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RESEARCH ARTICLE

Resilience of Grain Storage Markets to Upheaval in Futures Markets

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Abstract: The past two decades have had times when grain cash and futures markets did not converge during delivery. What was the economic impact of this non-convergence on storage markets? To answer this question the supply of storage is estimated for corn, soybeans, and wheat. The lack of convergence is measured using a historical basis. The econometric model shows no relationship between the supply of storage and the lack of convergence. Thus, empirical results suggest that markets were able to adapt to the lack of convergence. Overall, the research indicates the resilience of storage markets to structural change.

Keywords: Basis; Convergence; Hedging; Storage

1. Introduction

During much of 2005-2010, the U.S. wheat, corn and soybeans futures markets experienced non-convergence. Non-convergence occurs when futures contracts are settled much higher or lower than the corresponding market's cash price. Futures contracts nearing expiration are expected to be close to or equal to the cash price at delivery locations, as arbitrage is expected to cause the law of one price to hold [1]. As Garcia, Irwin, and Smith [2] argue, this divergence was created by a divergence in the price of deliverable warehouse receipts and the price of grain.

In a non-converging market, the hedger is still protected from price risk as long as the futures and cash prices move in the same direction. Cash market gains and losses can still be offset by futures market gains and losses. In this case, cash and futures prices do not converge to each other, but they converge on a predictable basis. On the other hand, if the basis at expiration exhibits random fluctuations, then a hedger is not insulated from price risk. The volume of futures trading remained high during the non-convergence periods, which suggests that hedgers may have been able to adapt.

Whether firms hedge or not, they typically base their price expectations upon the futures market. The particular concern is that the non-convergence could have caused the returns to storage to be overestimated. To address this concern, the primary objective of this research is to

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determine the effect of lack of convergence on the supply of storage. Note that mispricing in one market has the potential to spread to other markets [3,4], so the issue is of concern to world grain markets.

2. Theory of Storage

The theory of storage [5-8], defines the equilibrium relationship between cash and futures prices. This relationship can be stated in terms of the basis, the difference between the contemporaneous spot price in period t, S_t, and the futures price (as of date t) for delivery at date T, $F_{t,T}$. The theory is that the (negative of the) basis is composed of the cost-of-carry: Interest foregone to borrow to buy the commodity, $S_t r_t$, (where r_t is the interest charge on a dollar from t to T), plus the physical storage costs $w(T-t)$, minus a convenience yield, c_t, which is an implied return on inventories:

$$F_{t.T} - S_t = S_t r_t + w(T-t) - c_t \quad (1)$$

The futures price minus the spot price equals the basis. The basis is equal to $S_t r_t$, the opportunity cost, plus the marginal storage cost ($w(T-t)$ where w is the daily physical cost of storage), minus the convenience yield. Under the theory of storage, inventories are held only if expected returns are positive. A lack of convergence (with futures higher than cash) would distort this formula and project returns to be higher than actual. Therefore, a shift in the demand for storage could occur and more grain would be stored. The expected profit maximization for a storage provider, assuming that the producer is hedging, can be expressed as:

$$\max_Q E(\pi) = \big(E(F_{t+h} - F_t) - E(S_{t+h} - S_t)\big)Q - C(Q)$$
$$Q \le Capacity \quad (2)$$

where $E(\pi)$ is the expected profit, Q is the quantity stored, F_{t+h} is the distant futures price, F_t is the nearby futures price, S_t is the cash price, S_{t+1} is the distant cash price and $C(Q)$ is a cost function that includes storage fees, insurance, pest management and other costs associated with the storing of the grain. The amount of grain that can be stored is constrained by the capacity, where capacity equals the amount of storage available, for example grain elevators. Brennan [7] lets the amount of a commodity held in storage be determined by the equality of marginal cost of storage and the temporal price spread. In a competitive market a firm seeking to maximize net revenue will hold the amount of stocks such that the net marginal cost of storage per unit equals the expected change in price per unit of time.

Van Huellen [9] explains the non-convergence augments using the commodity storage model and a price-pressure component:

$$E(S_{t+h}) = F_{t,t+h} + \rho_t + E(Basis_{t+h}) \quad (3)$$

where $E(S_{t+h})$ is the expected future cash price, $F_{t,t+h}$ is the futures price at time t and contract maturity of $t+h$, ρ_t is a risk premium, and $E(Basis_{t+h})$ is the expected basis at time $t+h$. Non-convergence makes it difficult for firms to forecast basis. If they are unable to predict the non-convergence then their expected returns to storage will be inaccurate and there will be a loss of social welfare [10,11]. Hatchett and Brorsen [12] as well as Thompson et al. [13] suggest using only the most recent information to forecast basis during times of structural change, but even that is only partly successful.

The Chicago Board of Trade (CBOT) and Kansas City Board of Trade (KCBOT) made changes to grain futures contract specifications to combat the 2005-2010 non-convergence problems. Changes included limiting the number of warehouse receipts and shipping certificates that a trader could hold, expanding delivery locations, and variable storage rates [20]. Irwin [20] argues that the most fundamental change was the implementation of a variable storage rate (VSR) rule for CBOT wheat beginning in September 2010. The Chicago Mercantile Exchange (CME) did not introduce VSR to corn and soybeans markets but chose to increase their fixed storage fees in 2008 and later in 2020 [15]. The objective of implementing VSR was to improve convergence, and that is ultimately what it did. While index funds are often blamed for distorting markets, there is little empirical evidence that they do so [16-18].

3. Data and Methods

Data used for this research came from multiple sources. Futures prices for corn and soybeans were compiled by the Livestock Marketing Information Center (LMIC) and stem from reported prices of CBOT/CME Group futures contract settlement prices. The Kansas City hard red winter wheat contract was used for wheat and these prices come from Barchart. Cash prices for all three commodities were compiled by LMIC based on USDA reports with both #2 Yellow Corn and #1 wheat using Kansas City prices and #1 Yellow Soybeans using Central Illinois prices. The ending stocks for each commodity come from the World Agricultural Supply and Demand Estimates (WASDE) report. The annual ending stock quantities used for wheat are on May 1st, and corn and soybeans are on July 1st. The annual interest rate used is the market yield on U.S. Treasury securities at 10-year constant maturity, which comes from the Federal Reserve Economic Data (FRED). Non-convergence was measured using the basis of the 4 weeks prior to each contract's expiration date,

which is the 15th of that month.

The equation estimated for the supply of storage is:

$$ES_t = \beta_0 + \beta_1 OppCost_t + \beta_2 Returns_t + \beta_3 NonConvergence_t + \epsilon_t \quad (4)$$

where ES_t is the quantity of ending stocks of the commodity at time t, $OppCost_t$ is the cash price of the commodity multiplied by the annual interest rate at time t, which measures the opportunity cost of storing, $Returns_t$ is the expected returns on storage of the commodity using the futures price, at time t, *NonConvergence* is a measure of the basis, and ϵ_t is the random error term such that $\epsilon_t \sim N(0, \sigma_s^2)$. Note that the relationship to returns is sometimes considered nonlinear [19]. The linear approximation is used here due to the relatively small degrees of freedom.

4. Results and Discussions

Table 1 presents the estimates of Equation (4), the supply of storage equation using opportunity cost, the returns from storage and measurement of non-convergence. When trying to connect non-convergence to the amount of grain stored, Table 1 indicates that the measure of convergence is not statistically significant for any of the three commodities. Note that this finding is consistent with Revoredo-Giha and Zuppiroli [20] who found no change in hedging effectiveness in U.S. wheat markets over 2007-2012. Similarly, Karali et al. [21] found that non-convergence did not affect the economic relationship between soft red winter wheat delivery and non-delivery locations. Shi and Insengildina-Massa [22], however, found that hedging failure was more common in corn markets during 2007-2013.

The expected sign for the convergence variable is negative, so it would counter the naive expectation of higher returns on storage than actual returns. So, corn does not have the expected sign for the convergence variable. The other explanatory variables have the expected signs and are statistically significant.

5. Conclusions

The empirical results suggest that grain storage markets adapted to the lack of convergence between cash and futures prices. This research found a negative relationship between opportunity cost and ending stocks, as well as a positive relationship between returns to storage and ending stocks. Thus, firms appear to have formed price expectations based on the predicted change in futures prices rather than by assuming that basis would converge.

Table 1. Estimates of the effect of non-convergence on the supply of storage.

Commodity	Variable	Coefficient		t-val	p-value
KCHRW	Intercept	518	***	7.85	0.001
	Opportunity cost ($/bu)	–1463	***	–4.26	0.001
	Return on storage[a] ($/bu)	295	**	2.79	0.012
	Basis[b] ($/bu)	–35		–0.93	0.368
Corn	Intercept	1669	***	4.82	0.000
	Opportunity cost ($/bu)	–7754	***	–3.39	0.004
	Return on storage[a] ($/bu)	2978	***	3.62	0.002
	Basis[b] ($/bu)	37		0.46	0.649
Soybeans	Intercept	738	***	6.23	<0.0001
	Oppportunity cost ($/bu)	–1924	***	–4.18	0.001
	Return on storage[a] ($/bu)	1425	**	3.50	0.003
	Basis[b] ($/bu)	–286		–1.49	0.156

*p<0.1, ** p<0.05, ***p<0.01.

Notes: The time period was 2000-2021, which gave 21 observations. The dependent variable is ending stocks (May for wheat and July for corn and soybeans).

[a]Return on storage is the calendar spread (for example, KC HRW March 2018 Futures Contract Price minus KC HRW May 2017 Futures Contract Price).

[b]Basis is the average of the four weeks prior to the contract's expiration date.

Author Contributions

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Data Availability

The data are available upon request from the corresponding author.

Conflict of Interest

The authors declare no conflict of interest.

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