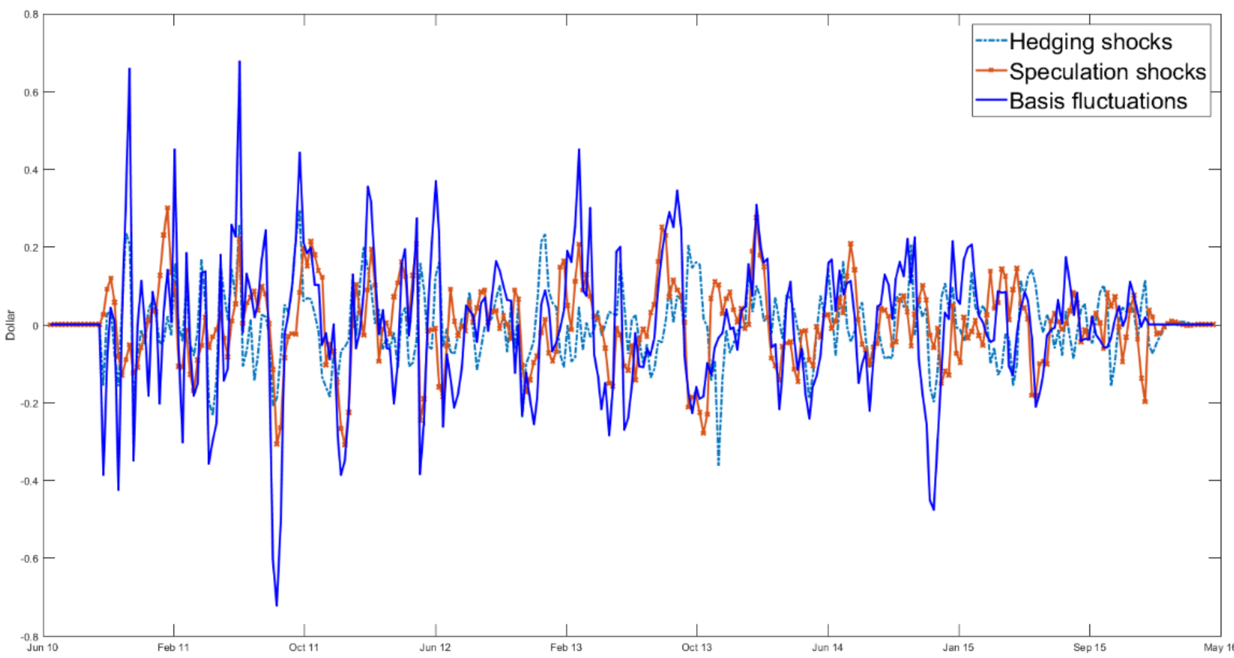

Figure 4. Historical Chicago basis fluctuations *v.s.* hedging and speculation shocks

Consistent with results from the impulse response functions, the hedging shocks, speculative shocks, and de-trended basis move together over time and in the same direction. Combined shocks from hedgers and speculators tend to account for the majority of basis volatility over time. Both hedger and speculator shocks move closely with basis volatility, although large spikes in basis volatility are explained most frequently by speculative open interest shocks. The decomposition graph supports the observation that both hedgers and speculators move basis over time, and that shocks to speculator open interest imply increased liquidity to the market during times of high basis volatility.

Figure 5 below provides historical volatility for Kansas City basis relative to shocks caused by speculator and hedger open interest. As before, both hedging and speculative open interest shocks move together with the de-trended basis over time. Compared to hedging shocks, the speculative shocks moved more closely with the basis fluctuations throughout the sample. This is particularly the case for large spikes in basis volatility. In nearly every case the shock to speculative open interest accounts for the large majority of the basis volatility spike. As with the Chicago basis, it would appear that speculators are providing liquidity to the markets during times of basis volatility.

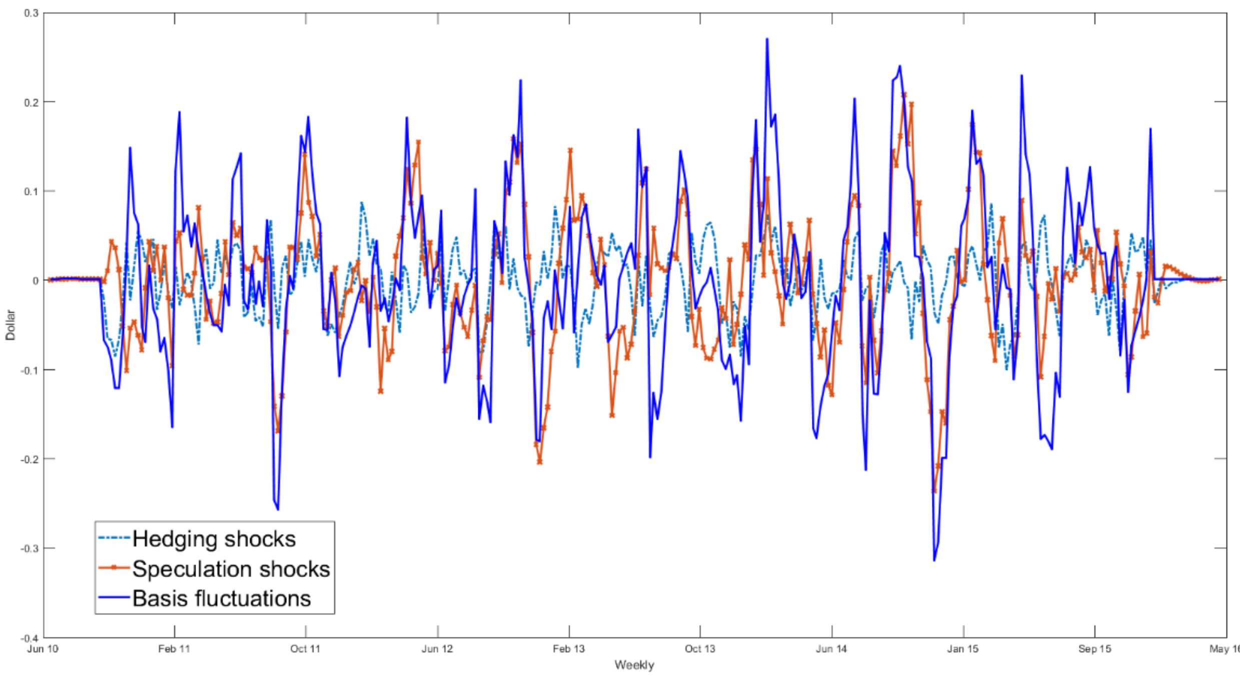

Figure 5. Historical Kansas City basis fluctuations *v.s*. hedging and speculation shocks

Figure 6 on the next page provides historical volatility for Minnesota basis relative to hedging and speculation shocks. The results here differ from the other two markets in that neither hedging nor speculative positions dominate in terms of their ability to explain basis variation. Multiple periods exist throughout the sample where large variations in basis occur that have little relation to open interest positions from either hedgers or speculators. The results here are likely due to the lower degree of overall liquidity, and the lower rate of speculator participation, in the Minneapolis market.

Figure 6 shows that speculator open interest explains a larger degree of basis volatility early in the sample, especially the second half of 2011 and beginning of 2012. That relationship breaks down during 2012 and 2013 with frequent spikes that are not captured by hedging or speculative OI behavior. The pattern becomes more pronounced in the latter part of the sample where volatility spikes become much larger, particularly from late 2013 through early 2015.

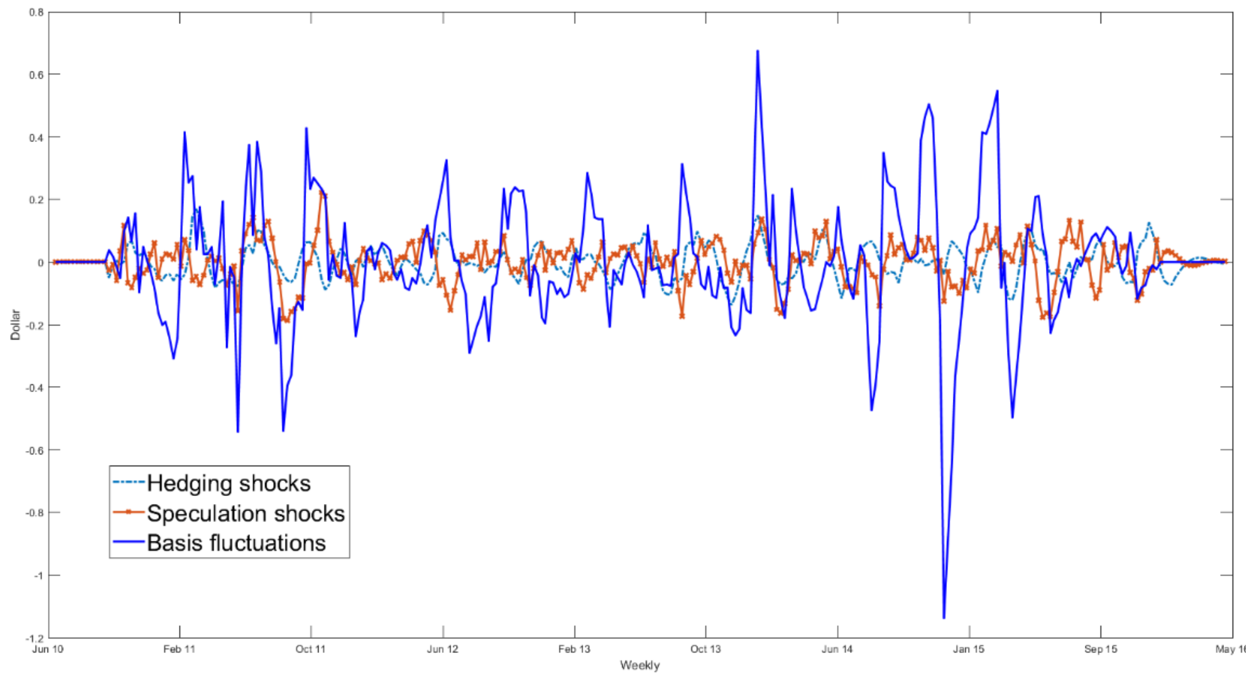

Figure 6. Historical Minnesota basis fluctuations *v.s.* hedging and speculation shocks

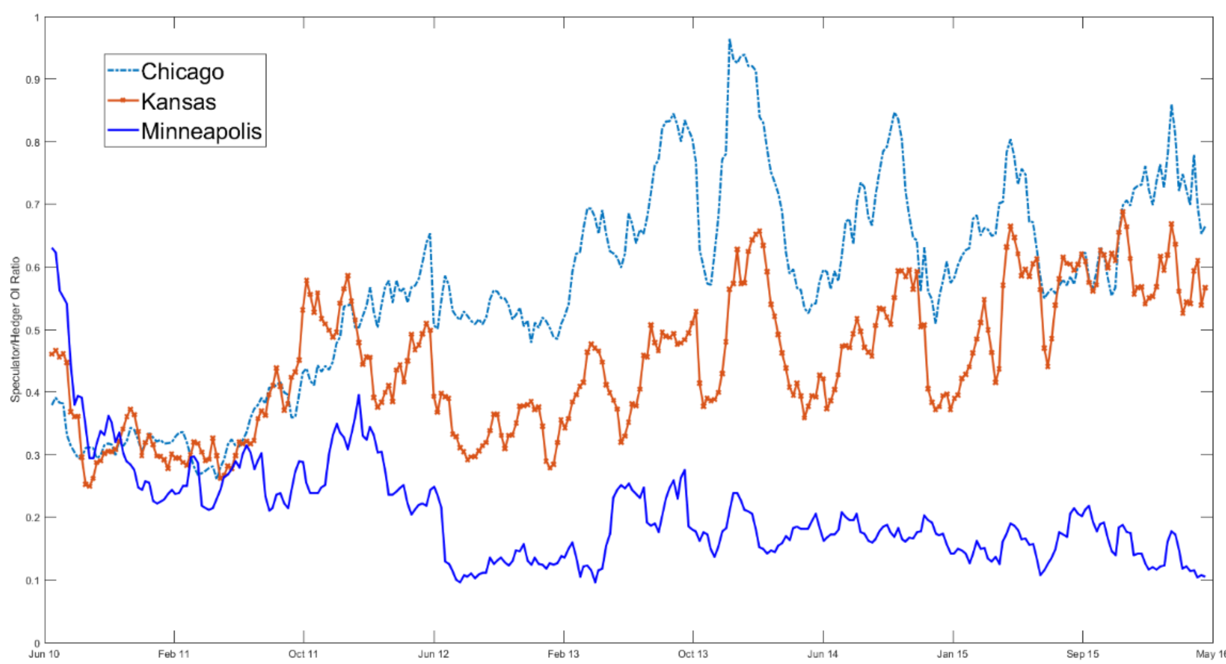

Figure 7. Speculator-to-Hedger open interest ratio

Figure 7 provides the ratio of Speculator-to-Hedger Open Interest across the sample period for all three markets. The ratio for Chicago contracts increases over time and falls mostly in the 60%-80% range in the second half of the sample period. Likewise, the ratio for Kansas City contracts increases early on, and then ranges mostly between 40%-60% for the majority of the sample period.

In contrast, the ratio for Minneapolis contracts shows stronger speculator participation early on, and then trends downward for the remainder of the sample. The ratio deteriorates during the first half of 2012 and never recovers, trading in a range below 20% for the second half of the sample period.

This is consistent with previous results regarding open interest and liquidity effects. Specifically, the decreasing presence of speculator open interest over time implies that futures contracts convey less information on investor expectations resulting in decreased basis efficiency (Hong and Yogo, 2012), and the limited capital from speculators creates adverse price effects for hedgers and other market participants (Acharya *et al*., 2013).

6. Concluding Remarks

This study observes weekly data for the cash-futures basis on three types of wheat grown in the Northwest U.S. The spot prices are paired with the futures contracts from Chicago, Kansas City, and Minneapolis which are commonly used as hedge instruments for each series. A Bayesian VAR model is employed to estimate volatility spillovers to the basis from shocks to total open interest levels for hedger and speculator positions. This represents an improvement over previous studies in that the model observes the dynamics of actual futures prices and open interest positions rather than futures returns and changes in net long open interest positions. This provides a more direct and robust test of the effect of price and liquidity shocks on basis behavior and the risk premium embedded within the basis.

Our results demonstrate a pattern of significant impulse responses to each basis measure from shocks in hedger and speculator positions for each market. Positive shocks to open interest from both hedging and speculation will create contemporaneous positive impacts on the cash-futures basis in the same week, which implies that increased levels of open interest strengthen the basis and increase convenience yields. This also implies the risk premium nested within the basis is affected by the shocks to hedging and speculative positions. During the sample period, shocks to open interest positions of both hedgers and speculators provided large contributions to basis volatility. The level of sensitivity to hedger vs. speculator positions seems mostly symmetrical for each of the three markets, and both hedgers and speculators contribute to large observed basis shocks.

Historical decompositions indicate that both hedger and speculator trading explain large portions of basis volatility in the short term. The influence of these traders is greater in the Chicago and Kansas City markets, and the differing result for Minneapolis is likely due to the lower degree of liquidity in that market. Speculator positions tend to play a larger role in basis fluctuations in the Chicago and Kansas City markets, and this implies that speculators have important information about market conditions that are reflected in current and future basis levels. This is less evident in the Minneapolis market where shocks to trader open interest positions affect the basis, but explain little of the basis variability over time and contribute less to the price discovery process.

The results are consistent with Szymanowska, *et al*. (2014) and imply that hedging pressure and open interest levels are factors in determining the term risk premium embedded within the cash-futures basis. The relative symmetry of the volatility spillovers from hedgers and speculators to the basis support the argument by Acharya *et al*. (2013) that liquidity provided by speculators reduces adverse price effects for hedgers. The results also support the findings of Gilbert and Pfuderer (2014) and, of Hong and Yogo (2012) that liquidity provided by speculators improves market conditions for hedgers and that information contained in open interest levels are reflected in the spot and futures price discovery process. Moreover, our results are based on aggregate open interest levels for hedgers and speculators. This implies that speculator provided liquidity benefits hedgers across the supply chain and is consistent with the results of Sanjuán-López and Dawson (2017).

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