IMPACTS OF CASH SETTLEMENT ON THE HEDGING EFFICIENCY IN FUTURES CONTRACTS OF LIVE CATTLE

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ABSTRACT

Cash settlement is a mechanism that practically eliminates all the problems concerning futures contracts settlement through spot delivery, leading to an increase in its use by market agents. Given the power of this specification, the main upcoming problem is the participants' distrust towards the price index that best represents the physical market. This work was developed to verify the impact that different specifications for price indexes may have upon live cattle futures contracts traded at the BM&F. From the results, it can be verified that all specifications show a high degree of hedging efficiency, and that the specifications weighted by a cheaper location probability presented the lowest variances.

Key words: financial settlement, futures contracts, price index.

1. Introduction

Traditionally, the contracts that are not previously compensated in futures markets are offset through the spot delivery or receipt of the product. Offsetting a contract means that buyers and sellers invert their position in the futures market before the maturity of the contract. For instance, if a hedger closed a sales (purchase) contract, he/she would simply acquire a purchase (sales) contract for the same due date, zeroing its position and leaving the market. The delivery of the traded commodity

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is done by the seller to the buyer in exchange of the payment of the value that is determined by the closing futures price from the buyer to the seller. This process is seen as fundamentally important in the promotion of spot and futures price conversion, which, in turn, increases risk transference and the price discovery function of futures markets. The non-occurrence of prices conversion during the delivery period will bring forth an opportunity of gains with arbitrage, that is, if the futures price are higher than the on demand price, arbitrators will buy the commodity in the spot market and sell it in the futures one, where they would have more profit. On the other hand, if the futures price were lower than the spot one, arbitrators would buy the futures contract and sell the commodity in the spot market, receiving the commodity in the futures contract of purchase and passing it on to the buyers in the spot market.

Costs associated to the spot delivery and compensation convenience have brought up many proposals for the substitution of spot delivery as a financial settlement of certain kinds of contracts. Typically, the value of the last settlement if based on some spot indicator, determined by a formula that is related to the prices of the spot market, independently from the futures market. In practice, when a contract is settled financially, given that all values are determined in the market daily, the total paid amount between buyers and sellers at the end is the difference between the indicator value in the spot market in the last day or the average of the last days of negotiations and the price of the contract the day before.

The economic function of a futures market is only efficiently performed when there is a high level of competition among participants. Thus, the prevention of distortions, such as *squeezes*[1] or *corners*[2], has been an area of great interest for the institutions of futures. However, the main problem with the financial settlement for agricultural commodities is related to the distrust towards the indicator that the spot market represents, creating the inability for base predictability for many local

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1 The *squeeze* situation is characterized as a situation where a short agent (sales person) in future markets cannot invert its position or acquire a commodity to deliver, except for a price that is substantially higher than he relative value of the contract or the commodity in the market (Downes & Goodman, 1993; Bessada, 1995).

2 According to Hull (1991), *corner* is a kind of irregularity in which the number of open contracts can exceed the amount of available merchandise for delivery. Thus, the holders of sold positions notice that they will find it difficult to deliver and get desperate to null their positions. The result is an increase in future and spot prices.

producers. In this sense, the objective of this work is to analyze the settlement system of live cattle contracts traded by BM&F. For this, the hedging efficiency obtained through the *Indicador do Boi Gordo* (IBG)[3], used nowadays for contracts settlement, is compared to the ones reached by alternative specifications which will be obtained.

2. Material and methods

2.1. Futures prices model with location option

The delivery option plays an important role in evaluation of futures contracts when the contract allows this flexibility. According to Margrabe (1978), Johnson (1987) and Boyle (1989), we may see that the futures price of a contract which admits the delivery of several goods of a set of **n** goods equals the value of a purchase option[4] on the lowest value of **n** goods, at a zero-exercise price. The formal model for futures prices with a location option presupposes: (1) the existence of a perfect market (without diversity); (2) a constant knowledge of interest rate **r**, once futures prices equal corresponding prices in the future; (3) that the seller will deliver the commodity, on the maturity of the contract, at the cheapest location; (4) that there are no transaction costs; and (5) that the prices at the acceptable delivery location are normally distributed.

The conventional notation is:

t : current time;

T : contract maturity;

$\mathbf{L_i}$: location **i** where the delivery can be made;

$\mathbf{P_{it}}$: current price at the delivery location $\mathbf{L_i}$, in $/@ for **i** = 1, 2, ..., n;

K : European Call and Put[5] exercise price in $/@;

$\mathbf{F_t (P_1, P_2, ..., P_n; T) = F_t}$: futures price at time **t** of a contract, letting its sellers deliver at some locations $\mathbf{L_i}$'s;

$\mathbf{EC_t (P_1, P_2, ..., P_n; K; T) = EC_t (K)}$: price of a European purchase option (Call) at time **t** on the lowest of prices **n** at the included delivery

3 Note of translation: Live cattle Indicator

4 The European Purchase option (Call) gives its holder the right to buy assets on the maturity date at a certain price.

5 The European Sales option (Put) gives its holder the right to sell assets on the maturity date at a certain price.

locations in the acceptable set, with an exercise price **K** and expiration date (t + T).

On the due date, the Call value is:

Max {[Min $((P_1, P_2, ..., P_n)$ - K], 0}; and $\mathbf{EP_t}$ $\mathbf{(P_1, P_2, ..., P_n; K; t{+}T)}$ = $\mathbf{EP_t}$ **(K)** : price of a European sales option (Put) at time **t** on the lowest value of prices n at the delivery location included in the acceptable set, with an exercise price **K** and expiration date (t + T).

On the due date, the Put value is:

Max {[K - Min $(P_1, P_2, ..., P_n)$], 0}.

The purchase of a futures contract having spot delivery at only one location as a form of settlement can be reproduced from the purchase of a European Call or sale of a Put. Taking on a neutral risk, the futures price is only a spot price estimated for the future. However, this structure of a single delivery location must be generalized when the set of possible delivery locations includes more than one market. In the case of **n** possible delivery locations, value **f** of a futures contract equals a Call purchase on the lowest price of **n** goods plus the sale of a Put at the lowest price of **n** goods, as follows:

$$f = EC_t\,(P_1, P_2, ..., P_n; K; t + T) - EP_t\,(P_1, P_2, ..., P_n; K; t + T) \qquad (1)$$

Margrabe (1978), Stulz (1982) and Johnson (1987) understood the parity relation between Put – Call as one option over the lowest price of n goods, providing the following alternative expression for equation (1):

$$f = EC_t\,(P_1, P_2, ..., P_n; 0; t + T) - Ke^{-rT} \qquad (2)$$

When the futures contract is begun, the value of the futures contract equals zero. Therefore, the futures price equals the exercise price value that makes the value of the futures contract equal to zero:

$$f = 0 ==> K = F_t\,(P_1, P_2, ..., P_n; t + T) \qquad (3)$$

From a combination of equations (2) and (3), an expression for futures prices is obtained when a delivery locations option is included in the specification of the contract, making it easier to be worked out:

$$F_t(P_1, P_2, ..., P_n; t+T) = e^{rT}\, EC_t(P_1, P_2, ..., P_n; t+T) \qquad (4)$$

If the value of ECt (K=0) can be found, then, the futures price value will directly do the same. Johnson (1987) and others derived a general expression for $EC_t(P_1, P_2, ..., P_n; K; t+T)$, which is equivalent to a purchase option for the minimum of n goods. The price in exercise, tending to zero, produces the following expression for EC_t (K = 0):

$$\begin{aligned} EC_t(K{=}0) = {} & P_1 N_n (d_{12}(P_1, P_2, \sigma_{12}^2), ..., d_{1n}(P_1, P_n, \sigma_{1n}^2), -\rho_{112}, -\rho_{113}, ..., \rho_{123}, ...) \\ & + P_2 N_n (d_{21}(P_2, P_1, \sigma_{21}^2), ..., d_{2n}(P_2, P_n, \sigma_{2n}^2), -\rho_{221}, -\rho_{223}, ..., \rho_{213}, ...) \\ & + P_n N_n (d_{n1}(P_n, P_1, \sigma_{n1}^2), ..., d_{nn-1}(P_n, P_{n-1}, \sigma_{n-1n}^2), -\rho_{nn1}, -\rho_{nn2}, ..., \rho_{n12}, ...) \end{aligned} \qquad (5)$$

Where:

$$d_{ij} = \frac{\ln \frac{P_j}{P_i} - \frac{1}{2}\sigma_{ij}^2 T}{\sigma_{ij}\sqrt{T}}$$

$$\rho_{iij} = \frac{\sigma_i - \rho_{ij}\sigma_j}{\sigma_{ij}} \qquad \text{for } i \neq j;\ i, j = 1, 2, ..., n.$$

$$\rho_{ijk} = \frac{\sigma_i^2 - \rho_{ij}\sigma_i\sigma_j - \rho_{ik}\sigma_i\sigma_k + \rho_{jk}\sigma_j\sigma_k}{\sigma_{ij}\sigma_{ik}} \qquad \text{for } i \neq j \neq k;\ i, j, k = 1, 2, ..., n.$$

$$\sigma_i^2 = Var(\Delta \ln P_i)$$

$$\rho_{ij} = Corr(\Delta \ln P_i, \Delta \ln P_j)$$

$$\sigma_{ij}^2 = Var(\Delta \ln \frac{P_i}{P_j}) = \sigma_i^2 - 2\rho_{ij}\sigma_i\sigma_j + \sigma_j^2$$

and N_n (.) is the n-dimensional cumulative normal distribution with the arguments defined above. The value of the option is, in fact, a pondered average of the prices at the locations in a set of possible deliveries. These weights can be interpreted as the riskless probability that a particular location will be cheaper, given not only the prices level, but also the correlation degree among them. These prices bring all the necessary information in order to evaluate the probability that certain location have of being cheaper if there is a correlation pattern among all delivery locations $\mathbf{L}_i$. This intuitively shows the use of a joint distribution for the set prices of deliverable locations. The determination of probabilities concerning each location is possible using a mathematical artifice called "Cholesky determination". According to Rencher (1995), this method consists of fragmenting the previously determined prices-correlation matrix and using it in the correction of original data.

In cases of four delivery locations, such as this study, the estimated value of the futures price is:

$$F_t = e^{rT} \sum_{i=1}^{4} P_{it} N_4(d_{ij}; d_{ik}; d_{iz}; \rho_i) \qquad i \neq j \neq k \neq z;\ i, j, k, z = 1, 2, 3, 4. \qquad (6)$$

$$N4(dIJ; dik; diz; \rho_i) = \int_{-\infty}^{+\infty} \int_{-\infty}^{dij} \int_{-\infty}^{dik} \int_{-\infty}^{diz} f(r,s,x,y) dr\, ds\, dx\, dy$$

The arguments of cumulative distribution with four variable levels are defined with the price option, in equation (5). This method can be extended to contracts based on financial settlement. For example, let us imagine a contract with multiple locations used in the obtainment of the indicator. $\mathbf{F}_t$ may be interpreted as a common price for the settlement (CPS) of the contracts pondered by the probability that the price for each area will be the cheapest one. This is because this price is determined on the week of maturity of the contract, representing a spot indicator to which the futures price will converge. As equation (6) shows, CPS estimates evolve the integral calculation with four dimensions for the normal multivariate cumulative distribution. Normal tetra-variable distribution expresses a situation in which different prices in deliverable locations are conjunctly set. For a given location, such as market 1, for example, to be the cheapest one over the total $\mathbf{P}_1$ price range, $\mathbf{P}_1$ must simultaneously be lower than $\mathbf{P}_2$ (determined above integration limit $\mathbf{d}_{12}$), lower than $\mathbf{P}_3$ (determined above integration limit $\mathbf{d}_{13}$) and lower than $\mathbf{P}_4$ (determined above integration limit $\mathbf{d}_{14}$). Thus, the use of the methodology which simulates common prices for the settlement of contracts, related to the probability of each location to be the cheapest one, is related to the suggestion made by some authors that the futures price of a contract with spot delivery in multiple locations is represented by the value of the deliverable commodity at the cheapest location. Among the authors which made such reference are Jones (1982), Garbade & Silber (1983), Kahl et al. (1989), Rich & Leuthold (1993), Chaherli & Hauser (1995), among others. The considerations made by these authors can be expanded, inferring that, as what happens in the spot delivery specification, when one works with financial settlement, futures prices will comply with the area taking part in the index establishment which has the lowest price.

Almost all existing futures contracts prevent against unequal prices based on spatial differences, having specified delivery terms (bonuses and discounts). Nevertheless, when differences in commercial prices are subject to structural changes, the included adjustment may not reflect existing intentions from when the terms were written. An alternative to bonuses/discounts is allowing the variation of the discount specification over time, as done in cotton contracts traded at the New York Cotton exchange. The change can be done with regular adjustments, depending on the behavior of the spot price before the maturity of each contract. In order to evaluate the discount adjustment, P_{it} in equation (1) is substituted by P''_{it}, defined as:

$$P''_{it} = P_{it} + \delta_{it} \; ; \; \delta_{it} = \frac{1}{t^*} \sum_{j=1}^{t^*} (P_{k,t-j} - P_{i,t-j}) \qquad i = 1, 2, ..., I. \qquad (7)$$

where: δ_{it} is the adjustment of the moving average $P_{K,t-j}$ is the last price at the specified location; $L_K \in \Phi_I$; $P_{i,t-j}$ is the last price at the non-specified location; $L_K \in \Phi_I$; $[t^* - t]$ is the horizon measurement of the moving average and Φ_I is delivery locations set L_i.

In financial settlement, as in the case of spot locations, this procedure aims at reducing the differences among the prices of the regions that compose the common settlement price.

2.2. Formation of an indicator

Many weight schemes have been used and suggested when terms for liquidating a contract financially are designated. The approach we used in this work reflects the information derived from the common prices settlement through the cheapest delivery probabilities (EMP probabilities). Some of the market principles are reflected not only through the delivery location prices, but also through the probability the location has of becoming cheaper at the end of the contract. As suggested by Hauser et al. (1992), the EMB probabilities averages for a determined period of time may be used as a weight in the price indicator. This kind of indicator has one of the desirable characteristics that a constant weight indicator would not necessarily have, that is, the ability to reflect the relevant information taken from the dynamism existing in spot markets. In order to illustrate such pondering scheme, the deliverable location set is considered. It contains four markets: market #1, market #2, market #3, and market #4. Equation (1) can be rewritten as:

$$F_t = e^{rT}\,[P_{it}W_{1t} + P_{2t}W_{2t} + P_{3t}W_{3t} + P_{4t}W_{4t}]; \qquad (8)$$

where: $W_{it} = N_4(d_{ij}, \rho_i)$; $i = 1, 2, 3, 4.$

Each price is deliberated by the probability that the commodity at the respective location will be as cheap as possible. N_4 is the normal accumulated distribution with four variables, whose argument d_{ij} (superior limit vector) and ρ_i (correlation matrix) are defined in equation (5). The probabilities averages determined by equation (5) are calculated for a given period in order to obtain an average EMB probability for each respective price. Then, the IEMB (Cheapest-Probability Weighted Indicator) is defined as a spot price indicator:

$$I_t^{EMB} = e^{rT}\,[P_{1t}\widehat{W}_1 + P_{2t}\widehat{W}_2 + P_{3t}\widehat{W}_3 + P_{4t}\widehat{W}_4] \qquad (9)$$

being: $\widehat{W}_i = \frac{1}{\tau}\sum_{k=0}^{\tau} W_{ik}$

where [0, τ] is the time interval based on which the EMB probabilities averages are calculated. This indicator differs from the one which were used for financial settlement in the past, because it uses information coming from a simulated spot delivery system, which can be used as a settlement price in the expiration of the contract. From now on, this kind of indicator will be referred to as EMB indicator (IEMB), pondered in order to reflect the connection between EMB probabilities and weights used for the long term indicator.

2.3. Hedging Performance Evaluation

According to Ederington (1979), hedging efficiency is measured as the percent reduction in return variance reached by a hedge position, in opposition to a hedgeless one. This efficiency measure takes on a price-variance minimizing strategy. A typical measure of efficiency is used to analyze the efficiency of hedging decisions taken by individuals for each settlement specification discussed in the sections above. Being π the gain or loss of a hedge, **h**, the spot position fraction with hedge, and **h***, the hedge proportion for the risk minimization, the hedging efficiency (HE) measure is defined as the difference between the hedgeless price variance, Var $((\pi_h = 0)$ and the assured position variance, Var $((\pi_{h*})$, divided by the hedgeless position variance:

$$HE = \frac{Var\,\pi_{h=0} - Var\,\pi_{h^*}}{Var\,\pi_{h=0}} = R^2 \qquad (10)$$

where $\mathbf{R^2}$ is the determination coefficient of Ordinary Least Square regression in spot prices over futures contracts price maturing in time **T:**

$$P_{it} = \alpha_{ij} + \beta_{ij} F_{jt} + \varepsilon_{ijt} \qquad (11)$$

where: **F** is the futures price defined in the market and also the common settlement price based on one of the processes defined previously; and $\mathbf{P_i}$

is the spot price at location L_i. The same procedure is used to evaluate financial settlement indicators, substituting **F** by the financial settlement indicator.

2.4. Testing nonnested[6] models for settlement specifications

One of the main functions of econometrics is testing the validation of models developed by economic theories. However, Davidson & MacKinnon (1981) and Godfrey & Pesaran (1983) state that many hypothesis-testing techniques simply allow restriction testing in a more general model. One of the exceptions to this generalization is a technique suggested by Pesaran & Deaton (1978), based on the works of Cox (1962) and Pesaran (1974). This technique is referred to as Cox-Pesaran-Deaton, or CPD test. It lets us test the authenticity of non-linear and multivarieted regression models, when there is a *nonnested* alternative hypothesis.

The nature of settlement processes, as well as differential and delivery spots determinations determine different specifications of settlement prices to the hedge efficiency relationship. Once this relationship cannot be obtained by parametrical restrictions impositions, it represents *nonnested* models. In order to evaluate statistical differences in hedging efficiency regressions, the hypothesis-testing approach is employed. This approach relies on the model performance prediction based on the spot prices data generation process (DGP). The ability to predict the model performance with grounds on the DGP of the dependent variable is key-concept for testing *nonnested* models and Cox (1962) was the first author to use such approach.

Supposing that the null hypothesis:

$$H_0: C_i = \beta_0 + \alpha_0 F_0 + \mu_0 \, ; \, \mu_0 \sim N(0, \sigma_0^2 I) \qquad (12)$$

is the real DGP for C_i (spot price at location L_i), where F_0 is the settlement

6 Two models are said to be *nested* when one is a special case of the other, achieved by parameters restrictions. Thus, for example, the Cobb-Douglas production function is *nested* to the constant substitution elasticity production function. On the other hand, if a model cannot be expressed as a special case of another due to parameters restriction, they are considered *nonnested* models (Doran, 1993).

price vector based on specification S_0. Other specification S_1 at settlement price F_1 is credited to the generation of the true DGP and is prognosticated on the basis of H_0:

$$H_1: C_i = \beta_1 + \alpha_1 F_1 + \mu_1 ; \ \mu_1 \sim N(0, \sigma_1^2 I) \tag{13}$$

These two models can be combined in a simple model:

$$C_i = \beta + (1 - \delta)\, \alpha_0 F_0 + \delta\, \alpha_1 F_1 + \mu \tag{14}$$

If $\delta = 0$, then H_0 is confirmed, whereas $\delta = 1$ depends on the confirmation of H_1. Thus, H_0 could be tested, in principle, by testing $\delta = 0$. However, since inclination coefficients in H_0 and H_1 cannot be directly estimated from (10), Davidson & Mackinnon (1981) suggested that we used in (10) the value proposed in C_i, based on the model given by H_1 in (9), and, then, that we tested if δ equals zero. When H_0 is true, they show that the estimator of δ, divided by the standard deviation, which is conventionally estimated, is asymptomatically distributed at a normal standard N (0,1).

2.5. Data

The spot markets to be considered in the study of futures contracts of live cattle will be: Três Lagoas/Araçatuba (Araçatuba – AR) – SP, Presidente Prudente (PP) – SP, Bauru/Marília (Bauru – BA) – SP, São José do Rio Preto/Barretos/Votuporanga (São José do Rio Preto - SJ) – SP, which are components of a set of regions which participate the formation of the indicator; and Triângulo Mineiro (TM) - MG, Campo Grande (CG) - MS, Paranavaí/Maringá/Londrina (Maringá -NP) - PR, Goiânia (GO) - GO e Dourados (DO) - MS, which are not part of the indicator. The prices for these regions will be obtained at CEPEA/FEALQ, which are institutions that are in charge of obtaining the indicator to be used in the financial settlement of the BM&F live cattle contract and present daily prices from April, 1994 to March, 1998.

3. Results and discussion

3.1. Hedging efficiency measured among spot prices of each area and contracts settlement forms

As a specification of an indicator based on the price of a single area, we used the price of the Araçatuba region. The common price for contracts settlement with multiple locations (PCL) and the indicator (IEMB) take into account prices from four areas of the State of São Paulo: Araçatuba, Presidente Prudente, Bauru and São José do Rio Preto. In cases of common prices of settlement and the indicator with bonuses and discounts (PCLPD and IEMBPD, respectively), the model region was Araçatuba.

In table 1, we could observe the individual hedging efficiency levels for locations that do or do not participate in the obtainment of the indicator. The results show that the kinds of specifications analyzed produce approximately the same level of efficiency for all regions. Regarding efficiency relations obtained with the specifications and futures prices (FP), the only differences were expressed by the common settlement prices (CLP) and the EMB indicator, which were 1 or 2% higher than the others.

Results presented in table 1 can be interpreted, for example, as the price variation in the area of Campo Grande (CG), being explained, in 94,71% of the cases, by the variation of the Live cattle indicator (IBG). Among the regions that do not contribute to the indicator, the one that is best explained by the settlement specifications is Triângulo Mineiro (TM) and the one which presented the worst determination coefficient (R^2) was Dourados (DO).

The hedging efficiency for live cattle measured among individual locations and the futures price, in Table 1, was low when compared to settlement specifications. This is possibly related to the fact that a live cattle is a non-storable commodity.

Such consideration is based on Leuthold et al.'s (1989) theoretical suggestion that, for non-storable commodities, the decision of varying production is the main influence in the relation of prices for these products.

Once these merchandises are not based on fixed stock proportions, as in the case of grains, futures market is mainly constituted of price anticipation. The base[7] for livestock (live cattle) is conducted, therefore, by the offer and demand and by the traders' expectation that these functions will vary along time.Thus, the set of spot and futures prices is not formally related to the period which precedes the contract maturity, besides the non-existence of a maximum or minimum theoretical limit for the base size.

Table 1 – Hedging efficiency in alternative specifications for settlements – maturity week

	AR	IBG	PCL	IEMB	PCLPD	IEMBPD	PF
AR	1.00	0.99	0.99	0.99	0.99	0.99	0.55
PP	0.99	0.99	0.99	0.99	0.99	0.99	0.57
BA	0.99	0.99	0.99	0.99	0.99	0.99	0.56
SJ	0.97	0.97	0.97	0.97	0.96	0.96	0.51
CG	0.94	0.94	0.94	0.94	0.94	0.94	0.51
GO	0.95	0.96	0.96	0.96	0.95	0.95	0.52
TM	0.96	0.97	0.97	0.96	0.96	0.96	0.58
NP	0.94	0.95	0.95	0.95	0.94	0.94	0.63
DO	0.92	0.93	0.92	0.92	0.92	0.92	0.59
PF	0.55	0.54	0.56	0.56	0.55	0.55	-

Source: research data

IBG, PCL, IEMB, PCLPD, IEMBPD and PF refer to live cattle indicator, common settlement price, cheapest-delivery pondered indicator, common settlement price with bonuses/discount, and cheapest-delivery pondered indicator with bonus/discount and futures price, respectively.

[7] The base is defined as the difference between spot and futures prices.

The results obtained for the hedging efficiency of the maturity week suggest that the spot prices of locations which do or do not participate the indicator obtainment are explained by any specification (AR, IBG, PCL, IEMB, PCLPD e IEMBPD). This fact can be related to evidences obtained by De Zen (1997) that there is a great integration of prices within the analyzed areas, where each location presents fast answers to changes in other locations. Besides, there are no market leaders. This author also infers that changes in prices can be caused by factors, which are particular of each area and transmitted to others. Due to the high capacity of auto-forecasting and forecasting prices of other areas, besides configuring important regions concerning production and processing, these specifications, as suggested by Barros et al. (1997), can be credited as having a high potential of credibility and visibility.

3.2. Base variance between spot prices of each area and alternative settlement specifications

Analyzing Table 2, we can infer that the differences in variance among location prices and settlement specifications presented relatively low values. However, some observations must be made towards differences related to increases or decreases in variance when other specifications are compared to the one which currently rules live cattle contracts commercialized at BM&F, the live cattle indicator (IBG).

The specifications which obtained the best performances, when compared to IBG, were: PCL and IEMB for the Araçatuba area (AR), where base reductions of about 45% are identified. In the area of Presidente Prudente (PP), significant reductions are observed when we use specifications AR (28.73%), PCL (70.72%) and IEMB (70.17%); and, in the Bauru area (BA), where reductions were of about 33% for specifications AR, PCLPD and IEMBPD, and 67% for PCL and IEMB. On the other hand, PCLPD and IEMBPD for the areas of Araçatuba (AR) and São José do Rio Preto (SJ), where we can observe respective reductions of 46.90% and 31.64% when these specifications are substituted by IBG, had the worst comparative performances. For other locations, variance changes of the base, when evaluated between IBG and other specifications were not significant. The analysis of variance of the related base with other liquidation specifications and the future price (FP) presented a reduction when compared to the one used nowadays (IBG), which varied from 0.50% to the AR specification to 2.69% for PCL.

Table 2 – Base variance between the spot price of study regions and settlement specifications (AR, PCL, IEMB, IBG, PCLPD e IEMBPD) – delivery week

	AR	PP	BA	SJ	CG	GO	TM	NP	DO	PF
AR	0.000	0.0129	0.0251	0.1941	0.5465	0.3805	0.2590	0.4641	0.3312	6.6298
PCL	0.0042	0.0053	0.0125	0.2055	0.5252	0.3685	0.2382	0.4254	0.3165	6.4841
IEMB	0.0041	0.0054	0.0124	0.2055	0.5245	0.3683	0.2385	0.4254	0.3165	6.4867
IBG	0.0077	0.0181	0.0382	0.2031	0.5410	0.3464	0.2334	0.4395	0.3084	6.6634
PCLPD	0.0145	0.0186	0.0257	0.2971	0.5473	0.3929	0.2586	0.4513	0.3484	6.5735
IEMBPD	0.0145	0.0186	0.0257	0.2971	0.5476	0.3929	0.2586	0.4514	0.3485	6.5738

Source: Research data

The obtained results suggest a concern in the sense of trying to achieve a reduction in the variance of the base between analyzed locations and the current settlement specification (IBG), and, consequently, improvements in its visibility and representation. This concern is related to the subject Barros et al. (1997) brought up by pointing out the good visibility and representation of the indicator as basic condition for its market acceptance for futures contracts settlement purposes.

By the same way, considering specifications IBG and Ar, the analysis indicate that, although they are both equally efficient, the base variance performance is better when we use IBG, presenting a lower variance and, therefore, being considered as having a better visibility and representation. When we compare PCL and IEMB to IBG, we can verify that hedging efficiency presented practically similar values. However, concerning base variance, specifications PCL and IEMB had better results, showing, therefore, that specifications based on the cheapest probability deliver provide better visibility and representation to the market. The use of specifications PCL and IEMB, reorganized by the definition of bonuses and discounts (PCLPD and IEMBPD) presented a performance which was inferior to the original ones and to IBG in terms of base variance. This result does not necessarily discharge its possible use for contracts settlement purposes. However, the study of alternative forms of bonuses and discounts, which would lead to a better visibility and representation, is important.

3.3. Results of hypothesis tests with J-tests

The results of non-nested tests, which identify which specifications of indicator obtainment are less rejected than others, are presented in Table 3. For example, line 2, in column 3, shows that the specification of the indicator pondered by the cheapest location probability (IEMB) is not rejected in favor of the current specification (IBG) in two out of eight tested markets. This does not mean, however, that in the six remaining markets, this specification is preferred to IEMB with a small advantage over the others, once, it gets nine non-rejections out of a total of 24 possible ones (eight locations times three specifications), whereas specifications IBG, AR, and IEMBPD are not rejected in seven, eight and seven markets, respectively.

PCL and PCLPD specifications were omitted in testing analysis for not presenting perceptible differences in relation to IEMB and IEMBPD. Thus, whatever is valid for these ones can also be applied to the latter.

Table 3 – Hypothesis tests results for live cattle commodity – the maximum number of markets where the null hypothesis can be rejected is eight.

	IEMB	IBG	AR	IEMBPD
IEMB	-	2	4	3
IBG	2	-	2	3
AR	3	2	-	3
IEMBPD	1	3	3	-

Source: Research Data

4. Conclusions

The results achieved pointed out that all specifications of the analyzed indicator obtainment produce a high level of efficiency when compared to indicator-participating or non-participating regions. This performance justifies the inclusion of such indicators as bearers of a high credibility and visibility potential.

In the base variance analysis between spot prices of each region and settlement specifications, we observed that specifications pondered by the cheapest probability location presented a slight advantage over the others, including the actual indicator (IBG).

Tests, performed with the objective of identifying less rejected specifications towards others, presented a slight overall advantage over the indicator pondered by the cheapest location probability (IEMB).

When we analyze hedging efficiency, the theory generally leads us to an analogy between spot and futures prices. However, this work shows alternative functions to measuring the efficiency of financially settled contracts, making a comparison between local spot prices and indicators. This methodology meets the proposition that there is a convergence between spot and futures prices on the contract settlement date. Thus, this study evaluated the precision degree related to each settlement specification, which can be used to settle futures contracts of the live cattle commodity traded by BM&F.

The specification based on price differentials (bonuses/discounts), in spite of not presenting the expected results, must be pointed out. There must be more investigation in a discussion which would lead to bonuses/discounts that would enable a better visibility and forecasting of the indicator, making its incorporation in the settlement mechanism possible.

From the evidences obtained through this work, we must emphasize the need for research institutions to provide more studies on the development of the indicators used in futures contracts.

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