Cash Settlement Impact on Fed Cattle Futures Contract Basis Risk in Brazil*

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Summary: 1. Introduction; 2. Conceptual issues; 3. Previous research; 4. Data and methodology; 5. Results and discussion; 6. Conclusions.
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This paper examines the impact of cash settlement on the Commodities & Futures Exchange (Bolsa de Mercadorias & Futuros, BM&F) fed cattle futures contract basis risk, in nine regions in Brazil. The analysis was conducted only during the contract maturity months, and the random component of the basis series, which represents the risk, was isolated through successive lags in the original series. Then, the standard deviations of the random component of the basis (that represent basis risk) were regressed on dummy variables for cash settlement and seasonal effects. The regression model was estimated for every location and sex. The results lead to the conclusion that basis risk has been reduced after the introcustion of cash settlement for both male and female animals in all nine regions. Moreover, basis risk is lower for contract maturity months placed in the first half of the year than in for those in the second semester.

Este artigo examina o impacto da introdução da liquidação financeira sobre o risco de base do contrato futuro de boi gordo da Bolsa de Mercadorias & Futuros (BM&F), em nove regiões no Brasil. A análise foi conduzida durante o mês de vencimento dos contratos e o componente aleatório das séries da base, que representa o risco, foi isolado através de defasagens sucessivas nas séries originais. Então, realizou-se uma análise de regressão dos desvios-padrões do componente aleatório da base contra variáveis binárias, para os efeitos da introdução da liquidação financeira e da sazonalidade. Os resultados levaram à conclusão de que o risco de base foi reduzido após a introdução da liquidação financeira para machos e fêmeas, em todas as regiões consideradas. Além disso, o risco de base apresentou-se menor para contratos com meses de vencimento no primeiro semestre do ano em relação aos com vencimento no segundo.

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1. Introduction

Fed cattle futures trading in Brazil began in 1980 on the São Paulo Commodities Exchange (Bolsa de Mercadorias de São Paulo, BMSP). In 1987, the Mercantile & Futures Exchange also began trading fed cattle futures contract, so that this commodity could be negotiated at both institutions. In 1991, the BMSP and the Mercantile & Futures Exchange merged to create the Commodities and Futures Exchange (Bolsa de Mercadorias & Futuros, BM&F), which introduced a new fed cattle futures contract to the market.

Since contracts began to be traded,[1] they have been settled by physical delivery, but there were problems with the physically delivered BM&F cattle contract:

a) high delivery costs;
b) disputes associated with the grading of fed cattle during delivery;
c) fed cattle futures market low liquidity, because some agents did not aim to deliver or accept delivery, thereupon they were afraid of participating in the market;
d) price fluctuations in regional cash markets, caused by the anticipation of traders expecting to deliver or accept delivery;
e) possibilities for squeezes due to low fed cattle futures market liquidity.

Over time, improvements have been made to overcome these problems and make the contract more useful for market agents. Perhaps the most important change in the contract specifications was the cash settlement procedure, announced by the BM&F in December 1994 for the August 1995 contract. The BM&F adopted cash settlement for the fed cattle futures contract in order to eliminate high delivery costs and problems associated with physical delivery, thus expecting to improve hedging performance and encourage agents to participate in the market, through the elimination of the physical delivery obligation. The index used to settle the contract is the fed cattle available price index (indicador de preço disponível do boi gordo, IBG), calculated only for the regions situated in the state of São Paulo, Brazil.[2] The IBG calculation is made by the Advanced Applied Economic Studies Center (CEPEA),

[1] *The fed cattle futures contract is specified only for males in Brazil.*

[2] *IBG is calculated only from male prices.*

at the University of São Paulo's (USP) School of Agriculture Luiz de Queiroz (ESALQ). A single-state index was chosen to settle the contracts, because the regions which compound the IBG calculation represent the main markets for cattle trade. In addition, the lack of available prices in other regions makes it difficult to calculate a national index.

According to the portfolio theory, the hedger takes a futures market position to minimize cash price risk, subject to expected return. In this context, Netz (1996) asserts that the agent faces basis risk (from hedged inventories) and price risk (from unhedged inventories). Thus, the lower the basis risk, the higher the contract usefulness as a risk transfer mechanism and price guarantee. However, high delivery costs and problems generated by physical delivery can make arbitrage opportunities less profitable and hinder price convergence, increasing basis risk and impairing hedging performance. Garcia & Sanders (1996) assert that if basis risk increases:

a) the futures contract's ability to transfer risk is reduced;
b) it becomes more difficult to assess cash forward market and price opportunities;
c) the use of futures contracts can decline.

Cash settlement is an alternative to physical delivery, abolishing problems and costs related to the delivery of the physical commodity. Nevertheless, it is not appropriate to assume that cash settlement reduces basis risk because it eliminates costs and problems associated with physical delivery. This will happen only if the index used to settle the contract reflects cash market prices. Thus, it is necessary to assess if and how cash settlement has had an impact on the BM&F fed cattle futures contract basis risk to discover whether this change has effectively improved hedging performance.

In Brazil, research on the commodities futures markets began recently and much interest has been expressed about this particular area. Basis risk analysis is important to assess hedging performance and to develop practices to minimize its impacts on the markets agents' decisions.

The objective of this paper is to assess cash settlement impacts on the BM&F fed cattle futures contract basis risk during the contract maturity month through a regression model for each sex and region. Additionally, another dummy variable has been included in the model to identify seasonal effects on basis risk. Nine regions in Brazil have been analyzed in this research: Araçatuba, Bauru/Marília, Barretos/São José do Rio Preto, Presidente Prudente (which are located in the state of São Paulo), Triângulo Mineiro (located in the state of Minas Gerais), Campo Grande, Três Lagoas (located in the state of Mato Grosso do Sul), Goiânia (located in the state of Goiás) and Norte do Paraná (located in the state of Paraná). Only the first four regions are included in the IBG calculation.

2. Conceptual Issues

Leuthold, Junkus & Cordier (1989) defined basis as the difference between the price at specific cash market and the price of a particular futures contract. Basis has a positive sign when the cash price exceeds the futures price or has a negative sign when the opposite occurs. When cash and futures prices are equal, basis becomes zero.

Basis behavior during the period preceding the contract maturity month is different for storable and nonstorable commodities. For storable commodities, cash and futures prices are formally related to the carrying charge, which depends on price levels, interest rates, storage costs and transportation rates, which are functions of demand and supply conditions. Nevertheless, the futures price will not exceed the cash price by more than the full carrying charge, otherwise there would be arbitrage opportunities and acting on these opportunities would force the difference between futures and cash back down to full carry. Considering that factors affecting carrying charges are relatively stable, likewise is the basis for storable commodities (Rich, 1990).

For nonstorable commodities, like animals, cash and futures price relationships are not formally related like in the case of storable commodities. For nonstorable commodities, the futures price is the anticipated forward cash price. Because there is no fixed supply or stocks, this anticipation is based on available information about cash market demand and supply conditions. Therefore, these functions and the way traders expect them to change, guide basis patterns for nonstorable commodities (Leuthold, Junkus & Cordier, 1989). Since the arrival of new information is uncertain and unpredictable, the price relationship for nonstorable commodities has tended to be more unstable than that for grains (Rich, 1990).

Although the basis behavior during the period preceding contract maturity month is different for storable and nonstorable commodities, cash and futures prices behave similarly during the contract maturity month. As the contract maturity date approaches, cash and futures price converge and the basis tend to be near zero for storable and nonstorable commodities. This convergence process can be forecasted by agents in order to prepare their market strategies. However, unexpected basis movements create basis risk. Therefore, the more the basis fluctuates randomly, the higher the basis risk. Garcia et alii (1984) asserted that unanticipated basis fluctuations reduce the ability of futures markets to transfer risk from hedgers to speculators, and can result in a lower income for hedgers. Since hedging risk is represented by basis risk, the more the basis fluctuates, the less the futures markets is able to reduce price risk.

Hull (1996) defines basis risk from the basis definition. Considering that a hedging is initiated at moment t_1 and terminated at moment t_2, S_1 and S_2 can be defined as the cash prices of the hedged asset at moments t_1 and t_2, respectively, and F_1 and F_2 as the contract futures prices at moments t_1 and t_2, respectively. Then, through the basis definition, b_1 and b_2 represent the bases at moments t_1 and t_2, respectively:

$$b_1 = S_1 - F_1 \quad (1)$$

$$b_2 = S_2 - F_2 \quad (2)$$

The price which will be paid or received at moment t_2 is equal to S_2, and the loss or profit from futures position is $F_1 - F_2$. Therefore, the effective price the agent will pay or receive through the hedging is represented in equation (3) and will be the cash price of the asset at moment t_2 plus the difference between the futures prices at moments t_1 and t_2, respectively:

$$S_2 + F_1 - F_2 \quad (3)$$

Replacing equation (2) into (3) we obtain:

$$F_1 + b_2 \quad (4)$$

F_1 is known at the moment the hedging is initiated, but b_2 is unknown. If it was possible to know the value of b_2 at the moment the hedge is initiated, we would obtain a perfect hedge. The hedging risk is the uncertainty associated to b_2, which is defined as basis risk.

Under physical delivery, cash and futures price convergence is assured through arbitrage opportunities. However, transportation costs and anticipated demand or supply by traders expecting to deliver or accept delivery in local cash markets can distort cash price, hindering the convergence process. According to Garbade & Silber (1983), the two main problems related to physical delivery are high delivery costs and short and long hedgers preparing to deliver or accept delivery, which can affect local cash market supply or demand conditions and, hence, cash market prices.

For live animals, arbitrage opportunities become more difficult due to the animals lack of standardization. Therefore, arbitrators need to carefully consider costs associated with disease transmission, death loss, quality, grade and breed differences, high transportation costs, weight, sex and yield grade differences. Taking these factors into account, it is not appropriate to assume that arbitraging will frequently correct pricing imperfections for livestock futures (Rich, 1990). Moreover, physical delivery brings to the delivery costs additional expenses related to futures markets rates, which increase costs of delivering the physical commodity, hindering price convergence and increasing basis risk.

According to Leuthold (1992), futures contracts are successful only if cash and futures price converge to the commercial value of the commodity at contract maturity. Therefore, basis predictability is necessary for hedging effectiveness. The hindrances to price convergence under physical delivery can be eliminated by cash settlement. Under cash settlement the futures contract is settled to an index, which represents cash market prices. It forces the futures price to equal the final cash settlement price and, therefore, basis risk is expected to be reduced.

Jones (1982) and Garbade & Silber (1983) asserted that when a futures contract is settled by a price index that represents an average price (cash settlement), basis becomes more predictable than when only a local price is considerated (physical delivery). Nevertheless, cash settlement can reduce basis risk and improve hedging performance only if the index used to settle the futures contract is a reliable indicator of the commercial value of the commodity.[3]

Although basis risk can be reduced by cash settlement, Cohen & Gorham (1985), cited by Kenyon et alii (1991), asserted that basis risk at contract maturity will never be zero, because cash settlement price is an average price

[3] *This statement is not necessarily always true. If the delivery system is a terrible one and the hedger faces extremely high risk and cost, basis risk might be reduced even if the index could not accurately indicate the commercial value of the commodity.*

in time, for different commodity grades and locations, while the hedger will always have his product at a local cash market, representing only a component of that average.

3. Previous Research

After the Chicago Mercantile Exchange (CME) implemented cash settlement for feeder cattle futures contract, in September 1986, some research has been conducted to verify its impacts on basis variability. Elam (1988) tested to see if hedging risk would be reduced by cash settlement rather than physical delivery. An equation was used to estimate hedging risk based on a sample of cash and futures prices. The Cattle-Fax prices were used as a proxy for cash settlement prices that were not available before 1986.

The results obtained by Elam (1988) indicated that the estimated hedging risk under cash settlement was lower compared to physical delivery, for steers and heifers weighing 600-700 pounds. For steers and heifers weighing less than 600 pounds, hedging risk was estimated to be lower for the new cash settlement contract fall hedges, but hedging risk was estimated to increase for spring hedges placed in the cash settlement contract. However, Elam (1988) warns that the results are valid only if the relationship between prices remains the same after cash settlement has been introduced.

Using the methodology proposed by Elam (1988) and the USFSP series to simulate prices under cash settlement, Schroeder and Mintert (1988) provided an estimate of feeder cattle hedge ratios associated with the new cash settled feeder cattle futures contract and compared the levels of hedging risk presented under the cash settled contract with the physical delivery contract.

Hedge ratios were estimated using both the historical USFSP price series and the physical delivery feeder cattle futures contract prices. The results were compared and lead to the conclusion that the hedging risk estimates using the USFSP series were generally lower than hedging risk estimates using physical delivery futures prices. Hedging risk reduction was higher for animals matching contract weight specifications and consistent in all markets considered in the study. The estimated optimal hedge ratios suggested an increase of 10 to 15% under cash settlement relative to physical delivery. Schroeder and Mintert (1988) asserted that cash settlement adoption would lead to a hedging risk reduction, which might differ across market locations not considered in their research.

Since these changes occurred in September 1986, more data was generated over time and became available for new research involving additional cash market locations. Rich (1990) conducted an empirical research of cash settlement impacts on the CME feeder cattle futures contract. Feeder cattle cash-futures price spreads were investigated from 1984 to 1988 for 27 selected US markets to assess the impact of cash settlement on basis and basis variability. Monthly, weekly and daily bases were calculated and the performed variability tests results indicated that cash settlement has reduced the variance of the basis in most locations, and that basis is subject to different economic forces at different times during delivery month.

To analyze the impact of cash settlement on feeder cattle basis volatility, a monthly regression analysis was conducted. Monthly basis variability was regressed on dummy variables for cash settlement, sex, and location. The results indicated that cash settlement was a statistically significant variable in every model, causing reduction in maturity basis volatility. However, the cash settlement's effects on basis variability have not been linked to sex differences. Moreover, the reduction in hedging risk was not evenly distributed across all markets.

Rich (1990) conducted an extensive analysis using data before and after cash settlement introduction. However, in his analysis, the basis variability during the contract maturity month is calculated assuming that all basis fluctuations in this period reflect basis risk. Presuming that any basis variation during contract maturity month is random and, therefore, risky, this can lead to incorrect results. Cash and futures prices convergence is expected during the contract maturity month and can be used by market participants in their marketing strategies. Therefore, the convergence process does not represent basis risk. For this reason, Leuthold (1979), cited by Garcia et alii (1984), suggested that basis fluctuations should be viewed in terms of a systematic component and an unsystematic or random component.

Kenyon et alii (1991) analyzed the impact of cash settlement on basis variability and predictability on the CME feeder cattle futures contract, based on feeder cattle futures price before and after cash settlement introduction. The results obtained indicated that the standard deviation was 3-14% lower after cash settlement, but this difference was not significant. Estimated basis equations in which basis was specified as a function of breed, sex, weight, grade, and season were used to predict termination basis and to determine the impact of cash settlement on the ability to forecast basis. The results suggested that hedgers ability to forecast basis in general was not improved significantly under cash settlement compared to physical delivery.

Rich and Leuthold (1993) expanded the sample size to a larger number of markets and analyzed how cash settlement issues have influenced hedging conditions at the individual market level and for the feeder cattle industry in general. The study analyzed basis behavior and hedging risk for 27 feeder cattle futures contracts before and after cash settlement. Hedging risk (represented by basis risk) was represented by basis standard deviations in the sample. A regression model was developed to isolate the impact of cash settlement on basis risk from other contract specification changes and to gain better insight into hedging risk across regions and between sexes. Using ordinary least squares (OLS), delivery week basis standard deviation was regressed on dummy variables to represent cash settlement, sex, and location effects.

Although not statistically linked to cash settlement, basis risk was found to be reduced at contract expiration for most individual markets. In 83% of the cases, mean basis was closer to zero after cash settlement. The regression model on weekly data suggested that basis variability was reduced after cash settlement, since the coefficient of the dummy variable for cash settlement was negative. However, in percentage this reduction represented a decrease of only 7,25% in hedging risk due to cash settlement.

4. Data and Methodology

4.1 Data[4]

Cash settlement for the BM&F fed cattle futures contract was implemented for the August 1995 futures contract. Before 1994, fed cattle futures market in Brazil have had very low liquidity, therefore the sample is composed by contracts from 1994 onwards. Moreover, the CEPEA/FEALQ began the IBG calculation in March 1994; therefore, regional male and female cash prices have been available for the nine selected regions only since then.[5] The available fed cattle cash prices include nine locations, which have been considered

[4] *Daily futures prices were obtained at the BM&F and daily cash prices were obtained at the CEPEA.*

[5] *Before 1994, cash price data were available only for male in the regions of Araçatuba, Bauru, Marília, Barretos, São José do Rio Preto, and Presidente Prudente. No local cash prices for specific locations were available for this research.*

in this study: Araçatuba, Bauru/Marília, Barretos/São José do Rio Preto, Presidente Prudente, Três Lagoas, Triângulo Mineiro, Campo Grande, Goiânia, and Norte do Paraná. Only the first four regions are included in the IBG calculation. Fed male and female animals have been considered in the analysis, although the IBG calculation only includes male regional prices. The BM&F fed cattle futures prices have been used and, since the contracts are quoted in dollars, fed cattle cash prices have been converted to dollars.

Regional fed cattle cash prices are available only from 1994 onwards, and futures trading months during this period were: October and December 1994; March, May, August, October, and December 1995; February, April, June, August, September, October, November, and December 1996; February 1997. Hence, the period considered in this analysis is from October 1994 to February 1997, due to data availability. The period before cash settlement includes four contracts (October and December 1994; March and May 1995) and the period after cash settlement includes 12 contracts (August, October, and December 1995; February, April, June, August, September, October, November, and December 1996; February 1997).

4.2 Methodology

Leuthold (1979), cited by Garcia et alii (1984), developed models to explain live cattle basis variation using variables which reflect current and expected supplies. He concluded that basis movements for distant contracts could be explained by factors affecting shifts in supply. However, during the delivery period, he attributed that the basis was more random due to increased speculative activity, reflecting commodity trading between cash and futures markets. Based on the work of Leuthold (1979), Garcia et alii (1984) suggested that basis fluctuations should be viewed in terms of a systematic component and an unsystematic or risky one.

According to Garcia et alii (1984), basis shows a systematic component represented by cash and futures prices convergence, and, if there are cash price seasonal patterns, they can be reflected in seasonal patterns from the basis fluctuations. Since this component does not represent risk, because it can be forecasted and used by market agents in their strategies, it is necessary to isolate the random component which represents the risk during the contract maturity month.

The authors isolated the systematic and the random components of the basis series to assess basis risk for selected cattle and hogs markets in the USA. The variate difference approach was used, which assumes that the mathematical expectation can be approximated by polynomials of the variable time. The expectation from the time series can be eliminated by differencing, leaving only the random element (the deviations from expectation) which represents risk.

Garcia et alii (1984) used the variance of the random element as a measure of basis risk, which is the dependent variable of the estimated model. The exogenous variables included are the consumer index price and a livestock cycle indicator (to represent the impact of long term price fluctuations on the unsystematic basis component), dummy variables (to isolate the effect of the contract maturity month and different markets), and average basis level.

As suggested by Garcia et alii (1984), basis variance is analyzed in terms of a systematic and a random component in this paper. Basis risk is represented by the standard deviation of the random element of the basis series during the contract maturity month. However, in order to assess if and how cash settlement introduction has affected basis risk during the contract maturity month in each region and for each sex, and to identify seasonal effects on basis risk, only the contract maturity months have been analyzed and only dummies are included in the model as exogenous variables.

Basis is calculated as local cash price minus the BM&F futures price during each day of the contract maturity month. During each contract maturity month, the random component of the basis series is isolated by successive lags in the original basis series until every one becomes stationary and the errors result in a white noise series. The basis series autoregresive process orders are determined by two criteria: Aikaike Information Criterion – AIC – and Schwarz Information Criterion – SC (Lutkepohl, 1993). These criteria are used to compare different lags in order to determine the best autoregressive model for the basis series.

All the basis series contract maturity months are submitted to AIC and SC in each considered region, for male and female animals. Thus, for each region there are 16 contract maturity months for males likewise for females, so that 32 basis series are submitted to AIC and SC for each region. After determining the basis series autoregressive process orders through these criteria, each basis series (corresponding to each contract maturity month) is autoregressed according to its determined lag, to isolate the white noise series from which standard deviations are calculated.

Each of the nine regions considered in this study contains male and female fed cattle cash prices. Since there are 16 contract maturity months, there are likewise 16 basis series for males and 16 basis series for females in each region. The standard deviations of the random element are determined for every contract maturity month. Therefore, for each region correspond 16 standard deviations of the random component for males and 16 standard deviations of the random component for females. In order to assess whether and how basis risk differs before and after cash settlement and to identify seasonal effects on the basis risk contract maturity month,[6] the standard deviations of the random component have been regressed on dummy variables to represent these effects. Using 16 observations, the regression model represented by (5) has been estimated for every region and sex by ordinary least squares (OLS):

$$\ln(\sigma_{basis\,ij}) = \beta_1 S_i + \beta_2 CS_j + u_{ij} \tag{5}$$

where:

$\ln(\sigma_{basis\,ij})$ = logarithm transformation of the standard deviation of the random component;[7] i refers to the contract maturity month and j refers to the before or after cash settlement introduction period;

S_i = dummy variable for seasonal effects which is equal to 0 when i refers to the contract maturity month placed in the second semester of the year and is equal to 1 for those placed in the first semester of the year;

CS_j = dummy variable for cash settlement, which is equal to 0 when j refers to the period before cash settlement introduction and equals 1 when j refers to the period after cash settlement introduction;

u_{ij} = model estimation error.

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[6] *In Brazil, there are seasonal patterns in cattle supply for slaughtering, because of the extensive raising system used. During the first semester of the year, pasture is not plentiful because the shortage of rain makes forage yield to decrease, and cattle slaughtering supply increases. On the other hand, during the second semester of the year, as weather becomes rainy, forage yield increases and leads cattle slaughtering supply to decrease.*

[7] *Logarithm transformation was used to stabilize the variance of the standard deviation of the random component series.*

The coefficient for the seasonal effect variable is expected to be negative and significant due to the seasonal patterns in cattle supply for slaughtering because of the extensive raising system used in Brazil. In addition, the most trading contract in BM&F is for October maturity month ("the peak of shortage in supply for slaughtering"). Moreover, the coefficient for the cash settlement variable is expected to be negative and significant because delivery costs which hinder cash and futures prices convergence and increase basis risk have been eliminated.

5. Results and Discussion

The basis series autoregressive process orders determined through AIC and SC criteria ranged from 1 to 5 for male and female, being 1 the most common order for both sexes in all nine regions. The presence of autocorrelation in the residual series was tested through the Ljung Box statistic (Q test) and none of the estimated regression presented this problem, indicating that those series are white noise. The standard deviations of the random component of the basis series were larger during the period before cash settlement introduction compared to the period after that for male and female in all regions. Tables 1 and 2 present the regression results in each region for male animals.

Table 1
Regression results for the standard deviations of the random component on dummy variables for cash settlement and seasonal effects (male)

	Regression analysis		Coefficients of the dummy variables	
Region	F-statistics	$\overline{R}^2$	S	CS
Araçatuba	65,590*	0.8898	-0.879 (-3.38)*	-1.481 (-8.06)*
Bauru/Marília	143,212*	0.9467	-0.785 (-4.61)*	-1.467 (-12.19)*
Barretos/SJRP	123,520*	0.9387	-0.670 (-3.49)*	-1.609 (-11.87)*
Presidente Prudente	47,557*	0.8534	-0.837 (-2.89)**	-1.402 (-6.85)*
Três Lagoas	73,469*	0.9006	-0.785 (-3.39)*	-1.417 (-8.66)*
Triângulo Mineiro	62,999*	0.8857	-0.848 (-3.16)*	-1.521 (-8.01)*
Campo Grande	52,107*	0.8647	-0.872 (-3.35)*	-1.277 (-6.93)*
Goiânia	59,094*	0.8790	-0.653 (-2.72)**	-1.359 (-8.00)*
Norte do Paraná	124,356*	0.9391	-0.681 (-4.56)*	-1.181 (-11.17)*

Notes: t test values are between parenthesis, beside dummy variables coefficients. S is the dummy variable for seasonal effects and CS is the dummy variable for cash settlement.

*significant at 1% level.

**significant at 2% level.

Table 2

Relative changes on hedging risk during the contract maturity month due to cash settlement

Region	% changes on hedging risk
Araçatuba	-77.26
Bauru/Marília	-76.94
Barretos/SJRP	-79.99
Presidente Prudente	-75.39
Três Lagoas	-75.76
Triângulo Mineiro	-78.15
Campo Grande	-72.11
Goiânia	-74.31
Norte do Paraná	-69.30

Source: Table 1.

Table 1 shows through F statistics that all regressions are highly statistically significant. The dummy variables for seasonal effects are significant in all regressions, indicating that basis risk is different for trading months placed in the first and in the second semester of the year. Since all the coefficients are negative, basis risk shows to be lower for trading months placed in the first semester of the year relative to those placed in the second semester of the year. This result is probably linked to the flow and quality of new information and its effects on cash and futures prices. During the first semester of the year, when cattle slaughtering supply increases, more information about fed cattle demand and supply conditions is available, improving the price discovery process. Thus, futures prices forecasts are more accurate and subject to less unexpected fluctuations. On the other hand, during the second semester of the year, when cattle slaughtering supply decreases, there is less available information about shifts in demand and supply conditions, which can lead to a more inaccurate price forecast, increasing basis risk.

In all regions, cash settlement dummy variables are highly significant and show negative signs, indicating that basis risk during contract maturity month has been reduced after cash settlement introduction.

According to Halvorsen and Palmquist (1980), to obtain a dummy variable effect on a semi-logarithmic equation it is necessary to calculate the antilog of the dummy variable coefficient and subtract from 1. This calculation gives the percentage change in the dependent variable attributable to the structural change. Thus, transforming coefficients of the cash settlement dummy variables, the relative changes in basis risk due to cash settlement are obtained in every region. The results are showed in table 2, according to which basis risk reductions due to cash settlement introduction are close in all concerned regions.

The regression results for females are presented in table 3. The F statistics show that all regressions are significant at 1%. All the dummy variables added to detect seasonal effects show negative signs and are statistically significant, indicating that basis risk for females is also lower for trading months placed in the first semester of the year in relation to the second. Cash settlement dummy variables also show negative signs and are statistically significant, indicating that basis risk has been reduced for females during contract maturity months, after cash settlement introduction in all regions concerned.

Table 3
Regression results for the standard deviations of the random component on dummy variables for cash settlement and seasonal effects (female)

	Regression analysis		Coefficients of the dummy variables	
Region	F-statistics	$\overline{R}^2$	S	CS
Araçatuba	92,699*	0.9198	-0.601 (-3.25)*	-1.324 (-10.13)*
Bauru/Marília	55,855*	0.8727	-0.755 (-2.91)**	-1.393 (-7.59)*
Barretos/SJRP	71,086*	0.8975	-0.545 (-2.43)***	-1.455 (-9.15)*
Presidente Prudente	32,349*	0.7967	-0.783 (-2.45)***	-1.269 (-5.61)*
Três Lagoas	53,656*	0.8681	-0.799 (-3.97)*	-0.934 (-6.57)*
Triângulo Mineiro	92,909*	0.9199	-0.701 (-3.52)*	-1.402 (-9.96)*
Campo Grande	73,589*	0.9007	-0.483 (-2.25)***	-1.437 (-9.45)*
Goiânia	78,019*	0.9059	-0.457 (-2.20)*	-1.439 (-9.81)*
Norte do Paraná	114,569*	0.9342	-0.469 (-2.93)**	-1.323 (-11.71)*

Notes: t test values are between parenthesis, beside dummy variables coefficients. S is the dummy variable for seasonal effects and CS is the dummy variable for cash settlement.
*significant at 1% level.
**significant at 2% level.
***significant at 5% level.

The relative changes on cross-hedging basis risk[8] are calculated according to Halvorsen and Palmquist (1980) and are presented in table 4. Basis risk reduction due to cash settlement was expected to be greater for males than for females, since the BM&F fed cattle futures contract is designed for male

[8] *Cross-hedging in the present paper refers to hedging female cash and male futures.*

animals. However, comparing tables 2 and 4, this does not occur in Campo Grande, Goiânia and Norte do Paraná. It could be argued that these results are possibly linked to regional cash market conditions, since each of those three regions belongs to different states. Further researches should be conducted to explain this point.

Table 4
Relative changes on cross-hedging risk during the contract maturity month due to cash settlement

Region	% changes on cross-hedging risk
Araçatuba	-73.39
Bauru/Marília	-75.17
Barretos/SJRP	-76.66
Presidente Prudente	-71.89
Três Lagoas	-60.70
Triângulo Mineiro	-75.39
Campo Grande	-76.24
Goiânia	-76.28
Norte do Paraná	-73.37

Source: Table 3.

6. Conclusions

The results obtained in this paper allow us to conclude that the introduction of cash settlement for the BM&F fed cattle futures contract has reduced hedging risk as well as cross-hedging risk in all nine regions. The percentage reduction in hedging risk due to cash settlement introduction ranged from 80,0 to 69,3%, and for cross-hedging risk ranged from 76,7 to 60,7%. It suggests that hedging performance has been improved through cash settlement introduction.

The dummy variables for seasonal effects were found to be highly significant in every considered region, indicating that hedges placed in the first semester of the year show lower basis risk in relation to those placed in the second semester. Therefore, the time of placing a hedge may influence its success. Hence, market agents need to be specially careful in adopting their marketing strategies when taking a futures market position for contract maturity months placed in the second semester of the year.

It is worthwhile to make some considerations before concluding this paper. First, the results obtained through the analysis are based on a small sample because of lack of available data. However, the individual observations were examined and supported to assert that basis risk was reduced. Second, the observations used in the analysis refer to the period after the adoption of the Plano Real by the Brazilian government. This institutional change has allowed the development of the agricultural futures market in Brazil due to inflation reduction. Therefore, basis risk reduction could also be associated with structural changes in the market. However, this will be a subject for a future research.

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Appendix

Results of the Tests to Determine the Process Orders of the Basis Series During the Contract Maturity Months and Standard Deviations of the Random Component of the Basis Series

Table A-1
Araçatuba

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	1.0195	1	1.0384
Dec. 1994	5	0.9336	5	1.3543
Mar. 1995	5	0.1043	5	0.2473
May 1995	3	0.2326	2	0.3450
Aug. 1995	2	0.2320	1	0.2789
Oct. 1995	3	0.1880	1	0.1985
Dec. 1995	5	0.1398	1	0.2297
Feb. 1996	1	0.1204	1	0.1499
Apr. 1996	2	0.2378	1	0.2928
June 1996	1	0.1096	3	0.1518
Aug. 1996	1	0.2060	5	0.1651
Sept. 1996	2	0.1595	1	0.2985
Oct. 1996	1	0.2325	1	0.2187
Nov. 1996	3	0.1308	2	0.2920
Dec. 1996	1	0.1646	1	0.1781
Feb. 1997	1	0.1797	4	0.2393

Table A-2
Bauru/Marília

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	4	0.8649	1	0.8521
Dec. 1994	5	1.0458	1	1.1975
Mar. 1995	5	0.3032	5	0.5250
May 1995	1	0.2997	5	0.0931
Aug. 1995	1	0.2700	3	0.2368
Oct. 1995	2	0.2181	4	0.1948
Dec. 1995	1	0.3721	4	0.2417
Feb. 1996	3	0.0928	1	0.1906
Apr. 1996	3	0.2023	1	0.2094
June 1996	1	0.0949	3	0.1186
Aug. 1996	1	0.1217	2	0.1202
Sept. 1996	1	0.1920	1	0.2693
Oct. 1996	3	0.1945	1	0.2195
Nov. 1996	1	0.2321	4	0.2865
Dec. 1996	1	0.1507	1	0.1413
Feb. 1997	1	0.1577	4	0.1778

Table A-3
Barreto/São José do Rio Preto

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	1.0431	1	1.0280
Dec. 1994	5	1.1069	5	1.3878
Mar. 1995	5	0.3518	5	0.3008
May 1995	1	0.3824	2	0.3096
Aug. 1995	2	0.2506	1	0.2923
Oct. 1995	3	0.2695	1	0.2857
Dec. 1995	1	0.2483	3	0.1229
Feb. 1996	1	0.1189	2	0.2044
Apr. 1996	2	0.2655	4	0.2335
June 1996	5	0.0502	1	0.1208
Aug. 1996	1	0.1326	5	0.1066
Sept. 1996	1	0.1734	1	0.2347
Oct. 1996	1	0.1584	1	0.2071
Nov. 1996	1	0.1660	1	0.3625
Dec. 1996	1	0.1304	1	0.1272
Feb. 1997	5	0.1352	2	0.2100

Table A-4
Presidente Prudente

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	0.9813	1	0.9661
Dec. 1994	1	1.2114	1	1.4006
Mar. 1995	5	0.3066	5	0.3401
May 1995	5	0.1394	5	0.0766
Aug. 1995	1	0.7020	5	0.2324
Oct. 1995	1	0.2808	1	0.2283
Dec. 1995	1	0.2865	1	0.3526
Feb. 1996	1	0.1199	1	0.1494
Apr. 1996	2	0.2804	1	0.5043
June 1996	1	0.1106	2	0.1386
Aug. 1996	4	0.1345	5	0.1699
Sept. 1996	1	0.1763	1	0.1657
Oct. 1996	5	0.0948	2	0.2445
Nov. 1996	1	0.1605	1	0.2703
Dec. 1996	1	0.1510	1	0.1395
Feb. 1997	4	0.1527	1	0.2086

Table A-5
Três Lagoas

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	0.8868	1	1.0037
Dec. 1994	5	1.0449	5	0.9008
Mar. 1995	5	0.1994	1	0.4823
May 1995	1	0.2899	5	0.1459
Aug. 1995	1	0.2107	4	0.2222
Oct. 1995	1	0.2001	1	0.4577
Dec. 1995	1	0.5391	1	0.3252
Feb. 1996	1	0.1061	1	0.1347
Apr. 1996	1	0.2871	1	0.2377
June 1996	5	0.0967	5	0.2338
Aug. 1996	3	0.1355	1	0.3984
Sept. 1996	4	0.1821	1	0.2762
Oct. 1996	5	0.2102	3	0.3217
Nov. 1996	5	0.1695	3	0.4342
Dec. 1996	1	0.1658	1	0.3892
Feb. 1997	4	0.1826	1	0.3743

Table A-6
Triângulo Mineiro

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	1.0042	1	1.0846
Dec. 1994	4	1.1304	4	0.2533
Mar. 1995	4	0.1717	4	0.5039
May 1995	2	0.4148	5	0.1561
Aug. 1995	1	0.6271	1	0.2518
Oct. 1995	3	0.2255	1	0.2106
Dec. 1995	2	0.2204	1	0.3215
Feb. 1996	1	0.0964	1	0.1096
Apr. 1996	2	0.2881	2	0.2636
June 1996	5	0.0561	1	0.1427
Aug. 1996	1	0.1573	3	0.1628
Sept. 1996	3	0.1584	1	0.1843
Oct. 1996	1	0.1921	1	0.2043
Nov. 1996	5	0.1460	3	0.1963
Dec. 1996	5	0.0925	1	0.2104
Feb. 1997	1	0.1266	4	0.1691

Table A-7
Campo Grande

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	1.0751	1	1.1390
Dec. 1994	5	0.9139	5	1.3637
Mar. 1995	5	0.1154	5	0.4978
May 1995	1	0.2602	1	0.2474
Aug. 1995	2	0.2350	1	0.2938
Oct. 1995	3	0.3078	1	0.2976
Dec. 1995	1	0.4301	1	0.3240
Feb. 1996	1	0.2048	1	0.2314
Apr. 1996	2	0.2797	2	0.2185
June 1996	1	0.1050	5	0.1396
Aug. 1996	1	0.1729	5	0.0894
Sept. 1996	1	0.1959	1	0.2310
Oct. 1996	1	0.2433	1	0.2206
Nov. 1996	2	0.1554	3	0.1959
Dec. 1996	1	0.1577	1	0.1303
Feb. 1997	1	0.1789	1	0.2019

Table A-8
Goiânia

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	4	0.9453	1	1.0420
Dec. 1994	5	1.2588	5	1.0534
Mar. 1995	5	0.1368	5	0.3020
May 1995	5	0.3984	1	0.3839
Aug. 1995	1	0.2145	1	0.2906
Oct. 1995	1	0.2080	1	0.2634
Dec. 1995	1	0.3237	1	0.3034
Feb. 1996	1	0.2632	1	0.3114
Apr. 1996	2	0.2932	2	0.2235
June 1996	5	0.1244	5	0.1123
Aug. 1996	2	0.1652	4	0.1084
Sept. 1996	1	0.2714	1	0.1774
Oct. 1996	5	0.2046	5	0.2114
Nov. 1996	4	0.1811	4	0.2094
Dec. 1996	1	0.1591	1	0.1467
Feb. 1997	1	0.1653	1	0.2255

Table A-9
Norte do Paraná

Contract maturity month to which refers basis series	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression	Autoregressive process order of the basis series	Standard deviation of the random component of the basis series autoregression
Oct. 1994	1	0.9670	1	0.9611
Dec. 1994	5	1.0543	5	0.7655
Mar. 1995	4	0.3564	3	0.4828
May 1995	4	0.3971	1	0.4718
Aug. 1995	4	0.5020	4	0.5825
Oct. 1995	2	0.1940	1	0.2493
Dec. 1995	1	0.3243	4	0.2559
Feb. 1996	3	0.1296	1	0.2579
Apr. 1996	2	0.2970	5	0.2095
June 1996	3	0.1195	1	0.1220
Aug. 1996	1	0.3063	1	0.2307
Sept. 1996	3	0.2232	1	0.1715
Oct. 1996	1	0.2840	3	0.2723
Nov. 1996	2	0.2750	5	0.2123
Dec. 1996	1	0.2580	2	0.1730
Feb. 1997	1	0.2285	1	0.2014