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IS GOLD A GOOD INVESTMENT TO PREVENT THE EFFECTS OF NEGATIVE VARIATIONS IN THE BRAZILIAN STOCK MARKET?

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1. INTRODUCTION

The belief that gold and stock prices tend to move in opposite directions predominates in the financial market and is widely accepted by investors, scholars and the specialized media. All of them share the premise that the link between gold and stock market is given by the fact that both assets move in opposite directions, when traded in the financial market. As gold is believed to preserve its real value and provide a hedge for investors with stock positions, has attracted investors' attention for many decades. Also, gold has achieved great reputation as a financial asset that offers diversification benefits against stock price changes and, at the same time, can play the role of safe haven against extreme stock market movements. The aim of this paper is to verify whether gold has such characteristic in the Brazilian market. Therefore, a test was conducted to examine the ability of gold to preserve the value of a stock-based investment portfolio traded on the São Paulo Stock Exchange (BM & FBovespa) in face of extreme market variations.

The capacity of gold to play the role of hedge against inflation was analyzed in some studies (CHUA and WOODWARD 1982, JAFFE 1989, BLOSE 2010, WANG et al., 2011), while other studies examined gold in relation to the stock market (BAUR and LUCEY, 2010). Baur and McDermot (2010) analyzed the safe haven capacity of gold in several countries and found evidence that investors from developed countries react differently to those in developing countries during the economic crises. The results of this research pointed out that gold has a minor importance as safe haven in developing countries. Others analyzed the behavior of gold in relation to oil price changes (REBOREDO, 2012). Beckers and Soenen (1984) examined the attractiveness of gold to investors and its hedging properties and found out that asymmetric risk diversification was achieved by holding gold positions for both American and non-American investors. Sjasstad and Scacciavillani (1996) found out that appreciations or exchange depreciations have strong effects on the price of gold. Capie et al. (2005) confirmed the positive relationship between the depreciation of dollar and the price of gold, pointing to gold as an effective hedge against the American dollar. Joy (2011) investigated whether gold could act as hedge or safe haven and found out that gold acted as hedge and as a weak safe haven against the American dollar. Baur and McDermott (2012) conducted a comparative study between gold and US government bonds and found out that investors are ambiguity-averse, which means that they buy gold when faced with extreme uncertainty about the state of the economy or the financial system, and when they receive ambiguous signals. In contrast, investors buy US government bonds when faced with extreme but unambiguous signals. On the other hand, in a study aiming at formulating a prediction model of the gold price, Baur et al. (2014), analyzed the behavior of gold in relation to several economic variables (e.g., stock indexes, commodity prices, US government bonds, exchange rates and currency depreciation). Carvalho et al (2017) verified that gold acts as hedge and weak safe haven against Brazil 50 Index (IBrX 50), which is designed to measure average stock performance tracking changes in the prices of the 50 most actively traded and best representative stocks of the Brazilian stock market.

However, can gold protect the investor from extreme devaluations in the Brazilian stock market? Thereby, to answer this question, this work expands the scope of

previous studies investigating the behavior of gold against 11 Brazilian stock exchange indexes, especially in extreme market conditions.

2. EMPIRICAL METHODOLOGY

According to the definitional approach described in Kaul and Sapp (2006), Baur and Lucey (2010) and Baur and McDermott (2010), what distinguishes an asset while hedge or safe haven is:

- Hedge: an asset is a hedge if it is uncorrelated or negatively correlated with another asset or portfolio on average.
- Safe haven: an asset is a safe haven if it is uncorrelated or negatively correlated with another asset or portfolio in times of extreme market movements.

Therefore, if gold has the capacity to act as a safe haven, then its value is not negatively affected by movements of extreme reduction in stock value, which implies a specific form of tail dependence. On the other hand, when gold acts as a hedge, uncorrelated or opposing movements between the value of gold and stocks are obtained only on average, and not in a specific region of their joint distribution (e.g., tails).

In this work we adopt the concepts of strong and weak safe haven, introduced by Baur and McDermott (2010). According to them, when an asset is negatively correlated to another asset in extreme movements, it is considered a strong safe haven; while when one asset is not correlated to another in extreme movements, it is considered a weak safe haven. This approach involves two steps. First, in order to analyze the tail dependence, we must identify extreme values, in particular the extreme losses for a chosen index and gold price. For this purpose, we used the extreme value theory to classify extreme returns as those that exceed a specific threshold. In Baur and Mcdermott (2010) and Joy (2011) the extreme market conditions were exogenously identified as a specific quantile (90%, 95%, etc.) of the return distribution. Second, we tested the tail and the average conditional dependence between gold and the chosen index. Therefore, we propose a conditional dependency ratio test for this purpose, such as that used in Reboredo and Rivera Castro (2014).

2.1. Identifying extreme values

In order to identify extreme values for gold and the stock market, we use the Peaks Over Threshold (POT) methodology, which classifies as extreme returns those that exceed a threshold, called μ. The selection of this threshold is very sensitive: a very low limit guarantees a series of maxima with a larger number of observations, whereas the opposite generates few excesses that leads to a large variation in the estimates (EMBRECHTS et al., 1997; COLES, 2001).

The threshold selection was done through a non-parametric approach called the Hill Estimator, applicable to distributions belonging to the Maximum Attraction Domain (MDA) for the Fréchet distribution. Given that the data do not reject the null hypothesis from this distribution, the Hill Estimator applies directly to the series of returns$\{r_t\}_{t=1}^{T}$, so there is no need to consider sub-samples.

Given the sample order statistics of the returns r (1) ≤ r (2) ≤ ... r (T) the Hill Estimator for a positive integer k is defined as:

$$\xi_{Hill}(k) = \frac{1}{k}\sum_{i=1}^{k}[\ln(r_{(T-i+1)}) - \ln(r_{(T-k)})] \qquad (1)$$

where *k* emphasizes that the estimator depends on k. In practice, the Hill estimator is plotted against it in order to find out a proper *k*, such that the Hill estimator appears to be stable (Tsay, 2010). In this plot, the Hill estimator is associated with different thresholds. The following ordered pairs are graphed:

$$\left\{(k, \alpha_{k,T}^{Hill}) : k = 2,3,...,n\right\} \qquad (2)$$

where $\alpha = \frac{1}{\xi_{\text{Hill}}(k)}$ is the estimated tail index.

The Hill estimator $\xi_{\text{Hill}}(k)$ converges in probability to ξ as $k \to \infty$. It is asymptotically normally distributed, with asymptotic variance given by ξ^2/k.

2.2. Maximum Likelihood Estimation for Conditional Dependency

This subsection presents the procedure to test the conditional dependence between gold and index data as a function of the Likelihood Ratio (LR) test. As this procedure will be reapplied to each one of the indexes analyzed, *B* notation is used throughout this work to indicate each index studied in a generic way. The Hill Estimator was used to identify the upper and lower thresholds for gold and the chosen index (*B*). From the thresholds identified, we classify the returns as: extremely positive, non-extreme and extremely negative.

We consider, therefore, sequence indicators $\{I_t^G\}_{t=1}^T$ and $\{I_t^B\}_{t=1}^T$ for gold and for *B*, respectively, in such a way that they could assume values j = 1; 2 or 3 at time *t* when returns are classified as extremely positive, not extreme or extremely negative respectively.

Thus, at time *t* and state *j*, conditional dependence of gold on the stock market is given by $Pr = (I_t^B = i)$ and this conditional dependence means that $Pr = (I_{t-1}^B = i) \neq Pr = (I_t^G = j)$. Given the conditional dependency matrix *P*:

$$P = \begin{pmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{pmatrix} \qquad (3)$$

where $p_{ij} = Pr = (I_{t-1}^B = i)$ for j, i = 1, 2, 3. The conditional probabilities p_{ij} can be estimated by maximizing the likelihood function under conditional dependence, given by:

$$\ell(P; I_1^G; I_2^G; I_3^G, ..., I_T^G) = \prod_{\substack{j=1 \\ i=1}}^{3} P_{ij}^{n_{ij}}, \qquad (4)$$

where n_{ij} is the number of observations of I_t^B with value i, followed by observations of I_t^G with value j. The estimated parameters obtained by maximizing the log-likelihood in Eq. (4) are simply the ratios of the counts for the corresponding cells:

$$p_{ij} = \frac{n_{ij}}{n_{i1} + n_{i2} + n_{i3}} \quad (5)$$

From this structure, different hypotheses about gold's hedge or safe-haven properties can be tested after the application of some probability restrictions in Matrix (3). It is possible to notice that the structure of this matrix holds all the information about the dependency structure between gold and the chosen index. Thus, if both have co-movements of returns, the probabilities move diagonally by connecting the upper left corner to the lower right corner of the Matrix (3) and must be greater than the probabilities for the same row that lies outside this diagonal, where P_{11} and P_{33} indicate upper and lower extreme dependence or tail dependence respectively. On the other hand, when negative extreme gold and index *B* movements go in opposite directions, the probability of occurrence of the diagonal linking the lower left corner to the upper right corner of Matrix (3) is greater than the probability of occurrence of the same row off this diagonal, where P_{31} and P_{13} indicate opposite movements in the tail of both assets. Finally, gold prices are independent of index *B* when the probabilities of each of the columns of Matrix (3) are equal. Thus, based on the dependence of the information collected in (3), we can consider different hypotheses.

2.2.1 Hypothesis 1

In Hypothesis 1, we consider gold property as a safe haven. If gold plays a role of safe haven against the selected index *B*, then the value of gold should remain not extreme or extremely positive when an extreme price fall occurs in the index tested. In both cases, either gold preserves its value or it is valued in the face of the devaluation of *B* in moments of market turbulence, which means that there is truly independence in the mix between gold and extreme negative movements of the stock. In the first case, when the value of gold remains not extreme, we will state that gold is a weak safe haven. In this situation, the probability that the gold will have a non-extreme price conditioned to a negative extreme movement of the index *B* (P_{32}) is greater than the probability that gold has a positive extreme value associated with an extreme fall of index *B* (P_{31}). This hypothesis can be formulated as:

Hypothesis 1: H0 :$P_{32} = P_{31}$(Gold is not a weak safe haven).
The rejection of hypothesis 1 indicates that gold can act as a weak safe haven.

2.2.2 Hypothesis 2

In Hypothesis 2, when gold acquires an extreme positive value, we consider gold to be a strong safe haven. In this situation, the probability that gold will take an extreme positive value conditional in extreme fall in the returns of index *B* (P_{31}) is greater than the probability that the gold will have a negative extreme value conditioned to an extreme downward movement of the index *B* (P_{33}), that is, there are opposing movements of the tail. This hypothesis can be formulated as:

Hypothesis 2: H0: $P_{31} = P_{33}$ (Gold is not a strong safe haven).
The rejection of hypothesis 2 indicates that gold can act as a strong refuge value.
We can elaborate the likelihood function on the null hypothesis of these two hypotheses, respectively, given by:

$$\ell_1 = (P; I_1^G, I_2^G, ..., I_T^G) = \prod_{\substack{i=1 \\ j=1,2}}^{3} p_{ij}^{n_{ij}} p_{32}^{n_{32}} p^{n_{31}+n_{32}},$$

$$\ell_2 = (P; I_1^G, I_2^G, ..., I_T^G) = \prod_{\substack{i=1 \\ j=1,2}}^{3} p_{ij}^{n_{ij}} p_{33}^{n_{33}} p^{n_{31}+n_{33}},$$

when the LR to test these hypotheses is given by:

$$LR = -2log[l_k(P; I_1^G; I_2^G, \dots, I_T^G) \,/\, l(P; I_1^G; I_2^G, \dots, I_T^G)] \quad (6)$$

where k = 1; 2. The likelihood ratio statistic is asymptotically distributed as x^2 with one degree of freedom.

When hypotheses 1 and 2 are rejected, gold can be a weak or a strong value refuge, which can be distinguished by testing whether $P_{32} > P_{33}$.

2.2.3 Hypothesis 3

We can consider the hedge capacity of gold, based on the information contained in the Matrix (3). When gold acts as a hedge, then there is no co-movement between gold and devaluation of the analyzed index (*B*), that is, they move in opposite directions under non-extreme market circumstances. In this case, the conditional probability that the gold will have a non-extreme value given a non-extreme fall of *B* must be greater than the conditional probability that the gold will have an extreme value. This hypothesis can be formulated as:

Hypothesis 3: H0: $P_{22} > P_{2j}$, j=1,3

The rejection of hypothesis 3 means that gold cannot hedge. If hypothesis 3 is accepted, we consider that gold can act as a hedge.

2.2.4 Hypothesis 4

Gold may act as a refuge value when the probability of the diagonal linking the upper left corner to the lower right corner of Matrix (3) is smaller than the probability of occurrence of the same line off that diagonal, that is, there is no co-movement between the gold and *B*, whether on average or in the tails of their joint distribution. Thus, we consider that P_{ii} is greater than the conditional probabilities in the same row. This hypothesis can be formulated as:

Hypothesis 4: H0: $P_{ii} > P_{ij}$, i, j=1,2,3

The rejection of hypothesis 4 indicates that there is no co-movement between gold and the chosen index. The result of hypothesis 4 is essential for the validation of results obtained from hypotheses 1 and 2, since the possibility of gold acting as a refuge value can only be confirmed if we verify that there is no co-movement of it in relation to the chosen index. Statistical LR can be used to test hypotheses 3 and 4, as in Equation (6).

3. DATA

The hedge and safe-haven properties against BM & FBovespa indexes were investigated using the likelihood ratio test proposed above. We used daily data for the period from 2000 to 2016. The data analyzed were obtained from the Bank of England

and the Federal Reserve Bank of St. Louis. The returns of gold and indexes were calculated on the basis of the continuous composition of the first difference of log prices. The price of gold was expressed in dollars per ounce. For the valuation of the indexes, it was used the same methodology adopted by BM & FBOVESPA. In this paper, we seek to use the indexes that represent the largest possible scope of the Brazilian stock Market, presented in Table 1, as follows:

Table 1- Selected indexes.

Broad Indexes	**Sector Indexes**	**Corporate Governance Indexes**
-Brazil 100 Index (IBrX 100)	-BM&FBOVESPA Electric Utilities Index (IEE) -BM&FBOVESPA Industrials Index (INDX) -BM&FBOVESPA Real Estate Index (IMOB) -BM&FBOVESPA Basic Materials Index (IMAT) -BM&FBOVESPA Public Utilities Index (UTIL) -BM&FBOVESPA Telecommunication (ITEL)[i]	Corporate Governance Trade Index (GCT)
Segment Indexes	**Other Indexes**	
-MidLargeCap Index (MLCX) -SmallCap Index (SMLL)	-BM&FBOVESPA Real Estate Fund Index (IFIX))	

Descriptive statistics for gold returns and indexes are presented in Table 2. The averages of returns were close to zero for all series and low values were found for the standard deviations. Thus, no significant trend was evidenced by the data. The difference between the maximum and minimum values shows that the indexes are more volatile than gold. The coefficient of linear correlation indicated that the price of gold and indexes are not dependent in all cases, therefore, opening for them the possibility of using gold as a hedge or as a safe haven.

Table 2 - Descriptive statistics for gold and index returns.

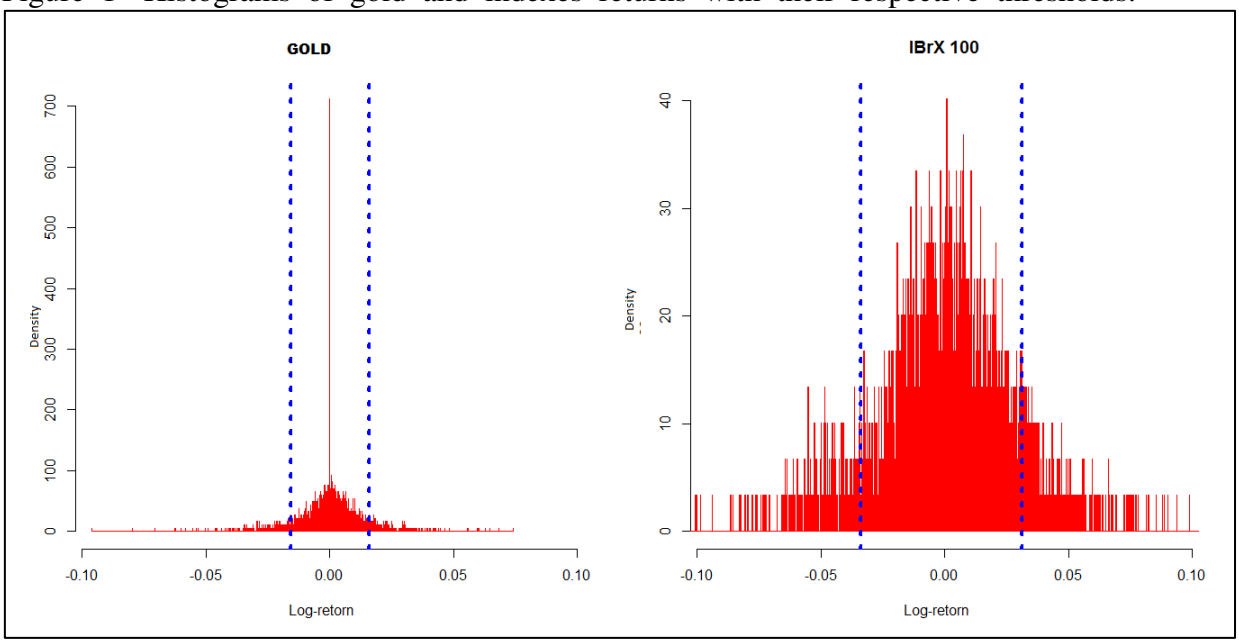
	Index	Mean (%)	Std.dev. (%)	Min. (%)	Max. (%)	Corr. gold
IBRX	GOLD	0,03	1,19	-9,60	7,42	--
IBRX	IBRX	0,04	2,41	-19,31	22,04	0,07
IGCT	GOLD	0,03	1,34	-9,60	7,42	--
IGCT	IGCT	0,02	2,54	-18,94	23,30	0,08
MLCX	GOLD	0,04	1,34	-9,60	7,42	--
MLCX	MLCX	0,03	2,53	-19,22	21,99	0,10
UTIL	GOLD	0,04	1,34	-9,60	7,42	--
UTIL	UTIL	0,06	2,49	-14,54	55,32	0,06
IMOB	GOLD	0,02	1,33	-9,60	6,84	--
IMOB	IMOB	-0,07	3,18	-22,90	21,96	0,07
SMLL	GOLD	0,00	1,34	-9,60	7,42	--
SMLL	SMLL	0,02	2,33	-17,79	0,21	0,06
IMAT	GOLD	0,03	1,34	-9,60	7,42	--
IMAT	IMAT	0,00	2,82	-21,57	20,44	0,10

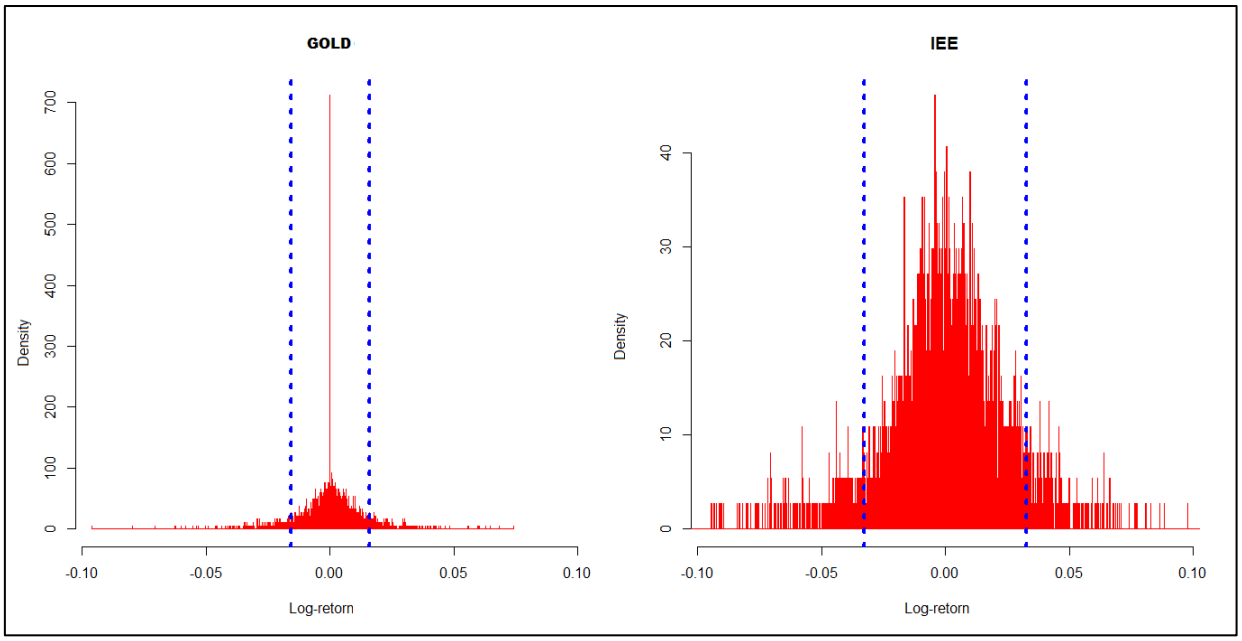
INDX	GOLD	0,03	1,32	-9,60	7,42	--
INDX	INDX	0,00	2,42	-18,94	20,17	0,07
IFIX	GOLD	-0,02	1,17	-9,60	4,84	--
IFIX	IFIX	-0,04	1,01	-5,63	4,00	0,14
ITEL	GOLD	0,06	0,01	-7,97	7,42	--
ITEL	ITEL	0,02	2,73	-19,49	0,19	0,02
IEE	GOLD	0,04	1,19	-9,60	7,42	--
IEE	IEE	0,04	2,36	-13,79	19,94	0,02

4. RESULTS

In order to identify the extreme returns of gold and the stock market, Hill estimator was applied to the series of returns obtaining the values of the upper and the lower limits of the tails of their respective distributions. These results, presented in Figure 1 and in Table 3, showed that the limits were different for the indexes and for gold, and also that there was an asymmetry between them, since the values of the thresholds that determine the tails of the distributions were different.

Figure 1 -Histograms of gold and indexes returns with their respective thresholds.

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700
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Log-retorn
IEE
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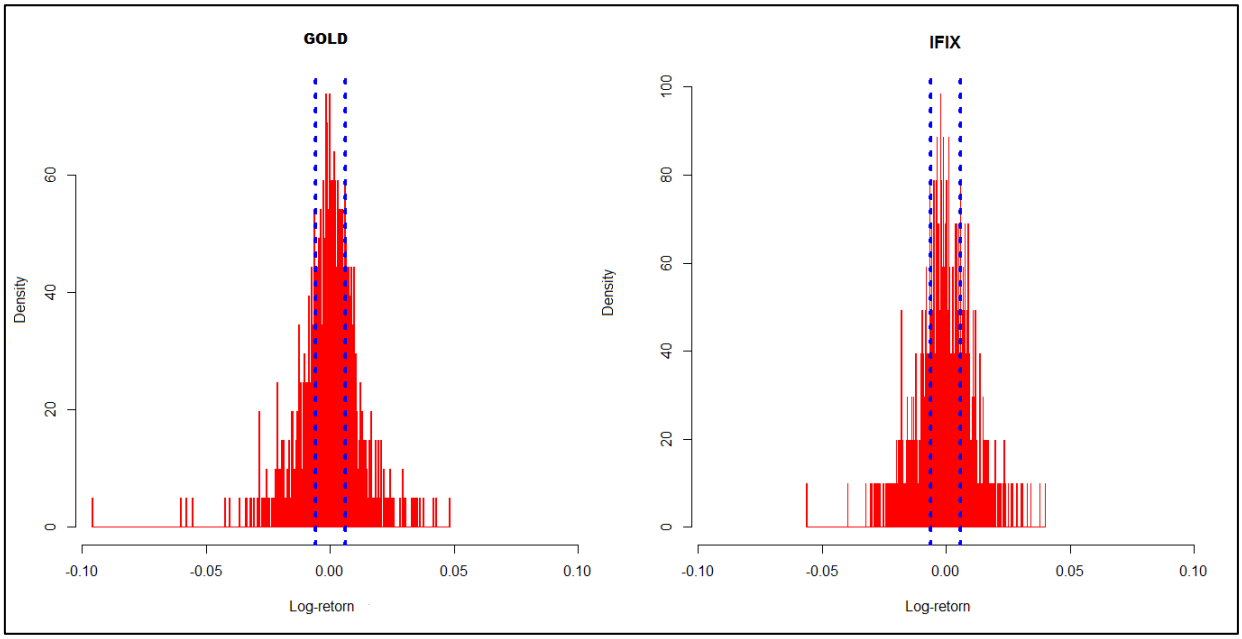
Log-retorn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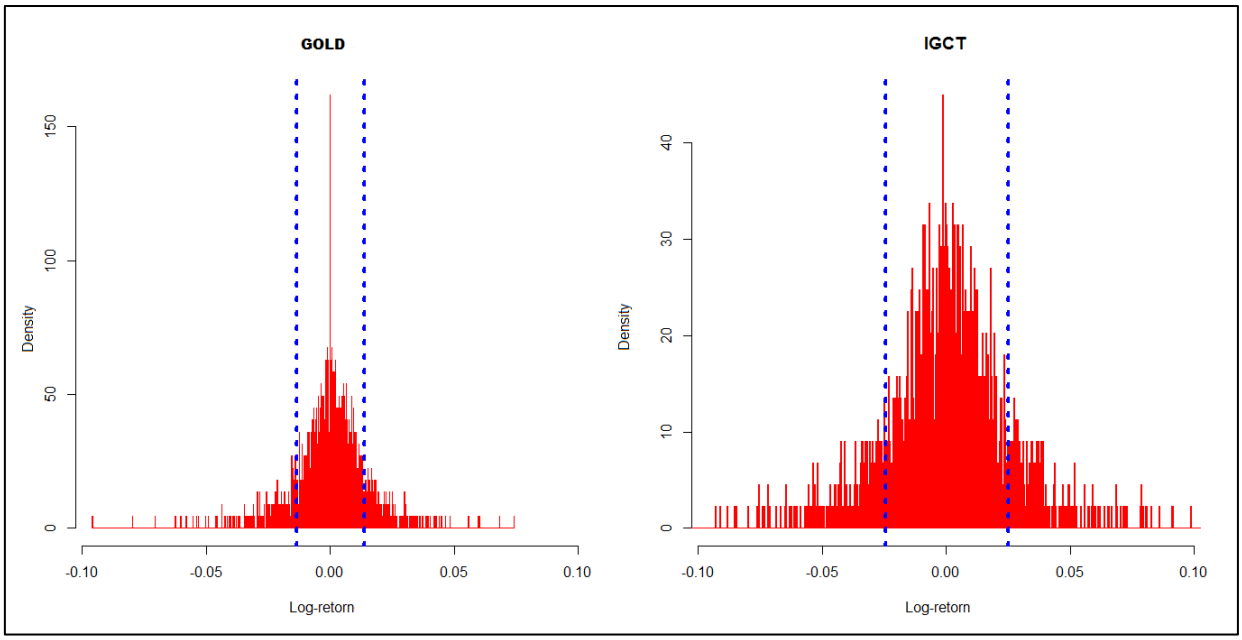
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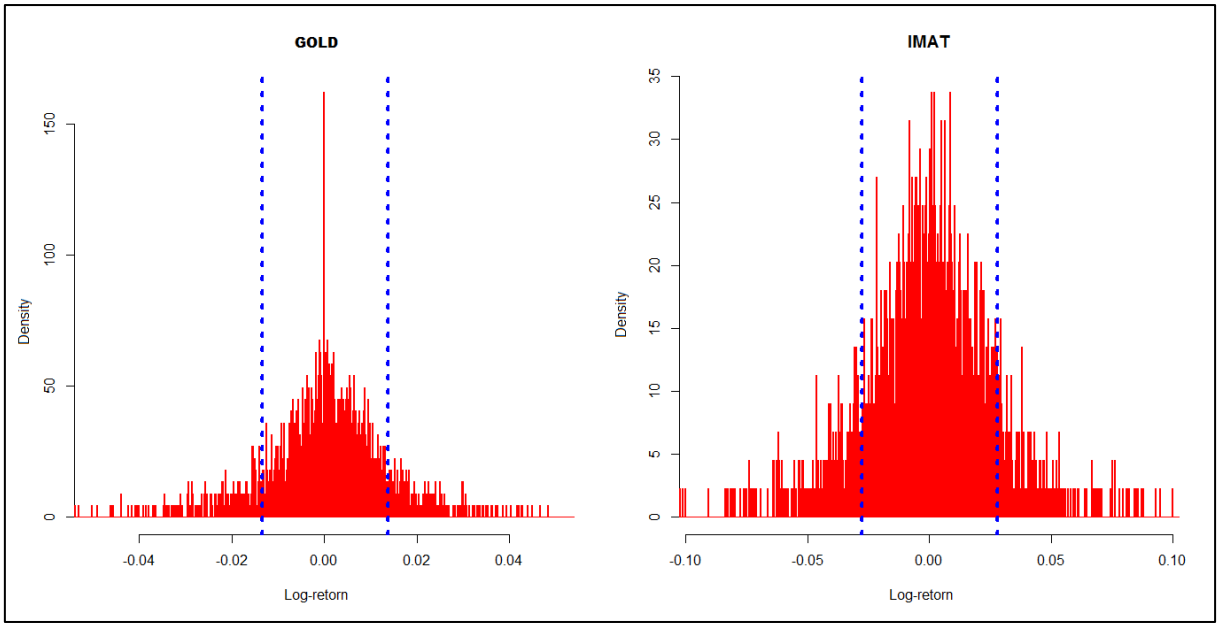
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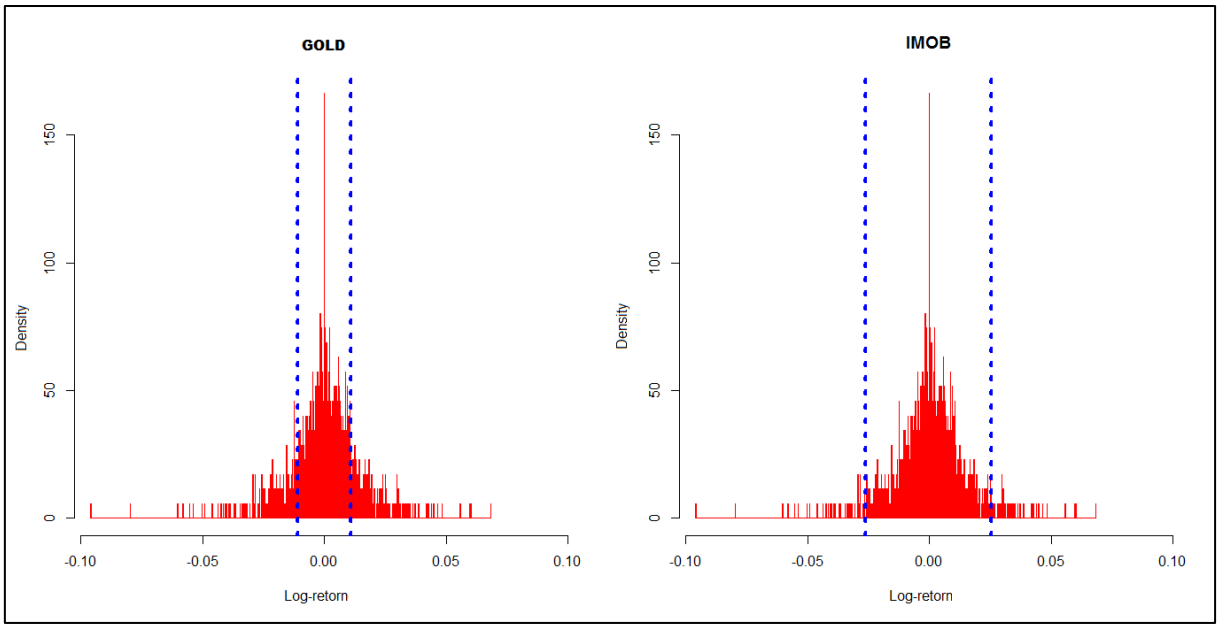
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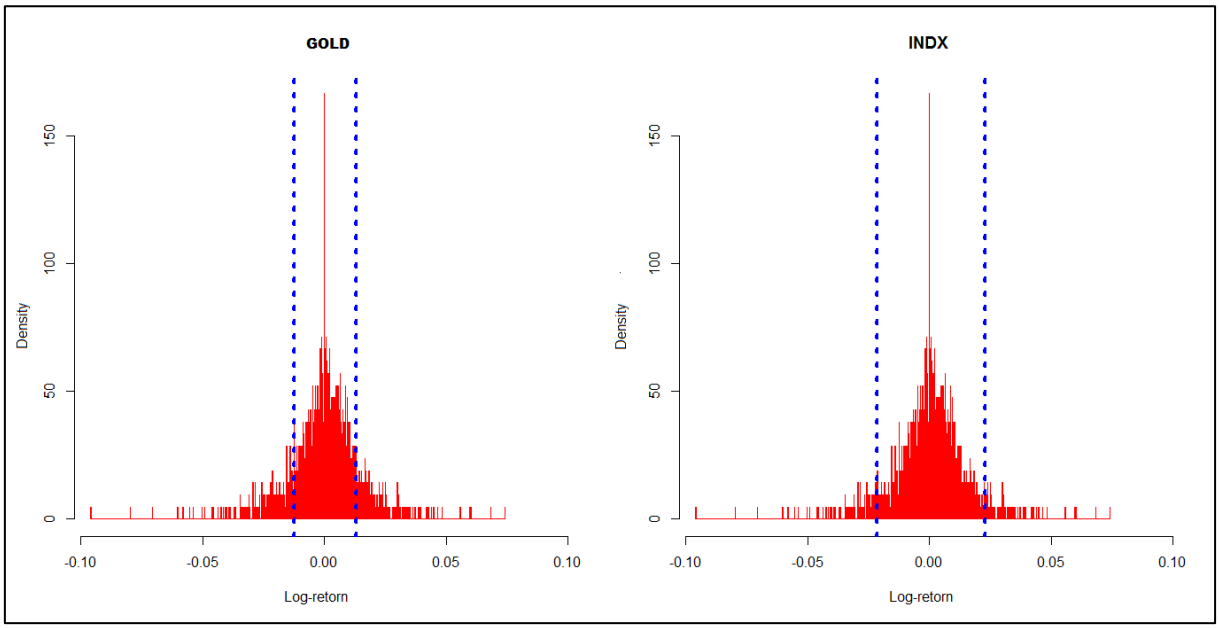
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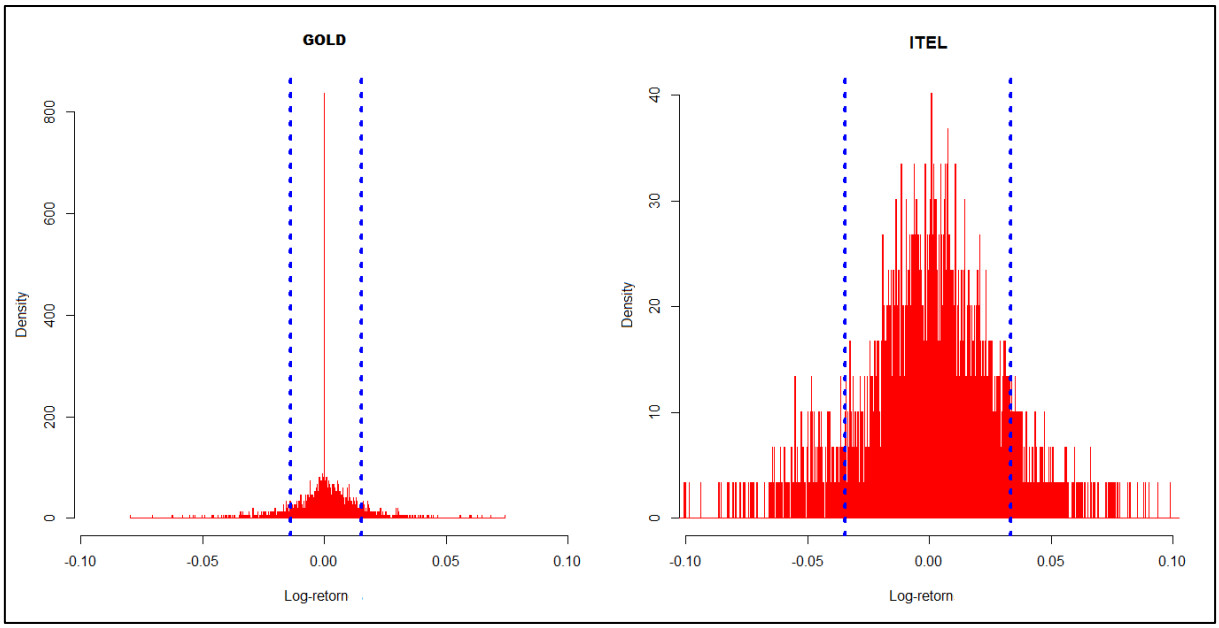
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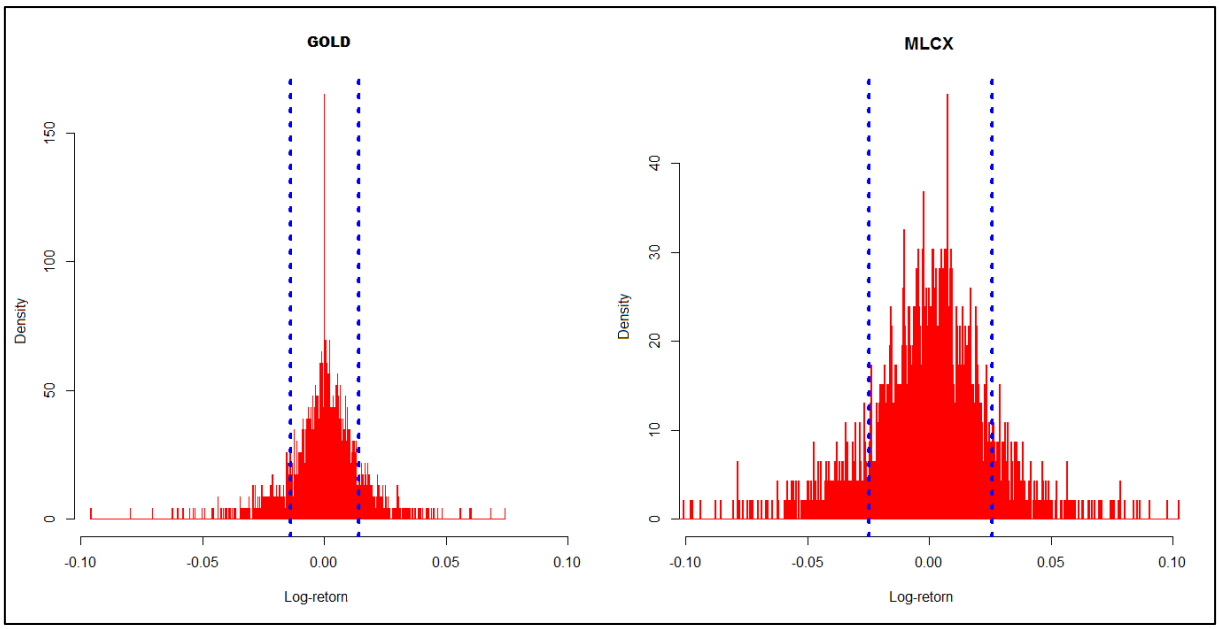
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Log-retorn
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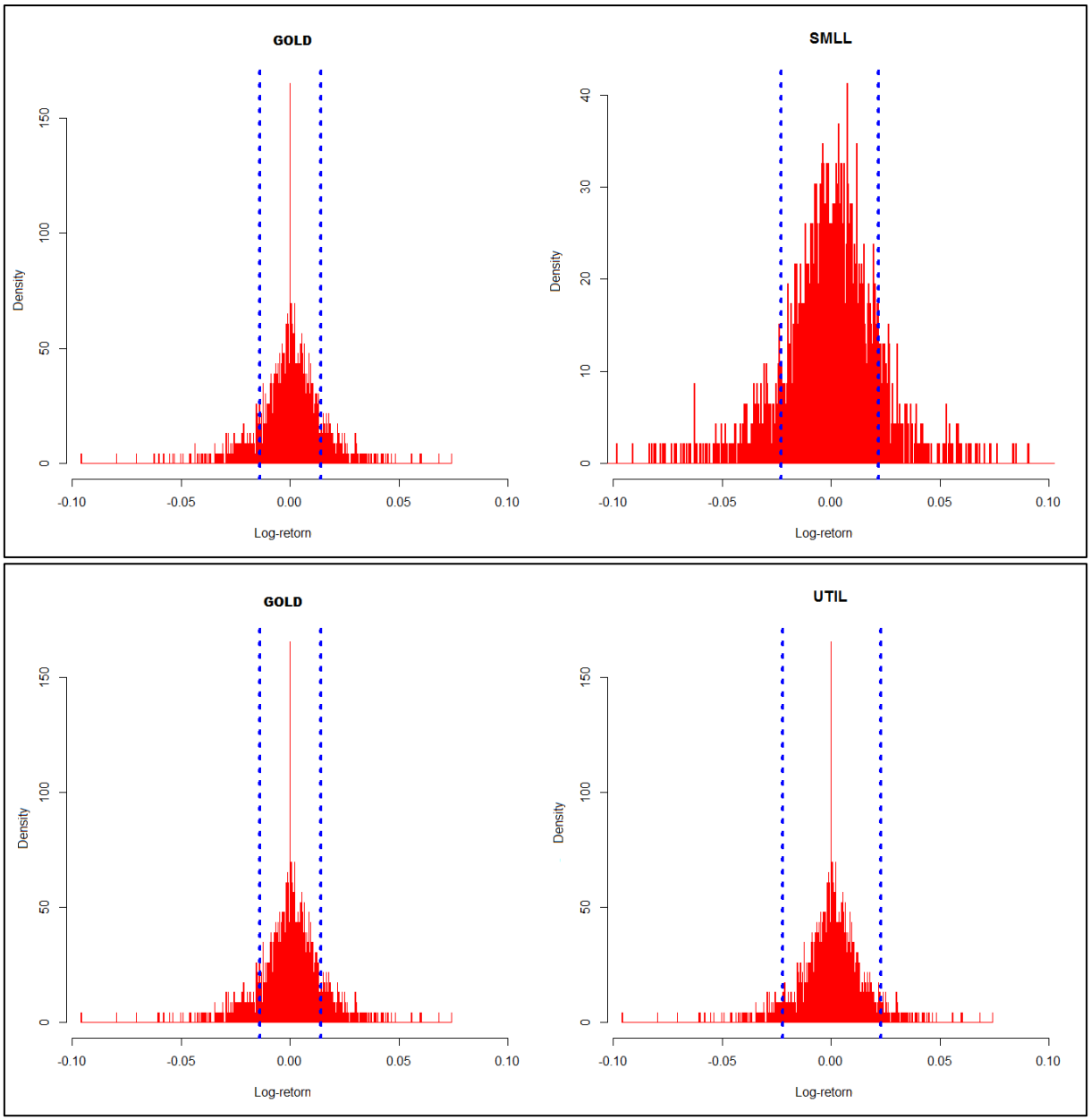

Table 3 - Thresholds calculated using the Hill estimator

	Index	Upper	Std. error	Lower	Std. error
IBRX	GOLD	0,0161	0,0010	0,0156	0,0010
	IBRX	0,0314	0,0010	0,0340	0,0010
IGCT	GOLD	0,0138	0,0010	0,0134	0,0010
	IGCT	0,0251	0,0010	0,0245	0,0010
MLCX	GOLD	0,0142	0,0010	0,0138	0,0010
	MLCX	0,0256	0,0010	0,0250	0,0010
UTIL	GOLD	0,0142	0,0010	0,0138	0,0010
	UTIL	0,0228	0,0010	0,0224	0,0010
IMOB	GOLD	0,0109	0,0010	0,0111	0,0010
	IMOB	0,0256	0,0010	0,0262	0,0010
SMLL	GOLD	0,0142	0,0010	0,0138	0,0010
	SMLL	0,0218	0,0010	0,0230	0,0010
IMAT	GOLD	0,0138	0,0010	0,0134	0,0010
	IMAT	0,0278	0,0010	0,0279	0,0010
INDX	GOLD	0,0129	0,0010	0,0126	0,0010
	INDX	0,0227	0,0010	0,0215	0,0010
IFIX	GOLD	0,0060	0,0010	0,0058	0,0010

	IFIX	0,0058	0,0010	0,0061	0,0010
ITEL	GOLD	0,0151	0,0010	0,0141	0,0010
	ITEL	0,0333	0,0010	0,0347	0,0010
IEE	GOLD	0,0161	0,0010	0,0156	0,0010
	IEE	0,0328	0,0010	0,0328	0,0010

After identifying the upper and the lower limits, we constructed the indicator series $\{I_t^G\}_{t=1}^T$ and $\{I_t^E\}_{t=1}^T$ of gold and *B* index, respectively, considering values 1, 2 and 3, at time *t* where returns assumed values: (1) below the lower limit; (2) between the lower limit and the upper limit; and (3) above the upper limit, respectively. Thus, we identified the returns of the lower tail, the central region and the upper tail of its distribution. Then, we estimate the conditional probability Matrix (3) in Equation (5) according to the log-likelihood estimated in Equation (5).

Table 4 presents the results of the conditional probability matrix between gold and selected indexes. The empirical results pointed to the absence of conditional dependence between gold and indexes, evidenced by the weak positive correlation of the series presented in Table 2.

Next, we tested the different hypotheses formulated above. First, we considered the value capacity of gold refuge by testing hypotheses 1 and 2.

Table 4 - Conditional Probability Matrix Estimates.

Gold	$P_{1,1}$	$P_{1,2}$	$P_{1,3}$	$P_{2,1}$	$P_{2,2}$	$P_{2,3}$	$P_{3,1}$	$P_{3,2}$	$P_{3,3}$
IBrX	0,15	0,78	0,07	0,06	0,88	0,06	0,08	0,77	0,15
IGCT	0,20	0,68	0,12	0,10	0,80	0,10	0,12	0,67	0,21
MLCX	0,22	0,69	0,09	0,09	0,81	0,10	0,11	0,68	0,22
UTIL	0,17	0,70	0,13	0,10	0,81	0,10	0,14	0,68	0,18
IMOB	0,19	0,68	0,13	0,14	0,72	0,14	0,12	0,69	0,18
SMLL	0,18	0,70	0,12	0,10	0,80	0,10	0,12	0,70	0,18
IMAT	0,17	0,71	0,12	0,10	0,80	0,10	0,12	0,67	0,22
INDX	0,17	0,70	0,12	0,11	0,78	0,11	0,13	0,68	0,20
IFIX	0,28	0,51	0,21	0,24	0,51	0,25	0,24	0,49	0,27
ITEL	0,12	0,81	0,07	0,08	0,84	0,08	0,10	0,76	0,14
IEE	0,11	0,84	0,05	0,06	0,87	0,07	0,08	0,80	0,12

The results in Table 5 indicate that hypothesis 1, which stated that gold was not a weak safe haven, was rejected for all indexes. Thus, it became evident that gold could act as a weak safe haven.

When we tested hypothesis 2, which stated that gold was not a strong safe haven, we found out that it was also rejected for all of them. Hence, gold could act as a strong safe haven.

Consequently, the rejection of hypotheses 1 and 2 demonstrated that gold could act both as weak and as a strong safe haven. In order to determine whether gold would act as weak or strong safe haven, we tested if $P_{32} > P_{33}$. Table 4 shows that this hypothesis was not rejected for all indexes, indicating that gold could have acted as a weak safe haven for all of them.

When we examined hypothesis 3, we verified that this hypothesis was not rejected for the IBRX, IGCT, MLCX, UTIL, SMLL, IMAT, INDX and IEE indexes, indicating that gold would have acted as hedge for the same. The existence of a low positive correlation coefficient presented in Table 2 corroborates this interpretation, since it shows that gold and indexes movements do not present significant co-movement in non-extreme situations. Thus, we accept the hypothesis that gold could act as a hedge in non-extreme market situations. However, this hypothesis was rejected for the IMOB,

IFIX and ITEL indexes, indicating that, in these cases, gold would not have acted as a hedge.

Finally, hypothesis 4 was rejected for the IBRX, IMOB, SMLL. INDX, IFIX, ITEL and IEE indexes. It is important to remember that the result of this last hypothesis was essential to sustain the results of the previous hypotheses. Until then, we had indicated that gold could act both as hedge and as a weak safe haven. However, to validate these conclusions, it was necessary to evidence the non-existence of co-movement between the gold and the indexes. The rejection of hypothesis 4, therefore, indicated that there was no such behavior in the joint distribution between them. Thus, we validated the conclusions of the previous hypotheses and concluded that gold acted both as a hedge and as a weak safe haven against extreme movements of the stock market during the period analyzed for these indexes.

On the other hand, hypothesis 4 was not rejected for the IGCT, MLCX, UTIL and IMAT indexes, indicating that there was co-movement in the joint distribution between gold and these indexes. Consequently, we did not validate the conclusions of hypotheses 1 and 2 and concluded that gold did not act as a safe haven (neither strong, nor weak) against extreme movements for these indexes, even though it had acted as a hedge for these indexes during the period analyzed.

Table 5-Hypothesis tests.

	Hypothesis 1	**Hypothesis 2**	**Hypothesis 3**	**Hypothesis 4**
IBRX	Rejection	Rejection	Non-rejection	Rejection
IGCT	Rejection	Rejection	Non-rejection	Non-rejection
MLCX	Rejection	Rejection	Non-rejection	Non-rejection
UTIL	Rejection	Rejection	Non-rejection	Non-rejection
IMOB	Rejection	Rejection	Rejection	Rejection
SMLL	Rejection	Rejection	Non-rejection	Rejection
IMAT	Rejection	Rejection	Non-rejection	Non-rejection
INDX	Rejection	Rejection	Non-rejection	Rejection
IFIX	Rejection	Rejection	Rejection	Rejection
ITEL	Rejection	Rejection	Rejection	Rejection
IEE	Rejection	Rejection	Non-rejection	Rejection

Table 6 presents a summary of the results of the performance of the gold against the indexes investigated, showing that gold acted as a hedge and as a low value refuge for the IBrX 100, IEE, INDX and SMLL indexes, and that it acted as a low safe haven, although it did not act as a hedge for the ITEL, IFIX and IMOB indexes. Finally, we verified that gold acted as hedge, although it did not act as safe haven (neither strong nor weak) for the IMAT, UTIL, MLCX and IGCT indexes. It is clear that gold has always acted either as hedge or as weak safe haven for the indexes analyzed. Also noteworthy is the fact that gold did not act as a strong refuge value against any of the indexes analyzed.

Table 6 – Hypothesis tests.

Index	**Results**
IBrX 100	It acts as a hedge and as a weak safe haven
IEE	It acts as a hedge and as a weak safe haven
INDX	It acts as a hedge and as a weak safe haven
IMOB	It does not act as hedge, but acts as a weak safe haven
IMAT	It acts as a hedge, but does not act as a safe haven (neither strong nor weak)
UTIL	It acts as a hedge, but does not act as a safe haven (neither strong nor weak)
ITEL	It does not act as hedge, but acts as a weak safe haven
IGCT	It acts as a hedge, but does not act as a safe haven (neither strong nor weak)

MLCX	It acts as a hedge, but does not act as a safe haven (neither strong nor weak)
SMLL	It acts as a hedge and as a weak safe haven
IFIX	It does not act as hedge, but acts as a weak safe haven

5. CONCLUSIONS

Investors and the financial media believe that the price of gold tends to move in the opposite direction of the stock price. Opposite direction movements would open the possibility of using gold as diversification and/or safe haven against extreme movements of BM & Bovespa.

In this paper, we tested whether gold acted as a hedge and as a safe haven against extreme movements in the Brazilian stock market during the period from 2000 to 2016. For this purpose, we used a likelihood ratio test to analyze the structure of dependence between gold and BM & FBovespa indexes. Initially, using the extreme values theory, we identified extreme movements in both markets and, thus, we could verify conditional dependence between gold and the stock market through the formulation of hypotheses.

From the analysis of the data, we obtained the following results for the period studied: (i) gold acted as an effective hedge and as a weak safe haven for the IBrX 100, IEE, INDX and SMLL indexes, which means that gold remained in a non- extreme state while these indexes have moved in an extreme way, guaranteeing protection to the investors in those moments; (ii) gold was a weak safe haven, although it did not act as a hedge for the ITEL, IFIX and IMOB indexes and (iii) gold acted as hedge, although it did not act as a safe haven (neither strong nor weak) for the IMAT, UTIL, MLCX and IGCT indexes. It is clear that gold, in all cases, acted either as a hedge or as a weak safe haven for the indexes analyzed, which indicates that including gold in an investment portfolio provides hedge benefits and safe haven for the investor. Also noteworthy is the fact that gold did not act as a strong refuge value against any of the indexes analyzed. This finding is consistent with the results found by Baur and Lucey (2010) and Baur and Mcdermott (2010), which verified that while in developed countries gold played a strong safe haven, in developing countries (Brazil included) gold predominated as a weak safe haven. This, according to the authors' speculation, could be due to the fact that developing countries could resort to other instruments of protection, such as the exchange rate or even securities of developed countries, before it was even necessary to resort to gold as a protection instrument.

We believe that this work may open space for more research on this subject, especially considering the work of Baur et al. (2014) to collaborate with the development of studies that allow the formulation of gold price forecast models in relation to several economic variables (e.g., stock indexes, commodity prices, US government bonds, exchange rates and currency depreciation).

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[i] The ITEL index had its last edition in 2012