Estimating the Location of World Wheat Price Determination

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Abstract: The United States may be losing its leading role in the world wheat market. Rising trading volume in foreign futures markets and shifting shares of world trade are suggested as evidence of this shift, but neither necessitates that futures markets in the United States are any less important for wheat price discovery. This paper uses the Hasbrouck (1995) Information Shares method to estimate the proportion of price discovery occurring in wheat futures markets in Chicago and Paris. Our preliminary results suggest that both markets are important for price discovery, but the Chicago market still leads. The proportion of wheat price discovery in each market remained relative stable over the period 2007-2013.

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"The market is not done in Chicago anymore. Prices of the European continent have taken the leadership of the world wheat market"

- Michel Portier, Director General, Agritel

1 Introduction

The United States (US) has been widely regarded as a world leader in the pricing, production, and trade of major grains. US wheat futures market prices are viewed as benchmarks, establishing the fundamental value of wheat for the entire world. At the same time, the US has been the third largest producer and the leading exporter of the physical commodity that underlies these wheat futures contracts.

Two concurrent trends suggest that the prominence of the US in world wheat markets is not assured. First, the US share of world wheat trade has declined as production and export of wheat from Kazakhstan, Russia, and Ukraine (KRU) increased. Second, US benchmark prices are being supplanted by new price benchmarks that more closely track supply and demand fundamentals in KRU.

This paper examines the relationship between price determination and discovery among four major wheat futures markets in the context of the globally distributed set of shocks to supply and demand fundamentals for the underlying physical commodity. We analyze the price determination process across wheat futures markets to identify the location of price discovery for wheat. In doing so, we determine whether new wheat price benchmarks are complements or substitutes for the price-determining role traditionally played by US wheat futures markets and whether the increasing importance of production in other areas is leading to a decreased price discovery role for US markets.

Our results have important implications for the US wheat industry, and are therefore of significant concern to producers, merchants, end-users, and policy makers. A shift in the location of price discovery may imply a decline in the export competitiveness of the US in world markets. For farmers, merchants, and consumers in the United States, the loss of price discovery at nearby futures exchanges means that prices in local markets - for example, the price of wheat at a grain elevator in rural America may be based on futures prices from more distant markets. Farmers and merchants in that local market will bear the risk of fluctuations in the basis, the difference between the distant futures exchange price and their local price.

Historically, futures exchanges located in the United States have been the worlds deepest and most liquid agricultural commodity markets with frequent transactions occurring between a large number of buyers and sellers. This market liquidity is thought to provide more accurate price discovery. Accordingly, traders of a given commodity tend to congregate at the most liquid exchange where trading is frequent and price discovery is best.

In the case of wheat, futures trading is not concentrated on a single exchange. Currently, active wheat futures contracts are traded on four major exchanges: the Chicago Board of Trade, the Kansas City Board of Trade, the Minneapolis Grain Exchange, and the Euronext exchange in Paris, France. Analysis of trading volume, or the number of contracts traded on each exchange, suggests that the Paris wheat futures contract is growing in importance relative to Chicago, Kansas City, and Minneapolis.

Figure 1 plots total monthly trading volume in these four markets across time on a logarithmic scale. It shows that Chicago is clearly dominant in terms of trading volume. The three US markets are relatively stable across time and the Paris market is growing trading volume. Wheat trading volume at Paris consistently surpassed Minneapolis in 2011.

One reason given for the rise in Paris trading is the increased importance of KRU in world wheat trade. US wheat exports have been generally stable since 1990, and USDA projects similar export levels over the next decade. Meanwhile KRU exports have grown substantially since the 1990s, with continued growth projected to 2024 (Westcott and Hansen, 2015). The Paris wheat market is thought to provide better price discovery and risk management for farmers, traders, and end-users involved in the marketing of KRU-origin grain.

To test the importance of the Paris wheat futures market relative to US markets, we apply market microstructure methods, specifically the Hasbrouck (1995) information shares method that measures the proportion of a common fundamental value for the underlying commodity revealed in each market. We find that the Chicago market generally leads, but that a non-trivial share of price discovery occurs in the Paris market. This share has been relatively stable over our sample period.

2 Methods

Empirical market microstructure methods are relatively novel in the context of agricultural markets. Some previous applications include measurement of price discovery in both electronic and open-outcry futures markets and estimation of bid-ask spreads and other measures of market quality and trading costs in livestock, grain, and cotton markets (e.g. Frank and Garcia, 2010; Martinez et al., 2011; Janzen, Smith, and

Carter, 2014). Market microstructure methods have also been applied to data measured in time intervals not commonly thought to be "micro" in the context of this literature. For example, Arnade and Hoffman (2015) estimate the relative proportion of price discovery in daily cash and futures market prices for soybeans and soybean meal.

The market microstructure literature contains two major methods to measure the proportion of price discovery that occurs in different markets. The Hasbrouck (1995) information shares (IS) model and the Gonzalo and Granger (1995) permanent-transitory model each use vector error-correction modeling techniques to isolate common factors present in the time-series of prices from each market. These common factors are interpreted as the benchmark or fundamental value of the underlying commodity. Relative prices across markets may vary but move together because of the potential for substitution in production and consumption across different types or locations for the underlying commodity and related cross-market arbitrage.

The IS model is explained in Hasbrouck (1995) with clarifications and extension to the case of $n > 2$ markets given in Yan and Zivot (2007) and Yan and Zivot (2010). We briefly summarize the model here.

Denote the vector of prices at period t as $\mathbf{p_t}$. We assume each series contains a common random walk component. Since innovations in this random walk are permanently impounded into observed prices, the random walk component represents the single underlying fundamental value that drives prices in all markets. We assume $\mathbf{p_t}$ is $I(1)$ or cointegrated of order one and, since there is a single fundamental value, there are $n-1$ cointegrating vectors β where $\beta_\mathbf{i}'\mathbf{p_t} = 0$. The known cointegrating vector (given for the $n > 2$ case in Yan and Zivot (2007)) assumes the difference between the first price $\mathbf{p_{t1}}$ and each subsequent price is $I(0)$.

The price vector then has a vector error correction representation, truncated at some lag K and expressed in first-differences as:

$$\Delta\mathbf{p_t} \quad = \quad \alpha(\beta\mathbf{p_t} - \mu) + \sum_{k=1}^{\infty}\Gamma_k\mathbf{p_t} + \mathbf{e_t}. \tag{1}$$

μ are the expected differences or spreads between prices in the leading market and each of the others markets in subsequent market. μ represents the known differences in prices between markets due to known differences in value based on location and quality attributes. $\mathbf{e_t}$ are the reduced form error terms with $E(\mathbf{e_t}) = 0$ and variance-covariance matrix $\mathbf{\Sigma}$. α are the error correction coefficients that represent the speed at which each market adjusts its price relative to the leading market.

Hasbrouck (1995) and Yan and Zivot (2010) show how the reduced-form errors can be decomposed into a permanent random-walk component and an transitory error component. The variance of the permanent component is $\psi' \boldsymbol{\Sigma} \psi$, where ψ is the cumulative impact of the reduced-form errors on prices. If $\boldsymbol{\Sigma}$ is not diagonal, this method cannot uniquely attribute covariance in the reduced form errors to each market, so a Cholesky decomposition is used to orthogonalize the errors. If $\mathbf{F}$ is the Cholesky decomposition of $\boldsymbol{\Sigma}$ such that $\mathbf{F}\mathbf{F}' = \boldsymbol{\Sigma}$, then the information shares are:

$$IS = \frac{(\psi' \mathbf{F})^2}{\psi' \boldsymbol{\Sigma} \psi}. \tag{2}$$

. Since the calculation of IS depends on the orthogonalization and thus the order of the variables in $\mathbf{p_t}$, Hasbrouck (1995) suggests that practitioners should reorder the variables and consider the estimations upper and lower bounds for the share of information discovered in each market.

3 Data

We use high frequency transaction price data for the four major world wheat futures contracts to study price discovery and the reaction of prices to new information. Our motivation for using high-frequency price data is two-fold. First, existing research suggests futures prices rapidly incorporate new information into existing prices. For example, papers studying the corn (Lehecka, Wang, and Garcia, 2014) and wheat (Bunek and Janzen, 2015) futures markets show that United States Department of Agriculture (USDA) reports on crop conditions, planted acreage, inventories and other fundamental information generate significant price changes only in the first fifteen minutes following a report's release. In the context of our study, this implies that commonly-used daily futures price data aggregates over important price discovery dynamics.

Second, the literature on VECM-based price discovery measurement suggests that there is a technical trade-off between sampling frequency and the ability of these methods to identify which market moves first in response to new information. Hasbrouck (2007) and Yan and Zivot (2010) point out this tradeoff and propose sampling at very high frequency to reduce correlation among the residuals ϵ_t. Since these methods rely on innovations in one price revealing themselves prior to prices, strong contemporaneous correlation among the residuals suggests that the sampling frequency is too low.

There appears to be no test in the literature to identify the "correct" sampling frequency. Sampling intervals between observations are often dictated by data availability. Yan and Zivot (2010) review empirical applications of the Hasbrouck (1995) information shares method and discuss how the optimality of sampling frequency is often judged by the spread between the upper and lower bounds placed on a market's information share. Previous studies find that sampling intervals from one second to five minutes can generate useful results in some contexts, while sampling at one minute intervals can generate poor results in other cases.

This paper considers transaction price data for the four major world wheat futures contracts, Chicago, Kansas City, Minneapolis, and Paris, purchased from CQG Inc. The data cover the period January 1, 2005 to December 31, 2015. Transactions in each market are time-stamped to the minute for most of this sample period. Since multiple transactions may occur inside a given minute, we first aggregate each price series to minute-level frequency by taking the last transaction price from each minute. When there are no transactions inside a given minute in one market, we replace these missing values with the most recent transaction price from that market.

For each trading day, our data covers a common three hour trading window. The three US wheat futures contracts have common trading hours, which differ from trading hours in Paris. Generally, we only observe transactions occurring in all four markets during the period from the open of trade in US markets at 8:30 am US Central Time to the close of trade in Paris at 11:30 am Central Time (or 4:30 in the Central European Time Zone.) Note that this common trading window does changes by one hour for two weeks each fall and spring as each time zone implements daylight savings time on different dates. For the purposes of this study, we maintain a consistent three hour window across our sample period.

For our initial analysis using the IS model, we use only prices from the Chicago market, widely considered to be the world benchmark with the highest trading volume, and the Paris market where trading volume is growing and anecdotal evidence suggests price discovery is moving. We consider data for the nearby contract for the 2007 through 2013 years for a given trading date, where the nearby contract is the closest to delivery of the March, May, or November/December contracts. We are limited to choosing among these contracts as they are the only ones with matching delivery dates across markets and are consistently listed for trading during the time period.

We also convert Paris prices which trade in Euros per metric ton to US dollars per bushel using daily exchange rate data from the St. Louis Federal Reserve Economic Database and a standard bushel weight for weight of 60 pounds. This allows us to visually observe and compare differences in price across markets and determine the expected spread or relative value of wheat at each location.

4 Results

We calculate daily the Hasbrouck information shares for the Chicago and Paris wheat markets. Summary statistics for these information shares are given in table 1. These summary statistics are derived from calculated shares for 1501 trading days from 2007 to 2013. This number is less than the total number of trading days over this period, as we lose some days due to low trading volume in the Paris market early in the sample period and due to differences in trading calendars across markets where one market is open and the other is closed. Since the information shares sum to one by definition, the mean daily information share in Paris is one minus the mean daily share in Chicago and the standard deviation of shares in each market is identical.

Results from table 1 show that the Chicago market dominates price discovery for wheat. Mean information share for the Chicago market is over three standard deviations above the mean information share for Paris. However, the Paris market contributes a non-trivial average share of approximately 25%. There are days in our sample period when the vast majority of price discovery occurs in Paris, as evidenced by the maximum for the Paris information share.

We also consider changes in relative information shares across time. Figure 2 plots the daily calculated information share for the Chicago and Paris markets over our sample period. Information shares appear to be relatively stable across time, though there are small sub-periods where the Paris market appears to be relatively more important than other periods. For example, Paris has a higher information share between mid-2010 and early 2011: the average share is 0.3 in the latter half of 2010 and the first quarter of 2011. While this change may not be statistically significant, it is suggestive evidence of KRU supply shocks influencing global price discovery. During this period, the KRU region experienced extreme drought and exacerbated the effects of this drought by enacting export bans on wheat (Wegren, 2011). If the Paris market for closely tracks supply and demand conditions in eastern Europe and there are periods where there are large shocks to global wheat supply and demand in this region, then we expect the share of price discovery in the Paris market to be large during these periods.

5 Conclusion

In this paper, we find that the observed increase in trading volume for the Paris wheat futures contract is not associated with a corresponding increase in the proportion of price discovery occurring at the Paris exchange relative to the benchmark Chicago futures market. While a non-trivial proportion of price discovery has occurred in the Paris market, this proportion does not appear to have changed across time. By using high frequency price data from multiple markets, we draw inference about structural changes in world wheat markets that would be impossible using production and trade data only available at an annual or monthly frequency.

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Figures

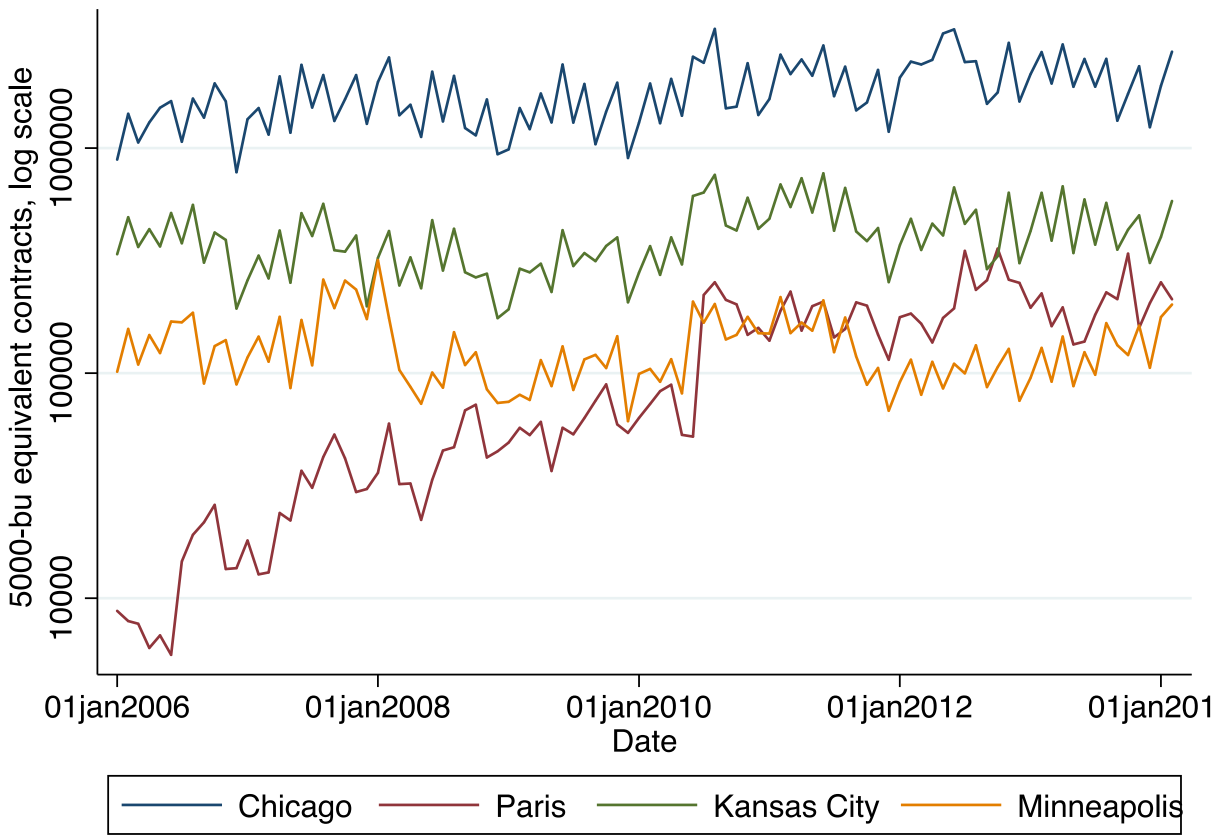

Figure 1: Monthly trading volume for wheat futures contracts, 2006-2014

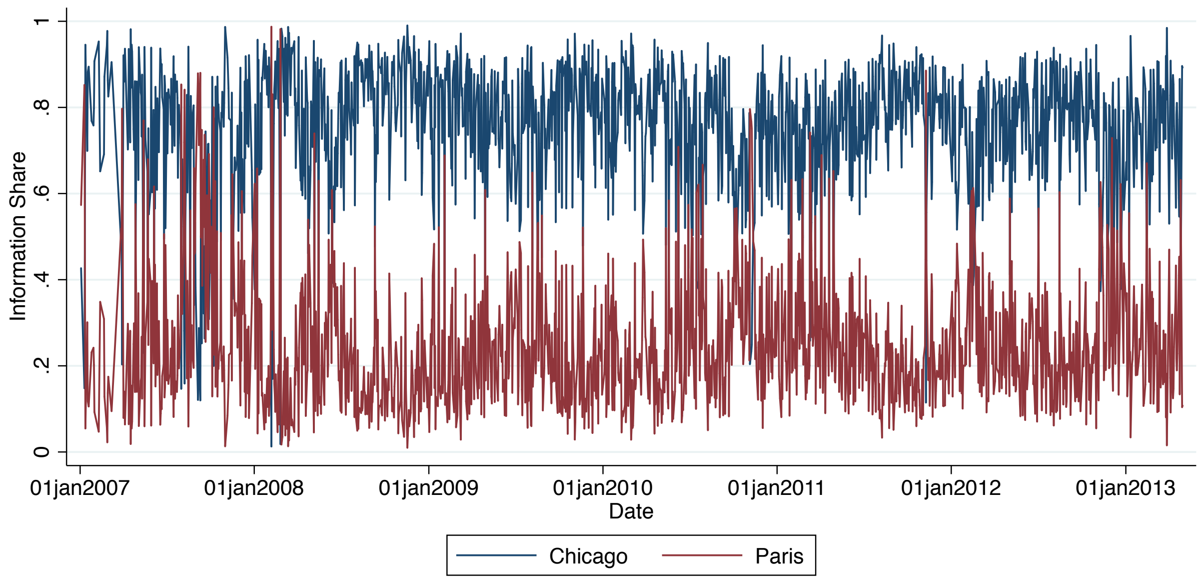

Figure 2: Information shares in Chicago and Paris wheat futures markets over time

Tables

Table 1: Summary statistics for calculated information shares, 2007-2013

Share of:	Mean	Std. Dev.	Min	Max
Chicago	0.7539	0.1507	0.0127	0.9901
Paris	0.2461	0.1507	0.0099	0.9873