

**UTILIZAÇÃO DE CONTRATOS FUTUROS DE COMMODITIES COMO FORMA DE O-
TIMIZAR CARTEIRAS DE INVESTIMENTOS DO MERCADO BRASILEIRO¹**

**USE OF COMMODITY FUTURES CONTRACTS AS A WAY TO OPTIMIZE INVESTMENT
PORTFOLIOS OF THE BRAZILIAN MARKET**

Marília Cordeiro Pinheiro

Mestra em Mercado Financeiro pela Universidade de Brasília (UnB)
Instituição em que trabalha
marilia.cordeiro90@hotmail.com

André Ricardo Moncaico Zanon

Mestre em Contabilidade e Mercado Financeiro pela Universidade de Brasília (UnB)
Banco Central do Brasil
zanonandre@gmail.com

José Alves Dantas

Doutor em Ciências Contábeis pela Universidade de Brasília (UnB)
Universidade de Brasília
josealvesdantas@unb.br

Bruno Vinícius Ramos Fernandes

Doutor em Ciências Contábeis pelo Programa Multi-institucional e Inter-regional de Pós-
graduação em Ciências Contábeis - UnB/UFPB/UFRN
Universidade de Brasília
bv.ramos@gmail.com

Resumo

Objetivo: Avaliar a eficácia da utilização de contratos futuros de *commodities* como mecanismo de otimização das carteiras de investimentos.

Fundamento: O estudo apoia-se na teoria de diversificação do portfólio, com a premissa de que os investidores são avessos ao risco e com isso elaboram carteiras tangentes à fronteira de eficiência, com maior retorno esperado para determinado nível de risco.

Método: Foram compostas carteiras com contratos futuros de *commodities* e elaboradas cinco estratégias de investimentos com e sem esses contratos, utilizando os retornos esperados e a matriz de covariância para calcular os pesos dos ativos nas carteiras. A análise contempla o

¹Artigo recebido em: 03/11/2018. Revisado por pares em: 18/03/2019. Reformulado em: 16/05/2019. Recomendado para publicação: 16/05/2019 por Anna Paola Fernandes Freire (Editora Adjunto). Publicado em: 02/09/2019. Organização responsável pelo periódico: UFPB

período de 2011-2016 e os subperíodos de 2011-2013 e 2014-2016, caracterizados, respectivamente, por expansão e contração econômica.

Resultados: Os testes empíricos revelaram que (i) os portfólios com contratos futuros oferecem potencial de diversificação para carteiras compostas majoritariamente pelo mercado de ações (ii) apenas carteiras com contratos vendidos de café tocaram a zona de eficiência, de forma que os contratos de boi e milho não mostraram evidências de contribuição para otimização. (iii) carteiras compostas majoritariamente pelo IFIX, IAM-B, dólar e CDI foram as composições mais eficientes devido a particularidades do mercado de capital brasileiro, como alta taxa de juros, ambiente inflacionário e depreciação cambial durante o período.

Contribuições: Os resultados do estudo (i) fornecem perspectiva sobre o uso dos contratos futuros de *commodities* para reduzir ou não os riscos de portfólios de investimentos; (ii) destacam que esses resultados podem ser distintos em momentos de expansão ou retração econômica; (iii) corroboram estudos anteriores sobre o uso de contratos futuros de *commodities* para otimização de carteiras de ações, porém se diferenciando quando levada essa análise para ativos imobiliários e títulos de renda fixa.

Palavras chave: Teoria do portfólio; Contratos futuros de *commodities*; Risco; Retorno.

ABSTRACT

Objective: This paper aims to evaluate the effectiveness of the use of commodity future contracts as a mechanism for optimizing investment portfolios.

Rationale: The study is based on portfolio theory with the premise that investors are risk averse and draw portfolios tangents to the efficiency frontier with the highest expected return for a certain level of risk.

Method: It we composed five portfolios strategies with and without three commodity future contracts, using the expected returns and the covariance matrix to calculate the asset weights in the portfolios. The analysis contemplates the period 2011-2016 and the sub periods of 2011-2013 and 2014-2016, characterized, respectively, by expansion and economic contraction.

Results: The empirical tests revealed that (i) portfolios with future contracts offer diversification potential for strategies with higher percentage of the stock market (ii) only portfolios with coffee sales contracts touched the efficiency zone, so that ox and corn contracts showed no evidence of contribution to optimization. (iii) Portfolios composed mainly of the IFIX, IAM-B, dollar and CDI were the most efficient compositions due to particularities of the Brazilian capital market, such as high interest rate, inflationary environment and exchange depreciation during the period.

Contributions: The results of the study (i) provide insight into the use of commodity future contracts to reduce investment portfolio risks, (ii) point out that these results may be distinct in times of economic expansion or contraction (iii) corroborates previous studies on the use of commodity future contracts to optimize stock portfolios, but differentiates when applied to real estate assets and fixed income securities. .

Keywords: Portfolio theory; Commodity future contracts; Risk; Return.

1 INTRODUCTION

Markowitz's portfolio theory is considered one of the pillars of modern finance. Its premise is that investors are risk-averse and, because of this, set up efficient "medium-variance" investment portfolios, namely portfolios that minimize risk for a given expected level of return while simultaneously maximizing the expected return for a given level of risk (Fama & French, 2004). This theory is based on the practice of portfolio diversification, introducing statistical concepts of covariance or correlation. According to Markowitz (1952), it is prudent for investors to avoid investing their resources in assets that have a high degree of covariance between them, and it is appropriate to set up portfolios with securities of companies belonging to different sectors of activity.

After the development of the capital market, innumerable innovations emerged to apply the concept of diversification focusing on the allocation of different asset classes for the composition of the optimal portfolio: government bonds, small-caps stocks, long-caps stocks, foreign securities, etc. (Fabozzi, Gupta, & Markowitz, 2002). Among these instruments exploited as a way of diversification, aiming at reducing the variance of portfolios, are commodity future contracts. According to Scherer, He, Fabozzi, Füss and Kaiser (2008), commodity future indices tend to be negatively self-correlated with stocks and bonds, and their use is a way of enhancing portfolio gains, which has led to increased investor interest in understanding the statistical and economic fundamentals of these instruments.

Internationally, articles have been and still are written on the use of future commodity indices for risk diversification. As an example, in the study by Conover *et al.* (2009) conducted an investigation into the efficiency of commodity future in portfolio diversification, considering the US capital markets. Belousova and Dorfleiner (2012) also conducted a research with the same objective, but for the context of the European market. Both articles found benefits in using commodity future as a way to diversify portfolios. In Brazil, Silveira and Barros (2010) prepared a study with the same theme, considering the period 1994-2007. Unlike the exemplified foreign articles, the results obtained from the inclusion of commodity future contracts in investment portfolios were not considered significant. However, it should be noted that after 2007, both the Brazilian capital market and the economy underwent a series of transformations, including the use of derivatives, which could modify the results of a new analysis.

In this context, the present study aims to evaluate the effectiveness of using commodity future contracts as a mechanism for optimizing investment portfolios. It seeks to deepen the empirical findings of other research - such as Silveira & Barros (2010), for example - on the use of commodity contracts as a financial instrument for portfolio diversification in the Brazilian market.

Considering the importance of commodities in the Brazilian economy and the current process of using commodity derivative financial instruments, it is relevant to ascertain their impact on reducing the risk of investment portfolios. To verify whether the inclusion of commodity future contracts reduces the risk of an investment portfolio, econometric and statistical tools were used to construct the minimum variance boundary and to test the significance of reducing the standard deviation, as a risk measure, arising from the use of commodity future contracts in investment portfolios.

The study contributes to the development of the literature on investment portfolio analysis using commodity future contracts, especially considering the lack of studies with this focus, especially in Brazil - notwithstanding the relevance of these assets in the Brazilian

economy. In addition to testing the relevance of these contracts as a portfolio risk management tool, by separating the sample period into subperiods representative of periods of economic expansion and retraction, it offers evidence that its usefulness may differ according to the behavior of the level of economic activity.

The article is divided into six sections, besides the introduction: section 2 presents the theoretical framework, which deals with the role of commodity future contracts for risk reduction and investment diversification, as well as other studies on the subject. Section 3 presents the development of research hypotheses and their theoretical background. Section 4 contains the methodological procedures to meet the specified objectives. Section 5 presents the results analysis, which analyzed the contribution of commodity future contracts to investment portfolios. Finally, section 6 presents the final considerations on this study.

2 THEORETICAL BACKGROUND

2.1 Risk Management and Derivative Instruments

Risk management has become one of the central studies of finance, in particular due to the development of new instruments that allow the mitigation of possible asset value losses or increases in the value of liabilities. Part of the risk management studies focuses on the use of derivatives used to hedge against exposure to risks arising from fluctuations in interest rates, exchange rates, commodity prices and stock prices (Smith Jr, 2008).

The derivative can be broadly defined as a private contract that has its price derived from an asset, index or underlying rate. The sum of gains and losses arising from this contract must be zero; For each gain obtained by one party, the other party suffers a loss of equal magnitude (Jorion, 2007). Derivatives are initially used for the purpose of hedging, which consists of a transaction to reduce or eliminate exposure to risk, protecting assets from unfavorable movements that cause their value to fall. This protection is possible because acquired derivatives have their value in the opposite direction to the instrument being hedged (Collier, 2009).

The hedge can be divided into two strands. The first is the static hedge, represented by future and forward contracts, in which the position of the derivative instrument is usually held to the horizon of the underlying asset. This type of hedge is ideal if the price of the derivative is linearly related to the price of the underlying asset. The second aspect is dynamic hedging, represented by stock options, where balances are made over the time horizon (Jorion, 2003).

However, in addition to the protection of losses, derivatives are also viewed from the perspective of potential earnings opportunity, being used for the purpose of speculation, where their intention is to obtain abnormal returns, assuming high risks (Geczy, Minton, & Schrand, 2007). Speculation occurs when the investor uses the derivative as a bet on fluctuations in economic variables, an operation that can lead to substantial losses due to the difficulty of predicting market movements (Ross, Westerfield, & Jaffe, 2009).

Thus, the answer to the question of whether institutions use derivatives for speculation or hedging is not yet certain. These instruments can lead to substantial losses beyond the risk tolerance of their business, and companies are still afraid to admit to speculative character (Smith Jr, 2008).

2.2 Investment Portfolio Hedge

The asset diversification is a more traditional form of hedge of an investment portfolio. In seeking a portfolio with a combination of assets that have a negative covariance, aiming to reduce portfolio variation (Ross, Westerfield & Jaffe, 2009). The modern idea of the portfolio is to invest in diversifying its portfolio to eliminate idiosyncratic risk, which is asset-specific risk. As a result, a portfolio is only a systemic risk, which corresponds to market risk that cannot be diversifiable, as it is inherent in all stocks being traded (Fu, 2009).

The development of the financial market allowed the creation of new instruments, such as derivatives, which were then explored in portfolio diversification. Derivatives, especially options and future contracts, are assets that play an important role in structuring equity portfolios because they provide advantages over the cost-effectiveness of diversification (Reilly & Brown, 2011).

To illustrate this advantage, Reilly and Brown (2011) present, as an example, a portfolio of stocks that make up the S&P 500 index. If there is a forecast of changes in the macroeconomic scenario, even though the portfolio is well diversified, it is subject to systematic risk from inflationary indices, for example, and the price of all stocks may fall. To protect yourself from these swings, the manager may use an S&P 500 index future contract, assuming a hedge position, as this derivative is negatively correlated with existing exposure.

The purpose of using future contracts within a stock portfolio depends on the investor's risk appetite. For investors with a higher degree of risk aversion, future contracts are introduced only for minimum variance, integrating the same time horizon as the hedged asset, plus a perfectly negative correlation. However, when considering the concept of mean variance, the speculative element is introduced, so that investors are not only concerned with risk hedging, but also with the return that can be provided by the future contract in the portfolio. In this case, the future contract is acquired to leverage expected returns and increase the risk premium of the portfolio (Alexander, 2008).

The use of the future contract in investment portfolios increased significantly from 2002 onwards, in particular due to the volatility of commodity prices, bringing future markets closer to financial markets, a transformation called derivative financialization (Domanski & Heath, 2007). This process was particularly reflected in the commodity future category, which had substantial growth in investment strategies (Belousova & Dorfleitner, 2012).

Daslaki and Skiadopoulou (2011) argue that the use of commodity future in portfolios increases the risk premium, as it makes it possible to reduce portfolio variance without sacrificing return for whatever risk tolerance coefficient. In addition, the authors add that the factors that make up commodity prices (weather, harvest, storage, extraction, technology) are distinguished from the factors that make up stock prices, causing these assets to be negatively correlated.

You and Daigler (2013) characterize commodity future contracts as highly liquid assets with low transaction costs and capable of providing abnormal returns. However, the authors warn that the scope of research on the subject is still limited, because most of them use commodity indices, which does not allow for the analysis of the isolated benefit of contracts, or use only the effect of one category of contract within an asset portfolio, which restricts conclusions about diversification.

The commodity future studies focus on their use for the purpose of hedging investment portfolios, and there is a gap in research on their use for speculation purposes, which can lead to large losses for investors (Adam, Fuss & Kaiser, 2008). Thus, the risks of these investment strategy instruments cannot be underestimated.

2.3 Commodity Future Contracts Risk

Commodities consist of heterogeneous asset classes, so that each species has its price driven by a variety of specific factors (Adam, Fuss, & Kaiser, 2008). When considering your future contracts, valuation is basically composed of macroeconomic factors that interfere with your supply and demand and expectations of your future prices and premium risk in your trades (Markert & Zimmermann, 2008).

According to Szymanowska, Roon, Nijman and Goorbergh (2014), the risk premium for commodity future contracts is derived from the base risk, which corresponds to the difference between the spot price of the underlying asset and its future price. This risk is unavoidable for commodity future contracts due to two factors: the first concerns uncertainty about production / transportation costs, plus the commodity owner's return on convenience that impacts base fair value; The second is uncertainty about fluctuations in future contracts market prices, as current commodity prices may vary significantly above future prices (Alexander, 2008).

The base risk increases with the use of future contracts for speculation, since when used for this purpose, the characteristics of future contracts differ from those of the underlying assets, so that this type of transaction tends to be noise in commodity future prices, acting on trading volume and price (Jorion, 2003).

Cao, Jayasuriya and Shambora (2010) analyzed the risks to which commodities are subjected from a long-term perspective, concluding that the success of investing in commodity future depends mainly on the commodity price increase and the replication of this movement in the future market, or a continuous increase in future prices, regardless of the underlying commodity. The oscillation of these prices is difficult to predict because it depends on a set of factors that directly interfere with the supply and demand of these assets: political and economic variables, climate issues, storage cost, among others

2.4 Commodity Future Market Studies in Brazil

In the Brazilian academic literature, although there is its own stock exchange for future trading since 1985, there is still little research exploring the dimension of commodity future contracts in the context of finance. Among the few articles produced on the theme, can be cited Silveira and Barros (2010), Da Costa and Piacenti (2008) and Bressan and Lima (2009), each addressing different aspects regarding commodity future contracts. Table 1 presents a description of the themes, aims and results found of these articles:

Table 1: Brazilian articles on commodities in the financial context

Title	Authors	Aims	Results
Analysis of the allocation of commodity future contracts in diversified portfolios	Silveira e Barros (2010).	To analyze the impact of the use of agricultural commodity future contracts on the risk and return of a diversified portfolio from 1994-2007.	No statistically significant evidence was found on the risk-return ratio of portfolios with commodity future contracts.
Use of agricultural future contract in the mean investment profile of pension funds in Brazil	Da Costa e Paincenti (2008)	To verify the feasibility of using commodity futures contracts in Brazilian pension fund portfolios, within permitted limits, using the VaR model.	The use of contracts in the portfolios was beneficial, reducing the risk more than proportionally to the return.
Price forecasting models applied to live cattle future contracts at BM&F	Bressan & Lima (2009)	To apply time series forecasting models as decision-making tools for buying and selling of live cattle futures contracts at BM&F at close to maturity dates.	The results demonstrated the potential of using dynamic linear models and ARIMA as decision making tools;

Source: Prepared by the authors.

3 DEVELOPMENT OF RESEARCH HYPOTHESES

The general objective of this paper is to evaluate the effectiveness of using commodity futures contracts traded on B3 as a mechanism for optimizing investment portfolios, in other words reducing their risk (standard deviation) to a certain level of return.

The research hypotheses were based on Markowitz's portfolio diversification theory. Considering that commodity futures contracts have a low correlation with traditional financial assets due to the distinct factors of their price formation (Daskalaki & Skiadopoulou, 2011; Belousova & Dorfleitner, 2012), it is expected that the contracts will be able to generate benefits from diversification and reduce the deviations of investment portfolios. However, commodity markets are characterized by their dynamics, with sudden fluctuations in prices and trading volumes, which may have the opposite effect of expectations.

Jensen et. al. (2000, 2002) point out that the benefit of diversifying commodity futures contracts only occurs during periods of economic cycle constraint. This factor occurs mainly due to the relationship between the inflation index and the price of commodities, which makes their futures contracts a form of protection against periods of high inflation. Thus, although Silveira and Barros (2010) have not found significant results from the use of futures contracts in the Brazilian market, it should be considered that the economic period of the analysis - 1994 to 2007 - differs from the current one, which may cause changes in the results found for the hypotheses.

Considering this context, and following Silveira and Barros (2010), four research hypotheses were formulated for the empirical tests, considering two distinct investment strategies for the contracts.

Initially, two hypotheses were formulated, considering the short-term strategy, defined as the use of first maturity commodity futures contracts in the portfolios, that is, with the closest maturity on the stock market. Each assumption is built for different investment positions:

H1: Commodity futures contracts in the short-term strategy, buying position, reduce the volatility of diversified investment portfolios.

H2: Commodity futures contracts in the short-term strategy, selling position, reduce the volatility of diversified investment portfolios.

Then two further hypotheses were elaborated, but considering the long-term strategy, which consists of the use of six-month futures contracts on the stock exchange:

H3: H3: Commodity futures contracts in the long term strategy, buying position, reduce the volatility of diversified investment portfolios.

H4: Commodity futures contracts in the long term strategy, selling position, reduce the volatility of diversified investment portfolios.

4 METHODOLOGY

4.1 Sample

For the composition of diversified investment portfolios, daily quotations of different asset classes were collected from January 04, 2011 to November 30, 2016. The categories not belonging to the derivative class were selected precisely on the basis of the diversification criterion, since they belong to different financial market niches. Table 2 presents the assets belonging to the sample:

Table 2: Sample and source of survey data

Asset	Description	Source
IMA-B	Index used as benchmark for B series securities, interest indexed + IPCA	Economática
Interbank Certificate of Deposit (CDI)	Short-term securities issued by financial institutions. It can be used as a proxy for a risk free asset.	Economática
Dollar	Exchange variation between the dollar and the real.	Economática
Ibovespa (IBOV)	Index used to represent a theoretical portfolio formed by the most traded stocks in the market.	Economática
Real Estate Exchange-Traded Fund	Average performance indicator of quotations of real estate funds traded in the stock market and counter operations.	Economática
Future purchase contracts and selling commodities	Live cattle (BGI), corn (CCM), arabica coffee (ICF), soybean (SJC), sugar (ACF), ethanol (ETF), gold (OZ1), oil (WTI) futures contracts traded on the stock market.	Reuters

Source: Prepared by the authors.

Only futures with daily liquidity on the stock exchange were used. Thus, it was found that only live cattle, arabica coffee and corn contracts meet the established criteria. One observation to be made is that in the period analyzed by Silveira and Barros (2010), 1994-2007, the only futures contracts with daily liquidity were live cattle and arabica coffee. It should be noted that during the period of this article, the corn contract started to have daily negotiations, being an increment in the sample. Thus, the present study advances in relation to

Silveira and Barros (2010), not only in relation to the time horizon, focusing on a period characterized by the economic contraction, but also expanding the assets considered in the study.

For data grouping and portfolio assembly, the average return and standard deviation were first calculated. The Ibovespa was chosen as the stock proxy because it is the most liquid and representative theoretical portfolio in the Brazilian stock market. Thus, based on these considerations, five portfolios were built:

- a) Portfolio composed by the combination of IBOV, IFIX, IMA-B dollar and CDI.
- b) Portfolio composed by the combination of IBOV, IFIX, IMA-B, US dollar, CDI and futures contracts of live cattle, arabica coffee and corn, purchase position and short term.
- c) Portfolio composed of the combination of IBOV, IFIX, IMA-B, US dollar, CDI and futures contracts for beef, arabica coffee and corn, buying position and long term.
- d) Portfolio composed by the combination of IBOV, IFIX, IMA-B, US dollar, CDI and live cattle, arabica coffee and corn futures contracts, selling position and short term.
- e) Portfolio composed by the combination of IBOV, IFIX, IMA-B, US dollar, CDI and live cattle, arabica coffee and corn futures contracts, selling position and long term.

Short-term strategies are composed of daily liquidity contracts with close maturity, while long-term strategies are composed of daily liquidity contracts with maturity over six months. The Ibovespa is the main performance indicator of the stocks of the most important companies in the Brazilian market. The IFIX corresponds to the asset used as a proxy for the real estate market, being an indicator of the average performance of real estate fund prices listed in B3. The IMA-B is a fixed income index of the AMBIMA family with profitability linked to the IPCA, in other words, return compensation for inflation. The Interbank Deposit Certificates (CDI) are securities of financial institutions with yield linked to the DI rate, which in turn follows the variation of the SELIC rate. The dollar used corresponds to the variation of the US currency against the Brazilian currency, being a proxy for a foreign exchange investment.

4.2 Initial Data Processing and Descriptive Statistics

First, the descriptive statistics of the data are calculated, and the average return (monthly), standard deviation (monthly) and Sharpe Index are calculated. The purpose of this procedure is to compare the risk-return properties and the different asset classes of the sample.

The monthly return was obtained by the following formula:

$$R_m = \frac{P_{it}}{P_{it-1}} - 1 \quad (1)$$

Where:

R_m : Average return

P_{it} : Closing price on last day of month

P_{it-1} : Asset opening price first day of the month

It should be noted that for the futures contracts of selling position, the inverse calculation of the other assets was used, given by:

$$R_m = \frac{P_{it-1}}{P_{it}} - 1 \quad (2)$$

To calculate the standard deviation, the formula used was:

$$s_i = \sqrt{\frac{\sum (R_i - R_{mi})^2}{n - 1}} \quad (3)$$

Where:

R_i : Return on asset

R_m : Average return on asset series

n : Number of observations on returns (equivalent to number of days)

The Sharpe Index, following Varga (2001), was obtained by:

$$IS = \frac{R_i - R_f}{s_i} \quad (4)$$

Where R_f is the return on the risk-free asset corresponding to the CDI.

To verify the potential for diversification, the correlation matrix between the variables was also calculated. The correlation is given by:

$$r = \frac{\sum_{i=1}^n (R_i - R_{mi})(R_j - R_{mj})}{\sqrt{\sum_{i=1}^n (R_i - R_{mi})^2} \sqrt{\sum_{j=1}^n (R_j - R_{jm})^2}} \quad (5)$$

4.3 Method of Building Effective Portfolios

Initially the daily returns of the assets were calculated using the logarithmic form that assumes that the returns follow a continuous and symmetrical distribution, close to normal (Soares, Rostagno & Soares, 2002):

$$R_{it} = \ln\left(\frac{R_i}{R_{i-1}}\right) \quad (6)$$

For short position futures contracts, daily returns were calculated inversely:

$$R_{it} = \ln\left(\frac{R_{i-1}}{R_i}\right) \quad (7)$$

After calculating the returns, efficient portfolios are prepared for each strategy described in the sample topic, following the methodological optimization procedure presented by DeFusco et. al. (2001). The assembly of efficient portfolios should take into consideration the expected return variables of the assets and the variance of these returns, forming the minimum variance boundary.

The expected return on a portfolio of n assets is given by the equation:

$$E(R_p) = \sum_{j=1}^n w_j E(R_j) \quad (8)$$

Where:

w_i : Weight of asset i within portfolio.

Therefore:

$$\sum_{j=1}^n w_j = 1 \quad (9)$$

The beginning of the portfolio's range of returns is represented by the asset with the lowest expected average return, while the maximum return corresponds to the highest average asset.

The variance of a portfolio consisting of n assets is given by (Ross, Westerfield, & Jaffe, 2009):

$$\sigma^2 = \sum_{i=1}^n \sum_{j=1}^n w_i w_j Cov(R_i, R_j) \quad (10)$$

To determine the minimum variance boundary for a set of n assets, the minimum and maximum expected returns must be determined. Hereinafter, the weights of the assets that will make up the portfolio of minimum variance, which mathematically means:

Minimize:

$$\sigma^2 = \sum_{i=1}^n \sum_{j=1}^n w_i w_j Cov(R_i, R_j) \quad (11)$$

Subject to:

$$E(R_p) = \sum_{j=1}^n w_j E(R_j) = r_{min} < z < r_{max} \quad (12)$$

In order to compare and test the significance of the returns obtained between the portfolios, the portfolio efficiency test proposed by Gibbons, Ross and Shanken (1989) is used. The test uses the Sharpe Index - an indicator widely used in portfolio optimization measurement because it is the ratio between a portfolio's premium and volatility - to measure the efficiency difference between two portfolios. The portfolio with the highest Sharpe Index is the one that touches the efficient frontier of investments. The relationship between the indices is tested as follows:

$$W = \left[\frac{\sqrt{1+IS_i^2}}{\sqrt{1+IS_j^2}} \right]^2 - 1 \quad (13)$$

Where:

IS_i^2 : Portfolio Sharpe Index without contracts

IS_j^2 : Portfolio Sharpe Index with contracts

Then, in order to apply the statistical test F , the following procedure is performed:

$$F = \frac{T(T-n-1)}{n(T-2)} W \quad (14)$$

Where:

T : Observation number

n : n number of portfolios

Thus, the following hypothesis test is performed:

$H_0 = W$ is equal to 0;

$H_1 = W$ is different, greater than 0.

If H_0 is rejected, it can be deduced that the inclusion of futures contracts improves portfolio efficiency.

5 RESULTS ANALYSIS

5.1 Descriptive Statistics

Table 3 presents the results obtained from the descriptive statistics calculations:

Table 3: Descriptive Statistics of assets between 2011 and 2016

	Average return % a.a	Volatility	Sharpe Index	Asymmetry
DI	11,01%	0,00%	-	0,38
IMA-B	12,88%	2,75%	0,68	0,035
Dólar	10,95%	14,28%	-0,01	-0,13
IBOV	-5,22%	23,74%	-0,68	0,12
IFIX	11,56%	6,86%	0,08	-1,25
Milho-short	1,18%	27,5%	-0,33	0,61
Boi-short	6,79%	9,6%	-0,49	1,31
Café-short	-16,31%	33,1%	-0,84	1,14
Milho-long	4,10%	25,25%	-0,27	-1,24
Boi-long	5,27%	25,50%	-0,22	0,08
Café-long	-13,87%	32,10%	-0,77	0,41

Source: elaborated by the authors

It is important to note that the futures contracts in Table 3 correspond to buying position, where the position of sale presents return and asymmetry with inverse signals and even standard deviation. The IMA-B and the IFIX were the only assets with higher returns than DI, resulting in a positive Sharpe Index.

This result may have been generated by the high interest rate for the period, as well as rising inflation. When considering commodity futures contracts, the best performers were coffee in the selling position, but although they had the highest returns, they also had the highest volatility, which generated a Sharpe Index lower than the IMA-B. From the data in Table 3, it is also noticed that commodities presented the lowest returns when considering the buying position: Coffee contracts followed by cattle contracts, in addition to presenting the lowest returns, also presented high volatilities when compared to other assets. Of assets not belonging to the class of futures contracts, the IBOV presented the lowest return and also the highest volatility, indicating the worst performance for this group.

The Table 4 presents the correlation matrix of the sample assets:

Table 4: Correlation Matrix between 2013 and 2016

	IBOV	IFIX	DOLAR	IMA-B	DI	BGI-SHORT	CCM-SHORT	ICF-SHORT	BGI-LONG	CCM-LONG	ICF-LONG
IBOV	1,00										
IFIX	0,01	1,00									
DOLAR	-0,05	-0,10*	1,00								
IMA-B	0,05	0,09*	0,02	1,00							
DI	0,01	0,06*	0,00	0,06*	1,00						
BGI-curto prazo	-0,01	0,00	0,00	-0,01	-0,02	1,00					
CCM-curto prazo	-0,01	-0,04	0,02	-0,05	0,01	0,02	1,00				
ICF-curto prazo	0,02	0,03	0,00	0,09*	0,02	0,06*	0,02	1,00			
BGI-longo prazo	-0,06*	0,08*	0,02	-0,05*	0,01	0,22*	-0,03	0,00	1,00		
CCM-longo prazo	-0,01	-0,02	0,02	-0,07*	0,01	0,02	0,06*	0,02	-0,01	1,00	
ICF-longo prazo	-0,01	0,03	0,00	0,09*	0,02	0,06*	0,01	0,81*	-0,05	0,01	1,00

Notes: * significant coefficients at 5%

Source: elaborated by the authors.

Again, it is noteworthy that the contracts in Table 4 correspond to the buying position, so that the selling position has a coefficient with an inverse sign. Considering Pearson's correlation coefficient and its significance, it is observed that the coefficients with positive sign between futures contracts and other asset classes were less than 0.5; which indicates a weak degree of correlation. The IBOV presented a negative correlation coefficient with all futures contracts, except for short term coffee. This factor is in line with previous studies showing that commodities have diversification potential relative to the stock market. When considering the 95% confidence level, only BGI in the long-term strategy presented a significant negative coefficient in relation to IBOV. For IFIX, the asset with the lowest correlation coefficient was the dollar, while for commodities, the long-term BGI showed a significant but low grade positive coefficient. Corn, for both strategies, returned negative coefficients in relation to the real estate index. For the dollar, all commodities had positive values close to zero, but none being statistically significant. The IMA-B presented an inverse relationship with the cattle and corn futures contracts, and for both, in the long term strategy, the coefficients were significant. However, in relation to coffee, the coefficients were positive and significant, which may be an indication that this type of asset in buying position is exposed to inflation fluctuations, since the IMA-B portfolio has inflationary indices as indexers. Finally, the CDI presented a negative coefficient only with the short-term cattle contract, while positive coefficients near zero with the other contracts.

5.2 Portfolio Diversification

Initially, portfolios were prepared considering the total sample period, 2011 to 2016, totaling 107 portfolios, with the following strategies:

- Portfolio without contract: IBOV, IFIX, IMA-B and dollar and CDI.
- Portfolio with short-term buying position contracts: IBOV, IMA-B, IFIX, US Dollar, CDI, Live Cattle (BGI), Corn (CCM) and Arabica Coffee (ICF).

- c) Portfolio with short-term selling position contracts: IBOV, IMA-B, IFIX, US dollar, CDI live cattle (BGI), corn (CCM) and arabica coffee (ICF).
- d) Portfolio with long-term buying position contracts: IBOV, IMA-B, IFIX, US dollar, CDI live cattle (BGI), corn (CCM) and arabica coffee (ICF).
- e) Portfolio with long selling position contracts: IBOV, IMA-B, IFIX, US Dollar, CDI, Live Cattle (BGI), Corn (CCM) and Arabica Coffee (ICF).

The minimum return point was 1.83% a.a., with a portfolio composed only of IBOV, while the maximum point was 13.87% a.a. with a portfolio composed only of the coffee futures contract sold. Overall, all futures strategies showed lower variance between return points from 2% to 10% per year. However, when considering the risk-return portfolio optimization zone, the efficient strategies were in the range of 10% to 13% of return, consisting mainly of IMA-B, CDI and dollar, with a percentage of less than 1% contract for short-term coffee sold.

Commodity prices should be considered to have started to fall gradually in 2014, creating high volatility in their prices, impacting futures contracts. When Table 3 is analyzed, it can be seen that while short futures futures contracts were the most returnable assets, they were also the most volatile, as they contributed to portfolio efficiencies, but with reduced participation.

Thus, only the strategy with short term futures contracts was efficient, whereas strategies composed exclusively by IFIX, dollar, IMA-B and CDI offered lower risk for the same return point as the other three futures contract strategies. The share of coffee sold ranged from 0.17% at the 11% return point to 0.43% at the 12.2% return point. Although the cattle and corn contracts did not have participation in the efficiency zone, the strategies with these contracts had a smaller variance than the non-contracted portfolio up to the 10% return point, especially since the latter is mainly composed of Ibov, which had low return and high volatility for the period. When comparing only strategies with futures contracts, portfolios with short-term futures purchased were the least efficient, followed by the long term.

The Gibbons significance test was then performed, based on the statistical difference of the Sharpe index between portfolios with and without commodity futures contracts. For long-term selling position contracts, the results were significant from 9% to 13%, while short term from 8% to 11.00%, with hypotheses 2 and 4 confirmed for these return zones. Long-term buying position contracts had a significant return from 0% to 7.5% and short-term buying positions from 0% to 5%, confirming hypotheses 1 and 3.

Overall, the results corroborate those of Jensen *et. al* (2000) and Gorton & Rouwenhorst (2006) for indicating potential diversification with the stock market, as the use of commodity futures contracts reduced the risk of Ibov's high percentage portfolios.

It should be noted, however, that according to Cheung & Mil (2010), portfolio optimization theory is not restricted to the negative correlation between assets, but also to the concept of efficiency based on the risk-return relationship. This consideration is crucial since, although Pearson's coefficient showed low correlation between futures contracts and IFIX, IMA-B, dollar and CDI, only coffee in the selling position indicated an improvement in portfolio optimization, so that The other futures strategies presented greater risk for returns equal to or less than strategies composed mostly of these four assets.

5.3 Sensitivity Analysis: Portfolio Diversification by Economic Cycle

As a way to analyze the investment of commodity futures contracts in different eco-

economic cycles, an additional analysis was made, separating the sample into two equal subperiods: 2011-2013 and 2014-2016, characterized, respectively, by economic expansion and contraction (FGV, 2017). The idea is to promote a sensitivity analysis, exploring whether the results obtained in the complete sample period behave differently by restricting themselves to periods characterized by economic expansion or retraction, considering that commodities are assets that have their price linked to economic conditions. For the segregation of these periods, we considered as reference the variation of Gross Domestic Product (GDP): the years that registered GDP growth (2011-2013) characterized the period of economic expansion; while the years with negative variation in the level of economic activity (2014-2016), the period of economic downturn.

For the first period, after data processing, 114 portfolios were prepared, with the following compositions:

- a) Portfolio without contract: IBOV, IFIX, IMA-B and dollar and CDI.
- b) Portfolio with short-term buying position contracts: IBOV, IMA-B, IFIX, dollar, CDI and live cattle (BGI), corn (CCM) and arabica coffee (ICF).
- c) Portfolio with short-term selling position contracts: IBOV, IMA-B, IFIX, dollar, CDI and Arabica Coffee (ICF).
- d) Portfolio with long-term buying position contracts: IBOV, IMA-B, IFIX, dollar, CDI and live cattle (BGI), corn (CCM) and arabica coffee (ICF).
- e) Portfolio with long term selling position contracts: IBOV, IMA-B, IFIX, dollar, CDI live cattle (BGI), corn (CCM) and arabica coffee (ICF).

For the 2011-2013 period, short-term ICF in the selling position was the highest annualized average return asset (23%), while its buying position had the lowest return (-23%). Among non-derivative assets, the dollar had the highest return, while Ibov had the worst return (2.59%). In the second period, 2014-2016, among futures contracts, long-term purchased BGI had the highest return (8%) and its buying position with the lowest return (-8%). For the other categories, IMA-B (13%) had the highest return while Ibov had the lowest (5%).

In the first period, all portfolios with futures contracts had less deviation within the range of 0% to 8% return. However, it should be noted that all portfolios located in this space were inefficient due to Ibov, which had high volatility and low profitability, so that the reduction of its portfolio participation reduced the deviation and gradually increased its return. Among the ranges of 8.25% to 12% return, the portfolios became efficient and mostly composed of CDI, IFIX and IMA-B, which had the best performance for the period mainly due to the high SELIC rate besides being less volatile assets than the stock market.

Considering deviation and return, the most efficient portfolio was the strategy of short and long-term futures contracts in the selling position, both due to the coffee sold contract. This asset, in addition to reducing portfolio deviation, allowed it to exceed 12% return, unlike other portfolios. On the other hand, considering the starting point of 8.25% return, the other futures contracts did not make the portfolios in this region efficient, and there is no evidence of their use as a way to minimize the risk for the period. When verifying the statistical significance of the results based on the Gibbons test, the results were significant from 0% to 8% for the portfolio with purchased long-term contracts. For the selling position portfolios, the results were relevant from the 8.25% point.

In the second period (2014-2016), only the short and long term futures portfolios sold showed the smallest deviation for the 0% to 12% return range, while the long-term contract strategies portfolios bought had the largest deviation within the range interval. Unlike the

first period, corn and cattle contracts were also relevant for reducing portfolio risk to 12%. However, considering portfolio optimization theory, portfolios in this interval zone were not efficient, since they presented greater deviation than portfolios with returns between 12.25% and 13.6%, composed mainly by the dollar, IMA-B, IFIX and CDI. The maximum point reached was 13.6% due to the performance of real estate funds for the period. When applying the Gibbons test, the results were statistically significant only for the range 0% to 5%, since beyond this return zone, the percentage of contracts in the portfolios became close to 0%, giving preference to other assets.

Once again, evidence was found of the potential for commodity diversification relative to the stock market. Several studies (Erbey & Harvey, 2006; Idzorek, 2007; Belousova & Dorfleitner, 2012) point out that the negative correlation with the market originates mainly from the use of commodities as inflation hedges, as stocks tend to be undermined in inflationary environments, considering the adoption of restrictive measures in monetary policy. However, with the exception of coffee sold in the first period, based on the theory of optimization, the contracts did not improve the risk-return ratio of the portfolios, since the efficient strategies were composed by IMA-B, IFIX, Dollar and CDI. The result is due to some particularities of the Brazilian market; Firstly, the yield of the CDI, a deviation asset close to 0%, is linked to the SELIC rate, which averaged 9% in the first period and 13% in the second period. The second point is that both periods are characterized by an environment of annual inflation growth, a factor that benefits the profitability of the IMA-B, a fixed income bond portfolio linked to the IPCA. Although commodities also benefit from inflationary shocks, their volatility is considerably higher than that of IMA-B, as asset performance outperformed commodities. Finally, IMA-B and CDI have low correlation, offering diversification potential with each other, and are low risk, which explains why they are the highest percentage assets in the efficiency zone.

6 CONCLUSION

This article aimed to evaluate the effectiveness of using commodity futures contracts as instruments to optimize investment portfolios from 2011 to 2016. To choose the futures contracts entered, the daily liquidity criterion was used in the futures market trading of B3. Thus, the contracts for the purchase and sale of live cattle, coffee and corn were selected for the sample. For assets not categorized as derivatives, IBOV, IMA-B, IFIX, US dollar and CDI were selected, each representing a distinct niche in the financial market. The DI rate represented the risk-free asset for calculating the Sharpe Index.

Based on the portfolio theory for full period analysis, futures contracts indicated potential for optimization for portfolios composed mostly of Ibov. This result corroborates with previous studies, considering that commodities are differentiated assets, whose returns benefit from inflationary shocks, as they reflect future price expectations. On the other hand, stock markets tend to be negatively affected by inflation, in particular due to contractionary monetary policy measures that slow the economy down. However, despite the potential for diversification from the stock market, only coffee futures contracts participated in strategies that touched the efficiency zone, as the portfolios were mostly composed of IFIX, IMA-B, dollar and CDI. The result is derived from particularities of the Brazilian economy, characterized by increasing inflationary cycles and high interest rates.

A second analysis was performed to verify the ability to optimize futures contracts for different economic cycles. Thus, based on CODACE, the sample was divided between the

periods 2011-2013, characterized by economic expansion, and 2014-2017, characterized by economic downturn. In the first period, the result reinforced that of the complete sample, as the most efficient portfolio of the period was composed by IFIX, IMA-B, dollar, CDI and coffee contracts in selling position.

For the second period, the efficient portfolios were composed exclusively by IFIX, IMA-B, dollar and CDI. For both periods, futures portfolios improved the risk-return ratio of portfolios composed mostly of Ibov, but did not touch the efficiency zone. Thus, strategies with futures contracts, with the exception of coffee sold, they were unable to outperform strategies linked to assets with yield linked to interest, inflation and exchange rates, especially due to the high volatility of derivatives. This result may be characteristic of developing countries, as the market still requires a higher risk premium on government bonds and foreign exchange from these economies.

The study contributes to the Brazilian academic literature, since the subject of the use of commodity derivatives in the scope of investments has not been well explored, although commodities are the most representative good in the Brazilian economy. Although converging in part with those of previous studies, the results are intrinsic properties of the Brazilian market, such as high interest rate and inflation policy. Thus, it is suggested for future studies to replicate and compare research in other developing economies, with the aim of verifying if there are fixed income assets are able to overcome strategies with futures contracts. Additionally, it is also suggested to further study the causality between Brazilian macroeconomic variables and commodity prices, in order to verify the impact.

REFERENCES

- Adams Z., Fuss, R., Kaiser, D. G. (2008). Macroeconomic determinants of commodity futures returns. *The handbook of commodity investing*, 87-112.
- Alexander, C. (2008). *Market Risk Analysis: Pricing, Hedging and Trading Financial Instruments*. John Wiley & Sons.
- Belousova, J.; Dorfleitner, G. (2012). On the diversification benefits of commodities from the perspective of euro investors. *Journal of Banking & Finance*, 36(9), 2455-2472.
- Bressan, A. A., & de Lima, J. E. (2009). Modelos de previsão de preços aplicados aos contratos futuros de boi gordo na BM&F. *Nova Economia*, 12(1).
- Cao, B., Jayasuriya, S., Shambora, W. (2010). Holding a commodity index fund in a globally diversified portfolio: a placebo effect? *Economics Bulletin* 30, 1842– 1851.
- Cheung, C. S., & Miu, P. (2010). Diversification benefits of commodity futures. *Journal of International Financial Markets, Institutions and Money*, 20(5), 451-474.
- Collier, P. M. (2009). *Fundamentals of risk management for accountants and managers*. Routledge.
- Conover, C. M., Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2010). Is now the time to add commodities to your portfolio?. *The Journal of Investing*, 19(3), 10-19.
- Da Costa, T. M. T., & Piacenti, C. A. (2008). Utilização de Contratos futuros agropecuários no perfil médio de investimentos dos fundos de pensão no Brasil. *Revista Contabilidade & Finanças*, 19(46), 59-72.
- Daskalaki, Charoula, & Skiadopoulos, George (2011). Should investors include commodities in their portfolios after all? New evidence. *Journal of Banking & Finance*, 35(10), 2606-2626.

- DeFusco, R. A., McLeavey, D. W., Pinto, J. E., Runkle, D. E., & Anson, M. J. (2015). *Quantitative investment analysis*. John Wiley & Sons.
- Domanski, D., & Heath, A. (2007). Financial investors and commodity markets. *BIS Quarterly Review*, 53-67.
- Erb, C. B., & Harvey, C. R. (2006). The strategic and tactical value of commodity futures. *Financial Analysts Journal*, 62(2), 69-97.
- Fabozzi, F. J., Gupta, F., & Markowitz, H. M. (2002). The legacy of modern portfolio theory. *The Journal of Investing*, 11(3), 7-22.
- Fama, E. F., & French, K. R. (2004). The capital asset pricing model: Theory and evidence. *The Journal of Economic Perspectives*, 18(3), 25-46.
- Fundação Getúlio Vargas [FGV] (2017, outubro). Comitê de Datação de Ciclos Econômicos (CODACE). Recuperado de <http://portalibre.fgv.br/lumis/portal/file/fileDownload.jsp?fileId=8A7C82C55EC04CF1015FE89DE84D289C>
- Fu, F. (2009) Idiosyncratic risk and the cross-section of expected stock returns. *Journal of Financial Economics*, 91(1), 24-37.
- Géczy, C. C., Minton, B. A., & Schrand, C. M. (2007). Taking a view: Corporate speculation, governance, and compensation. *The Journal of Finance*, 62(5), 2405-2443.
- Gibbons, M. R., Ross, Stephen A., SHANKEN, J. (1989). A test of the efficiency of a given portfolio. *Econometrica: Journal of the Econometric Society*, 57(5), 1121-1152.
- Gorton, G., & Rouwenhorst, K. G. (2006). Facts and fantasies about commodity futures. *Financial Analysts Journal*, 62(2), 47-68.
- Idzorek, T. M. (2007). Commodities and strategic asset allocation. *Intelligent commodity investing*, 113-177.
- Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2000). Efficient use of commodity futures in diversified portfolios. *Journal of Futures Markets*, 20(5), 489-506.
- Jorion, P. (2007). *Financial risk manager handbook*. John Wiley & Sons.
- Markert, V., & Zimmermann H. (2008). *The relationship between risk premium and convenience yield models*. John Wiley & Sons.
- Markowitz, H. (1952). Portfolio selection. *The journal of finance*, 7(1), 77-91.
- Reilly, F. K., & Brown, K. C. (2011). *Investment analysis and portfolio management*. Cengage Learning.
- Ross, Westerfield, & Jaffe. (2009). *Corporate finance*. McGraw-Hill.
- Scherer, B., He, L., Fabozzi, F. J., Füss, R., & Kaiser, D. G. (2008). The Diversification Benefits of Commodity Futures Indexes: A Mean-Variance Spanning Test. *The Handbook of Commodity Investing*, 241-265.
- Silveira, R. L. F. da; Barros, G. S. C. (2010). Uma análise da alocação de contratos futuros sobre commodities em portfólios diversificados. *Revista de Economia e Sociologia Rural*, 48(1), 195-222.
- Szymanowska, M., Roon, F., Nijman, T., & Goorbergh, R. (2014). An anatomy of commodity futures risk premia. *The Journal of Finance*, 69(1), 453-482.
- Varga, G. (2001). Índice de Sharpe e outros indicadores de performance aplicados a fundos de ações brasileiros. *Revista de Administração Contemporânea*, 5(3), 215-245.
- You, L., & Daigler, R. T. (2013). A Markowitz optimization of commodity futures portfolios. *Journal of Futures Markets*, 33(4), 343-368.