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# Concentration and Liquidity Costs in Emerging Commodity Exchanges

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We analyze the relationships among liquidity costs, volume, and volatility in the Brazilian agricultural futures market, along with the role of market concentration. We estimate a structural three-equation IV–GMM model using data from Bolsa, Brasil, Balcão corn and live cattle contracts from March 2014 to February 2016. Results show a negative association between liquidity costs and volume and a positive association between liquidity costs and volatility. Market concentration impacts corn and live cattle differently. Concentration contributes to volume reduction for live cattle and to liquidity costs reduction for corn. Our findings shed light on the microstructure of emerging markets.

*Key words*: bid–ask spread, volatility, volume

## Introduction

Commodity futures markets have transformed drastically in recent years, experiencing a strong increase in trading, consolidation of exchanges, and a shift from the pit to electronic trading platforms (Irwin and Sanders, 2012). As noted by O'Hara (2003), markets have two important functions: liquidity and price discovery. The crucial task for commodity exchanges is to ensure easy trade at low transaction costs in an environment where prices reflect information. However, despite recent progress, significant differences still exist between futures markets in emerging and more mature markets, particularly in terms of liquidity. In addition, studies about the market microstructure of commodity futures in emerging countries are still scarce due to a lack of liquidity and limited availability of data.

Developments in Brazilian markets provide an opportunity to study the market microstructure of agricultural commodity markets in emerging economies. Bolsa, Brasil, Balcão (B3, formerly Brazilian Mercantile and Futures Exchange BM&F Bovespa) has recently modernized its trading platform, making reliable, high-frequency data available. Despite these transformations, Brazilian commodity futures markets still exhibit characteristics intrinsic to emerging markets, including a relatively lower number of transactions and less trading volume compared to more developed markets. Lower liquidity increases trading costs (Lesmond, 2005) and may hinder price discovery, thereby increasing the probability of higher volatility and price manipulation and thus complicating hedging. The degree of concentration among traders and dealers is also relevant in the market microstructure of commodity futures markets. This is a topic of particular relevance for markets with lower liquidity since increased concentration may potentially decrease market quality, resulting in higher bid–ask spreads and volatility and lower volumes (McInish and Wood, 1996).

We contribute to a better understanding of the market microstructure and the behavior of liquidity costs in emerging commodity futures markets by simultaneously examining the relationships among

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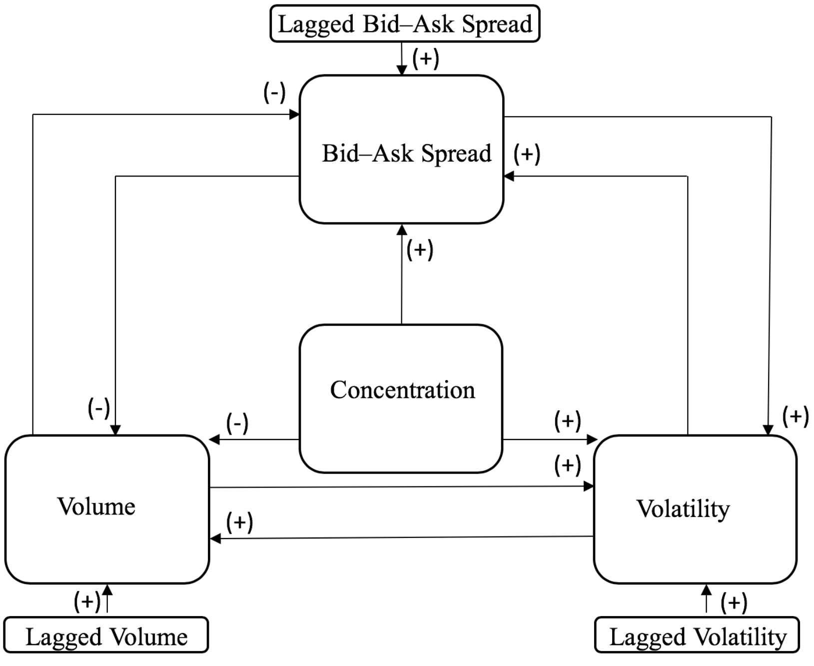


**Figure 1. Conceptual Framework**

*Notes:* Does not include control variables.

liquidity costs, volatility, volume, and market participants' concentration (see Figure 1) using the observed bid–ask spreads of the B3 corn and live cattle futures markets between March 2014 and February 2016.[1] Accounting for market concentration is particularly relevant in the context of emerging markets, where the existence of dominant players may pose hurdles to the flow of information and liquidity, ultimately hindering market efficiency. More specifically, our results suggest that creating incentives to decrease concentration levels in the inter-dealer system may help overcome a lack of liquidity and overall market-quality issues in emerging commodities markets.

Considering potential endogeneity bias originating from the relationships among the variables in the system, we estimated a three-equation structural model using the instrumental variable–generalized method of moments (IV–GMM) approach (Martinez et al., 2011; Wang and Yau, 2000; Wang, Garcia, and Irwin, 2014).

Our findings include three crucial points pertaining to the functioning of emerging commodities futures markets: i) the corn futures market exhibits lower liquidity costs than the live cattle market because of its higher volume, ii) the association between the bid–ask spread (BAS), volume, and volatility is consistent with that of more developed futures markets as liquidity levels increase, iii) we find that an increase in market concentration decreases volume in both the corn and live cattle markets. Additionally, increases in concentration also contribute to decrease liquidity costs (BAS) in corn markets. However, the negative impact of concentration on volume is significantly larger in the live cattle market than in the corn market.

## Previous Literature

As explained by Wang, Garcia, and Irwin (2014), studies on liquidity costs in agricultural futures markets tend to focus on the determinants of the BAS; the literature identifies volume and price volatility as the main driving factors. Most research on liquidity costs supports the negative

[1] Corn and live cattle contract exhibit the highest volume among the agricultural futures contracts traded at B3.

association between BAS and volume and the positive association between BAS and volatility (Frank and Garcia, 2011; Shah and Brorsen, 2011).

The relationship between price volatility and trading volume has been widely investigated, with most of the literature agreeing on a positive correlation. This relationship is tied to information flow and is built on the simultaneous information arrival hypothesis (Copeland, 1976; Jennings, Starks, and Fellingham, 1981) and the mixed distribution hypothesis (Clark, 1973; Tauchen and Pitts, 1983). The first hypothesis argues that traders assimilate new information at different times and adjust their positions as they are being informed. The ultimate result is a lead-lag relationship between volume and price volatility. The second hypothesis states that both price and volume respond simultaneously to the arrival of new information and are contemporaneously correlated, but no causal relationship is established between these two variables. Meanwhile, Wang, Garcia, and Irwin (2014) found that the dynamic relationship between volume and volatility in the Chicago Mercantile Exchange (CME) corn futures market is consistent with the sequential information arrival hypothesis.

Regarding the relationship between liquidity and the BAS, the inventory theory is one of the first efforts to explain the behavior of the BAS in response to volume and information flow. In short, this theory states that market makers offset imbalances in the market, which ultimately affects the BAS, which increases as imbalances accumulate.

By extending Madhavan, Richardson, and Roomans (1997), Hagströmer, Henricsson, and Nordén (2016) showed that the impact of trade volume on price is becoming negligible as algorithm trading attempts to minimize the influence of trade. However, no studies have been conducted on less liquid markets, such as agricultural commodity contracts in emerging countries, where trade volume may still influence price behavior.

Another aspect of market microstructure analysis that can influence the relationships among the BAS, volume, and volatility is the level of concentration in the market, which accounts for the number of contracts traded by each dealer. Unlike in equities and securities, there are no market makers in B3 futures markets. Hence all trade is carried out within an inter-dealership market.

Empirical studies on the impact of concentration on market quality at the microstructure level are scarce, probably due to the lack of available public data on the firms trading in the market (Koerber, Linton, and Vogt, 2013). Most literature concludes that competition has a significant effect on reducing the BAS. Branch and Freed (1977) argued that less concentration has a bigger impact on reducing spreads than volume. More recent studies show that most market-quality measures improve with less concentration (Van Ness, Van Ness, and Warr, 2005; Koerber, Linton, and Vogt, 2013; King, Osler, and Rime, 2013).

Studies regarding the behavior of liquidity costs in emerging commodities markets (Marquezin and Mattos, 2014; Liu, Hua, and An, 2016) suggest that, despite lower liquidity levels, deviations from what has been observed in more developed commodities markets are minor.

## Conceptual Framework

In terms of methodological advances in measuring and estimating the framework, Wang and Yau (2000) identified the presence of endogeneity in the relationships among the BAS, trading volume, and price volatility. Analyzing financial and metals futures contracts traded at CME and COMEX, they found the BAS, volume, and volatility to be dynamically and simultaneously determined. Martinez et al. (2011) and Wang, Garcia, and Irwin (2014) took a similar approach, using a system of dynamic structural equations, to address the endogeneity of the system. Building on the expected variables and relationships found in the literature and following a system similar to that in the articles addressing the endogeneity problem, we propose the framework depicted in Figure 1.

The proposed framework captures the contemporaneous endogenous relationships among the BAS, volume, and volatility. Concentration and lagged values of the variables enter the system exogenously. The methodology section elaborates on the nature of the relationships, the estimation strategy, and the translation of the model into a GMM system.

Our framework differs from the existing ones by addressing two pressing issues in emerging commodities futures markets: concentration and liquidity. First, we have extended the three-equation structural model (Martinez et al., 2011; Wang and Yau, 2000; Wang, Garcia, and Irwin, 2014) to account for the impact of concentration on the BAS, volume, and volatility. For this purpose, all equations include the daily HHI Index. Second, considering the persistent illiquidity in emerging commodities markets, this framework is applied to markets with different levels of liquidity to compare how it affects the relationships among the BAS, volume, and volatility.

## Methodology

We investigated the relationships among the BAS, volume, and volatility in emerging futures markets considering a potential endogeneity bias. These three variables were jointly determined (Hausman, 1978; Wang and Yau, 2000) using a GMM-style three-equation model:

$$(1)\quad \begin{aligned} BAS_{i,t} &= \beta_0 + \beta_1 Volume_{i,t} + \beta_2 Volatility_{i,t} + \beta_3 BAS_{i,t-1} + \beta_4 Concentration_{i,t} \\ &+ \beta_5 Months_{i,t} + \beta_6 Days\text{-}of\text{-}the\text{-}Week_{i,t} + \varepsilon \end{aligned}$$

$$(2)\quad \begin{aligned} Volume_{i,t} &= \beta_0 + \beta_1 BAS_{i,t} + \beta_2 Volatility_{i,t} + \beta_3 Volume_{i,t-1} + \beta_4 Concentration_{i,t} \\ &+ \beta_5 Months_{i,t} + \beta_6 Days\text{-}of\text{-}the\text{-}Week_{i,t} + \varepsilon \end{aligned}$$

$$(3)\quad \begin{aligned} Volatility_{i,t} &= \beta_0 + \beta_1 BAS_{i,t} + \beta_2 Volume_{i,t} + \beta_3 Volatility_{t,-1} + \beta_4 Concentration_{i,t} \\ &+ \beta_5 Months_{i,t} + \beta_6 Days\text{-}of\text{-}the\text{-}Week_{i,t} + \varepsilon \end{aligned}$$

where *BAS* is the daily average of best bid–ask spreads. The BAS is calculated and updated with every incoming order. *Volume* corresponds to the daily sum of the volumes associated with each traded transaction. *Volatility* is the daily standard deviation of traded prices.[2] *Concentration* accounts for the intraday Herfindahl–Hirschman index (HHI), which is commonly used in the economics literature to assess the concentration of industries. The HHI was first used by Tinic (1972) in the market microstructure literature and is calculated using the daily volumes traded by each dealer/broker (firm) in the market:

$$(4)\quad MS_i = x_i \Big/ \sum_{j=1}^{n} x_j;$$

$$(5)\quad HHI_i = \sum_{i=1}^{n} MS_i^2;$$

where $x_i$ is the participation of each of the $n$ dealers/brokers. Equation (4) yields the market share of each dealer/broker for each trading day. Equation (5) is the sum of squares of the market share of each firm.

We control for seasonality by including dummies for each month of the year. Following Frank and Garcia (2011) and Wang, Garcia, and Irwin (2014), day-of-the-week dummies are also included. All variables (except for the *Month* and *Days-of-the-Week* variables) are in log form.

We subsequently follow the discussion of the expected signs in the literature section, also summarized in Figure 1. We expect the volume coefficient to have a negative sign and the volatility

[2] We acknowledge that using alternative estimators such as Parkinson's High–Low or realized volatility measures could be useful. In fact, Parkinson (1980) argues that the estimator is the most efficient for the range between high and low prices observed during a day, which could lead to slightly better estimates.

coefficient to be positive in equation (1) on the dependent variable BAS. The concentration variable is expected to have a positive sign as more competitive markets cause lower levels of the BAS (McInish and Wood, 1996; Van Ness, Van Ness, and Warr, 2005).

In equation (2), BAS is expected to have a negative coefficient in relation to volume, as higher liquidity costs lead to lower trading profitability and hence lower volume (Wang, Garcia, and Irwin, 2014). The mixed distribution hypothesis, on the other hand, supports a contemporaneous positive impact of volatility on volume. The impact of concentration on volume is debatable: Mendelson (1987) and Koerber, Linton, and Vogt (2013) found concentration to positively impact volume, whereas McInish and Wood (1996) found the opposite.

In equation (3), the BAS coefficient is positive for the expected signs related to volatility, since a wider BAS naturally leads to higher price volatility. As stated previously, a positive relationship was expected between volume and volatility; however, the lagged volume coefficient is negative due to potential overreaction to new information. Meanwhile, concentration positively impacts volatility (Hamilton, 1979; McInish and Wood, 1996).

We performed the unit root augmented Dickey–Fuller and the Durbin–Wu–Hausman endogeneity test on the BAS, volume, volatility, and concentration for each of the markets analyzed.[3] The outcome of this test defines the methodology to be used. Endogeneity among the three variables would call for the use of the IV–GMM model to estimate the three-equation system. A lack of endogeneity but correlation between the error terms would lead to the use of a seemingly unrelated regression (SUR). Under no endogeneity and lack of correlation of the error terms, the estimation would be obtained by ordinary least squares (OLS).

## Data

Data were obtained from the B3 FTP system,[4] which stores all transactions for 2 years. The data comes at tick-by-tick frequency and is organized in three files.[5]

Since the main purpose of this paper is to identify the determinants of liquidity costs across emerging futures markets, an accurate definition of the liquidity costs is necessary. The most widely used proxy for liquidity costs in the literature is the bid-ask spread (BAS). We used data from the transaction, bid order, and offer order files. The BAS was measured directly, by reconstructing the order book and the top of the book. More specifically, we used all transactions from the buy and offer files, filtering according to order status and trading time, and the lowest ask and highest bid were obtained. This is a distinct feature, since a significant number of studies use estimators based on transaction data to calculate the BAS (Frank and Garcia, 2011; Martinez et al., 2011; Shah and Brorsen, 2011).

To account for potential differences among these markets, we selected the two most-traded B3 commodity contracts for every month, regardless of their expiration date: the corn (CCM) and live

[3] The procedure adopted for the Hausman test is identical to that used by Martinez et al. (2011). Its purpose is to test whether the variables *Volume* or *Volatility* are endogenous to the *BAS* equation (1). First, *Volume* is regressed on its set of explanatory variables as shown in equation (2), except for the *BAS* and *Volatility*, yielding the regression residual $\varepsilon_1$. The same procedure is followed for *Volatility*, leaving out the *BAS* and *Volume* from equation (3). Thus, the regression residual $\varepsilon_2$ is obtained. The next step is to run the BAS equation (1) including the two residuals. *Volume* and *Volatility* are endogenous to the *BAS* equation if they prove jointly significant in the *F*-test.

[4] ftp://ftp.bmf.com.br/marketdata/BMF. The file transfer protocol (FTP) site is used to disseminate the three market data files containing transactions (NEG), bid orders (OFER_CPA), and sell orders (OFER_VDA), as well as information on market data configuration.

[5] The first file contains information related to the bid orders (OFER_CPA) and the second file contains information related to the offer orders (OFER_VDA). The variables in these two files are the date and time of the event, to the millisecond, price of the (bid and offer) orders, volume, order number, state of the order (i.e., new, update, cancel, traded), the contract identifier (i.e., BGIH11, where BGI is the code for live cattle futures, H is the maturity month, in this case March, and 11 is the maturity year), and the bid or offer sequence number. The last file (NEG) records all transactions and, in addition to all variables cited previously, contains the sequence numbers relative to the buy and sell orders that compose each transaction. All three files are therefore connected through their sequence numbers.

**Table 1. Summary Statistics**

| | BAS (cents (R$))[a] | Volume (no. of contracts) | Volatility (cents (R$)) | Concentration[b] |
|---|---|---|---|---|
| Live Cattle | | | | |
| Mean | 0.17 | 1,889.40 | 1.99 | 0.25 |
| Std. Dev. | 0.08 | 1,428.31 | 8.29 | 0.09 |
| Min. | 0.05 | 33 | 0.02 | 0.11 |
| Max. | 1.08 | 13,847 | 74.29 | 0.82 |
| Corn | | | | |
| Mean | 0.07 | 2,192.36 | 0.25 | 0.27 |
| Std. Dev. | 0.02 | 1,312.06 | 0.47 | 0.08 |
| Min. | 0.03 | 110 | 0.03 | 0.11 |
| Max. | 0.15 | 8,803 | 4.39 | 0.67 |

*Notes:* [a] In R$/60kg-bag for corn; in R$/4,407 net kilograms for live cattle; R$ stands for Brazilian Real.
[b] HHI Index: An index of 1,0 represents a monopoly situation; an index approaching 0 indicates (nearly) full competition.

cattle (BGI) contracts. The corn contract is traded slightly more than the live cattle contract, its volume exceeding the latter's by about 16%.

## Exploratory Analysis

Table 1 shows summary statistics of the corn and live cattle contracts, with samples of 474 and 467 daily observations, respectively, from March 2014 to February 2016. The variables are continuous in time. Corn reaches an average of 2,192.3 contracts traded per day compared to 1,889.40 for live cattle. The average BAS[6] and volatility follow a direction opposite that of volume throughout the markets. Average volatility in thinly traded markets is expected to exceed that of more liquid markets (Adjemian, Saitone, and Sexton, 2016). In this case, Table 1 shows that the average daily volatility in the live cattle market (i.e., the market with the lower volume) exceeds that of the corn market.[7]

Figure 2 reports the level of market concentration in the corn and live cattle futures markets. Our sample identifies 41 dealers/brokers trading in the corn market and 42 in the live cattle market over the same period. The corn futures market is slightly more concentrated, with an average HHI index of 0.27 compared to 0.24 for the live cattle market. Figure 2 shows the HHI index along the trading days for each market, revealing that neither the corn nor the live cattle market operates in a perfectly competitive market structure.

Following previous literature (Martinez et al., 2011; Wang, Garcia, and Irwin, 2014), we used a IV–GMM model to estimate the three-equation system. Equation (1) uses lagged volume and the first difference of volatility as instruments. Equation (2) uses lagged BAS and the first difference of volatility, and equation (3) uses lagged BAS and lagged concentration. Due to a lack of consensus in the literature on an instrumental variable for concentration, we used its lag, which is exogenous to the model and at the same time still correlated to the original variable.[8]

We also tested for endogeneity in the BAS, volume, volatility, and concentration. Table 2 presents the results of the Durbin–Wu–Hausman test for endogeneity. Overall, the results from Table 2 report more likelihood of endogeneity in the less liquid live cattle market than in the more liquid

[6] Information about the patterns of the BAS are included in Appendix A.

[7] The BAS, volume, volatility, and concentration series of both corn and live cattle contracts are tested for stationarity using the Augmented Dickey–Fuller test. The results show that the null hypothesis is rejected at the 1% level for the variables in all cases, meaning that all series are stationary and no differencing is needed.

[8] Using the Cumby–Huizing modified Breusch–Godfrey test, we detected autocorrelation in the volume and volatility equations for live cattle and in the volatility and BAS equations for corn. However, the dynamic nature of the model contributes to mitigating autocorrelation issues. We tested for heteroskedasticity using the Pagan–Hall test. The null of homoskedasticity was rejected mostly in the volume and volatility equations in both markets.

**Table 2. Durbin–Wu–Hausman Endogeneity Test**

| Variable/Equation | BAS | Volume | Volatility | Concentration |
|---|---|---|---|---|
| Live Cattle | | | | |
| BAS ($t$-value) | | 6.792*** | 10.873*** | 0.127 |
| Volume ($t$-value) | 0.022 | | 12.821*** | 0.032 |
| Volatility ($t$-value) | 0.085 | 17.261*** | | 2.742* |
| Corn | | | | |
| BAS ($t$-value) | | 0.116 | 2.227 | 3.545* |
| Volume ($t$-value) | 0.362 | | 3.037* | 1.407 |
| Volatility ($t$-value) | 0.306 | 6.664*** | | 0.054 |

*Notes:* Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

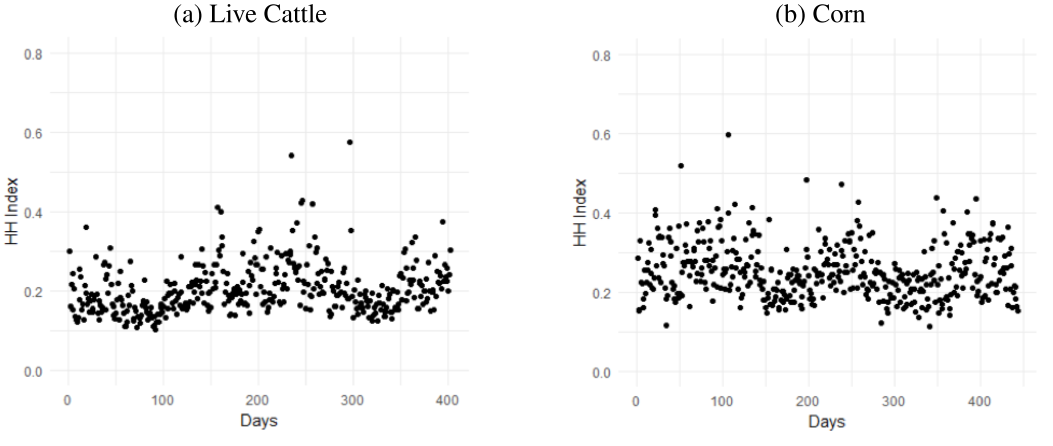


**Figure 2. Daily HHI Index**

*Notes:* The index was calculated based on the quantities bought and sold by all brokers along the trading day. Each point on the graph represents one trading day and its HH index. An index of 1,0 represents a monopoly situation; an index approaching 0 indicates (nearly) full competition.

corn market. For live cattle, volume and volatility are endogenous to the BAS equation, volatility was found to be endogenous to the volume equation, and BAS, volume, and concentration were found to be endogenous to the volatility equation. In the corn system of equations, concentration is endogenous to the BAS equation, volatility to the volume equation, and volume to the volatility equation.[9]

## Regression Results

### *Corn Market*

The lagged BAS has the highest coefficient of all lagged variables in equation (1), meaning that it is the most persistent variable. Martinez et al. (2011) and Wang, Garcia, and Irwin (2014) also found significant persistence of the BAS and volatility in the CME corn futures market. The results of the IV–GMM for the corn market are shown in Table 3. As expected, volume has a negative significant impact on BAS in the corn market: A 10% increase in volume leads to a 1.4% reduction in the BAS.

[9] Having found endogenous variables, we applied the Stock–Yogo test for weak instruments and rejected the null of large bias, meaning that all instruments are well identified.

**Table 3. IV–GMM Output for the Corn Market**

| | Equation (1) BAS | | Equation (2) Volume | | Equation (3) Volatility | |
|---|---|---|---|---|---|---|
| **Dependent Variable** | **Coeff.** | *z* | **Coeff.** | *z* | **Coeff.** | *z* |
| Constant | 0.019 | 0.04 | 1.297 | 1.41 | −2.615** | −2.03 |
| BAS | | | −0.642*** | −7.10 | 0.501*** | 3.33 |
| Volume | −0.138*** | −5.22 | – | – | 0.253** | 2.18 |
| Volatility | 0.070*** | 4.47 | 0.349*** | 7.29 | – | – |
| Lagged dependent variable | 0.420*** | 7.95 | 0.404*** | 10.40 | 0.312*** | 6.84 |
| Concentration | −0.446** | −1.98 | −0.133* | −1.79 | 0.006 | 0.06 |
| January | −0.012 | −0.24 | 0.059 | 0.57 | 0.143 | 0.98 |
| February | 0.003 | 0.05 | 0.164 | 1.56 | −0.055 | −0.36 |
| March | −0.115** | −2.09 | 0.107 | 0.97 | −0.046 | −0.29 |
| April | −0.129** | −2.47 | 0.016 | 0.15 | −0.038 | −0.25 |
| May | −0.175*** | −2.98 | 0.299*** | 2.69 | −0.242 | −1.49 |
| June | −0.099* | −1.80 | 0.394*** | 3.63 | −0.167 | −0.99 |
| July | −0.127** | −2.29 | 0.221** | 2.01 | 0.048 | 0.29 |
| August | −0.143** | −2.55 | −0.102 | −0.85 | 0.855*** | 5.30 |
| September | −0.059 | −1.13 | 0.287*** | 2.77 | −0.053 | −0.34 |
| October | −0.009 | −0.17 | 0.231** | 2.27 | 0.046 | 0.30 |
| November | −0.022 | −0.40 | 0.060 | 0.57 | 0.226 | 1.52 |
| Monday | −0.067** | −1.94 | −0.083 | −1.20 | 0.057 | 0.58 |
| Tuesday | −0.102*** | −3.08 | 0.125* | 1.85 | −0.106 | −1.12 |
| Wednesday | −0.018 | −0.54 | 0.163** | 2.46 | −0.106 | −1.12 |
| Thursday | 0.016 | 0.49 | 0.109 | 1.62 | −0.023 | −0.23 |

*Notes:* Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

The BAS, on the other hand, has a much greater impact on volume. Results from equation (2) show that a 10% increase in BAS reduces volume by roughly 6.4%.

The literature has broadly identified a positive relationship between the BAS and volatility. Our findings in the corn market are consistent with the literature, with the BAS showing more impact on volatility than vice versa: A 10% increase in BAS increases volatility by roughly 5%, but a 10% increase in volatility increases the BAS by only about 0.7%. Wang and Yau (2000) and Wang, Garcia, and Irwin (2014) also found this increased association of volume and volatility with changes in the BAS.

We indeed found the expected positive relationship between volume and volatility in equations (2) and (3). Positive changes in volume bring new information to the markets. In face of this new information, both traders and liquidity providers (dealers) adjust their positions, which contributes to increasing price volatility. This hints at support for the simultaneous information arrival hypothesis (SIAH, Jennings, Starks, and Fellingham, 1981; Wang, Garcia, and Irwin, 2014). A 10% increase in volatility causes a 3.5% increase in volume in equation (2). Conversely, the impact of a change in volume on volatility (equation 3) is smaller: A 10% increase in volume only causes a 2.5% increase in volatility. The volume and volatility generated by the arrival of new information will affect the BAS differently, depending on the nature of the information shock and the depth of the market. The more liquid the market, the smaller the impact of volume and volatility on BAS tends to be.

Our results on the impact of concentration on the BAS, volume, and volatility show that a 10% increase in concentration in the corn market reduces volume by about 1.3% and the BAS by about 4.4% (equations 2 and 1, respectively) while showing no effect on volatility. The negative relationship between concentration and volume can largely be found in the literature (Koerber, Linton, and Vogt, 2013). The negative relationship between concentration and the BAS, however, is

**Table 4. Percentage of Contracts Traded by the Top, Middle, and Bottom Thirds in the Live Cattle and Corn Markets**

| | Live Cattle | Corn |
|---|---|---|
| Top Third | 94.76% | 95.31% |
| Middle Third | 4.39% | 4.18% |
| Bottom Third | 0.84% | 0.49% |

*Notes:* We organize our sample in decreasing order of the number of contracts traded by dealer/broker. We divide the total number of dealers/brokers into thirds. Then, we measure the fraction of trading quantity carried out by the top, middle, and bottom thirds each day.

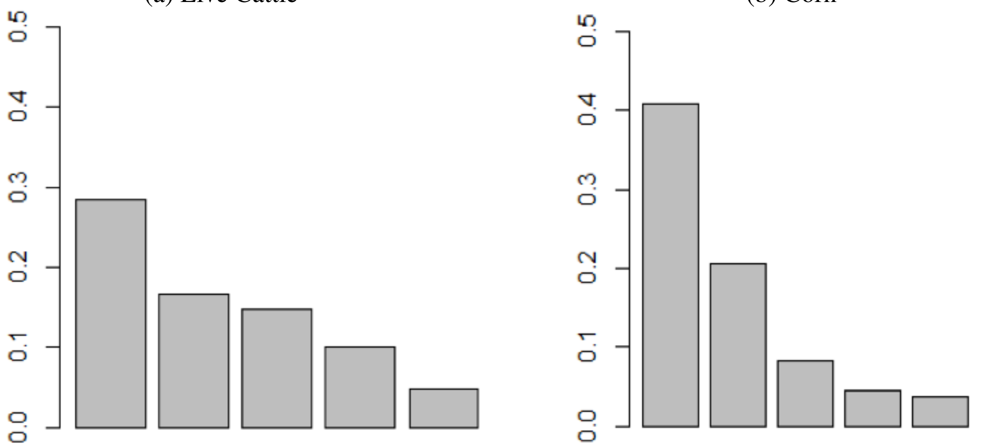


**Figure 3. Percentage of Contracts Traded by the Top Five Dealers in the Live Cattle and Corn Markets.**

unique. It means that BAS levels tend to decrease as market concentration increases. Most studies point out that an increase in concentration drives up BAS levels, which is clearly not the case in the B3 corn market.

A plausible explanation for this result is the presence of foreign investors, alongside the noncompetitive structure of the corn inter-dealer market—shown in Figure 3 and Table 4. Unlike live cattle, corn is a storable commodity. The share of contracts traded by foreign investors in the corn market is much higher than that of the live cattle market. Foreign investors play an important role in lowering the BAS as they contribute to arbitraging the domestic corn price against the international corn price (CME).

Brazil currently has two corn harvests a year. The first is the summer crop, which takes place in the first half of the year between January and April. The winter crop is mostly harvested in the second half of the year, between May and August (Mattos and Silveira, 2016). The two most significant instances of low BAS, high volume, and low volatility thus occur at the end of the summer and winter harvest cycles.

### *Live Cattle Market*

The volume coefficient in the live cattle BAS equation is not statistically significant but has a positive sign. Its nonsignificance implies that volume is not a determinant of the BAS in live cattle markets. This result suggests that the BAS in some emerging agricultural futures markets may have determinants other than those that are well-established in the literature. A 10% increase in the BAS, on the other hand, tends to reduce volume by 3.8%. The bigger impact of the BAS on volume suggests that liquidity providers (dealers/brokers) do not simply respond to changes in volume but

**Table 5. IV–GMM Output for the Live Cattle Market**

| | Equation (1) BAS | | Equation (2) Volume | | Equation (3) Volatility | |
|---|---|---|---|---|---|---|
| **Dependent Variable** | **Coeff.** | *z* | **Coeff.** | *z* | **Coeff.** | *z* |
| Constant | 1.109* | 1.73 | 1.072 | 0.97 | 0.146 | 0.06 |
| BAS | – | – | −0.380*** | −4.85 | −0.185 | −0.87 |
| Volume | 0.101 | 1.33 | – | – | −0.059 | −0.18 |
| Volatility | −0.070** | −2.31 | 0.258*** | 7.42 | – | – |
| Lagged dependent variable | 0.497*** | 10.10 | 0.321*** | 7.91 | 0.389*** | 8.32 |
| Concentration | 0.045 | 0.75 | −0.360*** | −4.26 | 0.566 | 0.64 |
| January | −0.298*** | −3.97 | 0.008 | 0.06 | −0.507* | −1.81 |
| February | −0.199*** | −2.56 | −0.124 | −0.93 | −0.671** | −2.19 |
| March | −0.183** | −1.98 | 0.460*** | 3.41 | −0.002 | −0.01 |
| April | −0.282*** | −2.94 | 0.485*** | 3.64 | −0.009 | −0.03 |
| May | −0.332*** | −4.10 | 0.182 | 1.37 | 0.023 | 0.07 |
| June | −0.243*** | −2.66 | 0.412*** | 3.08 | 0.115 | 0.34 |
| July | −0.226*** | −2.57 | 0.326** | 2.41 | 0.256 | 0.68 |
| August | −0.139* | −1.68 | −0.089 | −0.61 | 1.188*** | 3.63 |
| September | −0.330*** | −3.50 | 0.477*** | 3.62 | −0.255 | −0.78 |
| October | −0.231*** | −2.92 | 0.253** | 2.00 | 0.187 | 0.55 |
| November | −0.084 | −1.07 | 0.257** | 2.03 | −0.212 | −0.73 |
| Monday | 0.096* | 1.90 | −0.144* | −1.72 | −0.371* | −1.93 |
| Tuesday | −0.122** | −2.50 | 0.309*** | 3.77 | −0.147 | −0.82 |
| Wednesday | −0.038 | −0.80 | 0.212*** | 2.65 | −0.046 | −0.26 |
| Thursday | −0.062 | −1.27 | 0.150* | 1.85 | −0.230 | −1.30 |

*Notes:* Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

rather use the BAS to manage their order inventory. By posting more aggressive bid and ask prices, liquidity providers stimulate order flow, increase volume, and reduce transaction costs (Pennings et al., 1998). Table 5 reports the IV–GMM results for the live cattle market. Similar to the corn market analysis, we find that the BAS is the most persistent variable, as the significance of the lagged BAS shows.

The live cattle market also exhibits a positive relationship between volume and volatility, albeit in one direction only: While changes in volatility contribute to increasing volume, changes in volume do not affect volatility (equation 3). Therefore, the SIAH cannot be confirmed for the B3 live cattle market.

Volatility has a negative impact on the BAS: A 10% increase in volatility reduces the BAS by roughly 0.7%. However, the impact of the BAS coefficient on volatility is not statistically significant. Changes in volatility tend to increase the BAS in the corn market and reduce it in the live cattle market, while changes in the BAS only cause volatility spikes in the corn market.

The concentration analysis shows that the top three dealers in the live cattle market trade more balanced shares of the contracts compared to those in the corn market: around 28.4%, 16.6%, and 14.6%, respectively. A common consequence of the increase in concentration is the negative impact on volume traded. A 10% increase in concentration in the live cattle market tends to decrease volume by 3.6%, roughly two and a half times the effect found in the corn market. We have found no significant relationship between concentration and the BAS or between concentration and volatility in the live cattle market.

Seasonality is similar in both the live cattle and corn futures market. We find the BAS to be lowest in May and second-lowest in September. The volume equation shows the highest coefficients for April and September, while the volatility equation shows the highest coefficient in August. April and

September are thus the months when the BAS is at its lowest and volume at its highest. Regarding day-of-the-week effects, the BAS is at its lowest on Tuesdays, which is also when volume is at its highest.

## Conclusion

The commodity futures trade has changed significantly over the past few years. The introduction of electronic platforms has made access to these markets easier and improved transparency. These changes have also been implemented in emerging commodity futures markets, even though they differ from more mature markets in certain respects, most notably liquidity. We investigated the behavior of the bid-ask spread (BAS) and its relationship with volume and volatility in the Bolsa, Brasil, Balcão (B3) live cattle and corn futures markets. Using a structural equation framework, we performed a comparative analysis across the markets and controlled for the impact of market concentration on the BAS, volume, and volatility.

We reconstructed the BAS using high-frequency data from the B3 order book. Our findings suggest that the average BAS is lower for the corn market than for the live cattle market. This pattern can be partially explained by the lower level of liquidity in the live cattle market compared to the corn market. In addition to liquidity, other factors may also explain this result: The arbitrage of domestic against international corn price made by foreign traders may play a role alongside the underlying inter-dealer structure, with varying degrees of concentration.

Maintaining lower levels of BAS benefits the proper functioning of futures markets as it contributes to keeping liquidity costs low and stable. Consistent with the literature, our analysis shows that the BAS responds negatively to changes in volume and positively to changes in volatility. The responses also differ in magnitude, however, according to the level of liquidity in each market as well as other characteristics intrinsic to these markets, such as inter-dealer market structure.

Our results are in line with previous literature (Martinez et al., 2011; Shah and Brorsen, 2011; Thompson, Eales, and Seibold, 1993; Wang, Garcia, and Irwin, 2014). However, the similarity depends on the level of liquidity of the markets analyzed. The more liquid the B3 market, the closer the relationships among the BAS, volume, and volatility and, as a consequence, the resemblance to more developed agricultural markets. Thus, the results found for the corn market are closer to those found in the literature, both in terms of magnitude and signs. The effects of a lack of liquidity, on the other hand, can be seen in the live cattle market, where the relationships among the BAS, volume, and volatility are not as well defined as in the corn market and only opaquely resemble the microstructure of advanced agricultural markets.

This study also highlights the degree of market concentration as a relevant variable when analyzing the microstructure of emerging futures markets. The impact of concentration on market quality depends on the market analyzed. Our findings suggest that an increase in concentration contributes to a decrease in volume in both the live cattle and corn markets, although the negative impact of concentration on volume is bigger for the former. Moreover, concentration also leads to a lower BAS in corn markets. Hence, the underlying inter-dealer system is an important element in liquidity and overall market-quality enhancement. This result is particularly useful for policy makers and trading venues in emerging markets.

In addition to the higher level of liquidity, the presence of foreign investors is another factor that may explain the lower BAS levels in the corn futures market. The share of corn futures contracts traded by foreign investors rose progressively between March 2014 and February 2016, a trend that was not as prominent in the live cattle market. Foreign investors contribute to improving overall market quality as they help generate lower BAS levels and increase competition among traders (Lee and Chung, 2018). The impact of foreign investment on concentration in B3 (as well as the link with world market prices) is an avenue for future research.

The findings enhance our understanding of the relationships among the BAS, volume, volatility, and liquidity in the context of market concentration and at different levels of liquidity. Furthermore, this study shows that non-negligible differences in functionality—particularly differences linked to liquidity levels and degrees of market concentration—may exist even among the most-traded B3 contracts, such as live cattle and corn contracts. As in more developed exchanges, market participants in emerging exchanges are also sensitive to liquidity costs and will trade more and benefit from lower volatility if these costs are kept low and stable. In this sense, the path to properly functioning agricultural futures markets includes increasing liquidity levels and market competition, ultimately leading to a better environment for hedgers (i.e., those seeking to mitigate price risks).

Directions for further research include verifying the relationship patterns among the BAS, volume, and volatility in other B3 futures markets, including financial contracts, as well as mapping the impact of market concentration on these markets. Also, little is known about the market microstructure of commodities options markets at emerging exchanges. Finally, the relationship between futures and options, the information content of options and its role in BAS and volatility, as well as the relationship between futures contracts and volume, are research subjects worth pursuing in the future.

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## Appendix A: Empirical Regularities of BAS for Corn and Live Cattle at Bolsa, Brasil, Balcão

The trading activity of corn and live cattle at Bolsa, Brasil, Balcão (B3) exhibits a number of intrinsic characteristics, one of which is the fact that trading concentrates around a few contracts. In the live cattle market, 12 contracts are available throughout the year. The most-traded contract on every single day from March to May, however, is the contract with maturity in May. Likewise, the contract with maturity in October is the most traded between June and October.

This structure is more homogeneous in the corn market, where the most-traded contact between January and February is the one expiring in March. In March and April, the contract expiring in May is the most popular. The most-traded contract between May and August expires in September, the most-traded contact in September and October expires in November, and the most-traded contract in November and December is the one with maturity in January. The nearby futures contract thus appears to be the main focus of trading.

In this context, Figure A1 reports the BAS by contract for each trading day between March 2014 and February 2016. Live cattle (a) and corn (b) contracts are arranged by month on the horizontal axis, where each dot corresponds to the daily average BAS for the most-traded contract on that day.

Analysis of the live cattle market reveals that BAS values are lower and less dispersed between April and October. During this period, the two most-traded contracts are those with maturity in May and October, respectively. The corn market analysis shows that BAS values are lowest and least dispersed in May. April, June, and July also show relatively low and not very dispersed BAS levels. Between May and July, the focus of trade lies on the contract with maturity in September, which is also the most heavily traded of all corn contracts. Other contracts show higher and more dispersed BAS levels.

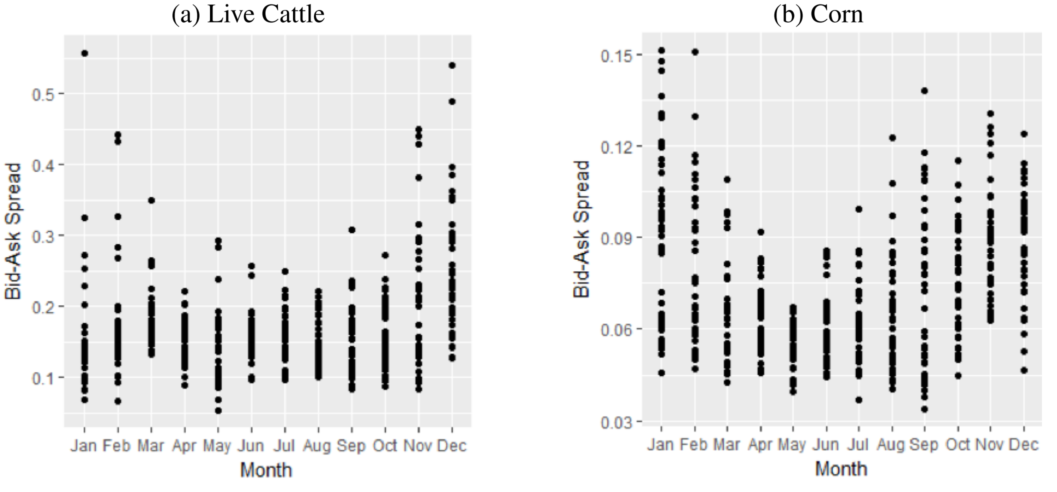


**Figure A1. BAS Term Structure across the Trading Year for Live Cattle and Corn Contracts Traded at B3, March 2014–February 2016**

## Appendix B: Robustness Analysis

We used Cook's distance measure to check for outliers in analyzing the residuals. No outliers were detected in the model residuals, either for the corn or the cattle equations.

We also used the LM form of the Andersen test, commonly referred to as the underidentification test, as well as the Sargan–Hansen test of overidentifying restrictions. Table B1 reports the results of both tests.

The results of the underidentification test warrant the rejection of the null hypothesis that the equation is underidentified. At the same time, it is not possible to reject the joint null hypothesis of the overidentification test that the instruments are valid instruments, uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. As discussed previously, the null of large bias is rejected, meaning that all instruments are well identified.

**Table B1. Overidentification and Underidentification Tests**

| | Test/Equation | |
|---|---|---|
| | **Overidentification** | **Underidentification** |
| Live Cattle | | |
| BAS ($t$-value) | 0.000 | 44.877*** |
| Volume ($t$-value) | 0.000 | 164.921*** |
| Volatility ($t$-value) | 0.000 | 6.076** |
| Corn | | |
| BAS ($t$-value) | 0.000 | 12.129*** |
| Volume ($t$-value) | 0.000 | 173.626*** |
| Volatility ($t$-value) | 0.000 | 98.788*** |

*Notes:* Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level, respectively.

## Appendix C: Background Information on Corn and Live Cattle Contracts Traded at B3 and CME

The corn contract with cash settlement (CCM) has been traded at B3 since September 2008, when it was introduced as an alternative to the corn contract with physical delivery and, ultimately, as a way of attracting new traders. Between March 2014 and February 2016, an average of 565.9 corn contracts were traded at B3, against an average of 304,014.4 contracts at CME over the same period. The live cattle contract with cash settlement (BGI) was introduced at B3 in December 1994. Although older than its B3 corn counterpart, the average number of contracts is lower: 146.5 between March 2014 and February 2016.[10] Cattle contracts traded at CME averaged 53,380.7 over the same period.

The live cattle contract is traded electronically from 9:00am to 4:00pm and the corn contract from 9:00am to 3.30pm Brasilia time. Contract size for corn is 450 bags of 60 net kilograms and tick size is R$0.01, for live cattle, contract size is 4,407 net kilograms and tick size is also R$0.01. The maturity months for corn contracts are January, March, May, July, August, September, and November. Live cattle contracts expire every month. The period under analysis runs from 3 March, 2014, to 29 February, 2016, totaling 24 months.

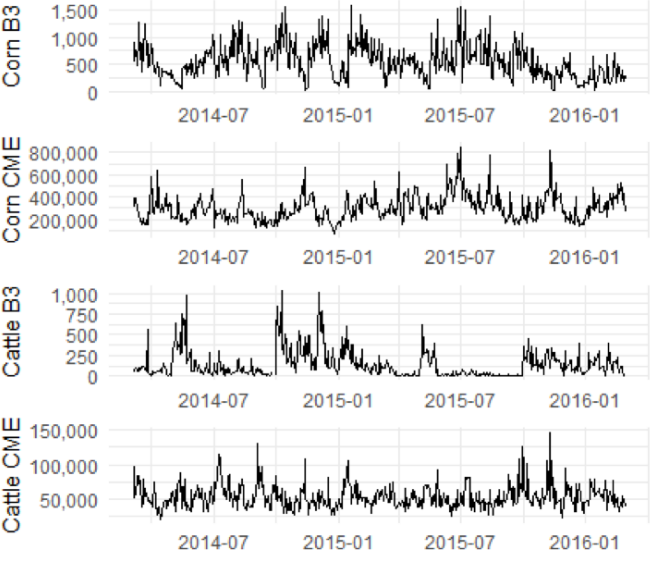


**Figure C1. Number of Traded Nearby Contracts Rolled on the First Day of the Month**

[10] The low trade volume shown in the B3 live cattle market may reflect the severe drought in central Brazil in the first half of 2015, which contributed to significantly reduce the supply of live cattle in the second half of 2015.