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Exploring Arbitrage Strategies in Corporate Social Responsibility Companies

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Abstract: Today, Socially Responsible financial investment has taken on particular importance. Investors normally select their most profitable investments, but over the years they have appreciated that companies develop Socially Responsible policies. Financial indices have also created Socially Responsible versions. In this paper, we run a statistical arbitrage technique known as Pairs Trading using stocks of the FTSE4GOOD Socially Responsible Index. Different strategies will be tested to demonstrate that there are no significant differences between the performance of the portfolio composed by Corporate Social Responsibility (CSR) stocks and those composed by ordinary stocks.

Keywords: Corporate Social Responsibility; Hurst exponent; Pairs Trading; correlation; co-movement

1. Introduction

Socially responsible investment (SRI) can be defined as decision making based on environmental and social criteria and not exclusively on financial results [1,2]. This type of investment can also be called ethical, green or sustainable investment [3].

Berlarsi et al. [4] has focused on whether the company's financial situation can be improved by opting for a socially responsible policy. The studies focus on the relationship between three factors: performance, financial results and the quality of business sustainability [5].

It is not clear the association between Corporate Social Responsibility (henceforth CSR) and financial performance. Part of the financial literature find a negative association because CSR supposes a cost. Jaggi and Freedman [6], Molloy et al. [7] and Clarkson and Li [8] report a mixed or negative relationship between environmental performance measures and accounting profitability.

Zhang and Guo [9] find that there is no significant relationship between social responsibility and corporate market performance and that indicators have stronger explanatory power than market indicators.

On the other hand, there are other studies that confirm that companies that apply socially responsible policies obtain higher financial returns [10–12]. Herremans [13], McGuire et al., [14] and Barnett [15] determine that benefits of CSR, such as increase in employee morale, goodwill, etc, exceed its costs. Pava [16] and Cochran and Wood [17] also find weak evidence to suggest that a positive association exists.

Alexander and Buchholz [18], Waddock and Graves [19] and Clarkson et al., [20] introduce a financial resources approach arguing that only firms with enough resources are able to invest in CSR, that is why CSR is associated with a better performance than others. Wang and Sarkis [21] use a sample of 1980 firms from the top 500 Green companies in the United States for a period of 5 years

(2009–2013) to conclude that implementation of CSR governance contributes influences positively in the financial performance.

Ameer and Othman [22] find that companies focused on sustainability practices have better financial performance compared to those without such commitments in some activity sectors. Katsikides et al. [23] used the "event-study" methodology to analyse the relationship between Corporate Social Responsibility (CSR) and stock market performance finding that some CSR events have a significant effect on stock market performance. Artiach et al. [24] find that Dow Jones Sustainability Index (DJSI) firms are significantly different from other firms on the dimensions of size, profitability and level of growth options. Brammer et al. [25] investigated the relationship between CSR and financial performance, measured using stock returns, for a sample of UK quoted companies. Authors found that firms with higher social performance scores tend to achieve lower returns, while firms with the lowest possible CSR scores of zero outperformed the market. Lins et al. [26] found that firms with high CSR ratings outperform firms with low CSR ratings during the financial crisis by at least four percentage points. However, authors also found that this excess return disappeared during the recovery period after the crisis.

A third group reports no direct association between CSR and financial performance. Ullmann [27] argues that the relationship between CSR and financial performance is complex and difficult to determine. The studies by Lee [28], Becchetti et al. [29] and McWilliams and Siegel [30] did not find evidence of a relevant association between CSR and financial performance.

In a similar line are the results obtained in the financial literature regarding to the performance of SRI funds. Pioneers works of Diltz [31], Guerard [32] and DiBartolomeo and Kurtz [33] reported a better performance than unscreened ones.

Statman [34] found that the SRI slightly outperformed the S&P 500 over a period of 8 years. Cox et al. [35] extended the analysis to the US market finding that poor corporate social performance leads to a reduction in the number of long-term institutional investors holding the firm's stock. Using a factor model, Derwall et al. [36] concluded that a stock portfolio consisting of companies labeled "most ecoefficient" sizably outperformed its "less ecoefficient" counterpart over the period 1995–2003. Konar and Cohen [37] reported that market value of firms in the S&P 500 that make reduction in emissions of toxic chemicals results in a increase in market value. Belghitar and others [38], analyze the mean variance between the FTSE4GOOD and conventional investments in which they show that there are no significant differences between those indices. Sariannidis et al. [39] studied the impact of several macroeconomic variables on the Dow Jones Sustainability and Dow Jones Wilshire 5000 indices; using the GARCH method with monthly data, they found that the sustainability index reacts with a one-month delay to changes in oil and 10-year bond prices; they therefore concluded that we are facing inefficient markets and investors will wait to see trends in macroeconomic data before investing in socially sustainable securities.

El Ghoul et al. [40] found that companies with a better reputation for CSR enjoy significantly lower equity costs; therefore, these companies have higher value and lower risks. Chen et al. [41] found that those companies with better CSR performance can reduce their idiosyncratic risk. In other words, companies that develop a CSR can improve operational performance and ensure continuous cash flow in the long term and save on capital costs in the short term, thus creating overall value for the company [42].

However, Geczy et al. [43] and Teper [44] and White [45] found a negative one. Also, Bauer et al. (2005) [46] found that US and German ethical funds underperform their benchmark in terms of their risk-adjusted returns. Ziegler et al. [47] tested an investment strategy consisting in buying eco stocks and selling stocks of firms with little or null climate change mitigation polices. Authors obtained a negative abnormal return. Barnet and Soloman [48] extended the analysis to a panel of 61 SRI funds. Authors showed that the relationship between financial and social performance is neither strictly negative nor strictly positive. This paper also found that some types of social responsibility are linked to higher financial performance than others.

This work tries to obtain new evidences of the profitability of investment strategies based on CSR criteria using statistical arbitrage techniques. We will prove that CSR does not affect significantly to the arbitrage strategies and an investor which runs his investment based on CSR criteria is able to obtain a similar performance than other investors. For that, we will take the components of the FTSE4GOOD index (FTSE4Good refers to a series of stock market indices on the London Stock Exchange, which groups together companies with sound environmental, social and governance practices. [49]) and the FTSE100 index (FTSE-100 is the benchmark stock index of the London Stock Exchange. It comprises the 100 largest market capitalisation companies in the UK.) to run a Pairs Trading strategy in different scenarios.

Pairs Trading is an investment strategy based on the notion of two stock quotes *co-movement* with each other. If the two prices differ, a long-short position can be used to benefit from the expected future price reconversion. Although pairs can be formed from fundamental similarities between firms, the modern embodiment of the strategy is typically based on statistical principles, choosing stock pairs whose share prices have previously moved very closely according to some statistical measure (Farago et al. [50]).

2. Methodology

Pairs trading is an arbitrage trading strategy consisting in exploiting price movements of assets which are related to each other. This strategy is based on the existence of an equilibrium relationship between pairs of assets.

There is not consensus about the origin of Pairs Trading. A part of the financial literature accept that this methodology was introduced in mid-1980s, when a quantitative analyst of Morgan Stanley, Nunzio Tartaglia, joined a group of experts of different fields to develop a quantitative arbitrage strategy based on securities that had the tendency to move together. Other researchers such us Wilmott [51] attribute to a computer scientist and trader, Gerald Bamberger, the foundation of Pairs Trading earlier than Nunzio.

Financial literature has introduced different methodologies for pair selection. Important contributions are the distance method [52], those based on correlation [53] and cointegration [54], the copula method [55] or Hurst exponent based method [56,57].

2.1. Distance

This approach was developed by Gatev et al. [52] and subsequently applied by Andrade et al. [58], Engelberg et al. [59], Perlin [60], Do et al. [61], Bowen et al. [62] and Do et al. [63]. It will measure the co-movement of two stocks as the squared distance of the standardized price series. In addition, it assumes that the co-movement of the pair will be greater when the distance between their prices is smaller.

The distance squared of the standard stocks prices (EDD) is calculated as follows:

$$EDD = \sum_{t}(S_A(t) - S_B(t))^2 \qquad (1)$$

where S_A and S_B are the standardized prices of A and B shares in period t.

Once the distance between the stocks has been calculated, the pairs with the shortest distance will be chosen.

2.2. Correlation

This method will focus on the selection of values based on the degree of correlation that exists between their returns [53]. To analyze the potential pairs and study their degree of correlation, Pearson correlation coefficient will be used. This coefficient for two stocks (A and B) is given by the expression:

$$\rho = \frac{\sum_{i=1}^{n}(A_i - \bar{A}_i)(B_i - \bar{B}_i)}{\sqrt{\sum_{i=1}^{n}(A_i - \bar{A}_i)^2}\sqrt{\sum_{i=1}^{n}(B_i - \overline{B_i})^2}} \tag{2}$$

where A_i and B_i are the log-return of stocks A and B respectively and $\bar{A}_i$, $\bar{B}_i$ are the mean of A_i and B_i respectively.

The higher the value of this coefficient, the more similar they move, both when faced with increases and decreases in value. Therefore, those pairs of values with a higher Pearson correlation coefficient will be chosen.

2.3. Cointegration

The concept of Cointegration was developed by Engle and Granger [64] and introduced into the field of statistical arbitrage by Vidyamurthy [54].

If P_t^A and P_t^B, are the prices of A and B stocks, and it is assumed that the price of both stocks individually are not stationary, but there is a parameter γ, which converts through the following equation into a stationary process:

$$P_t^A - \gamma P_t B = \mu + \epsilon_t \tag{3}$$

where:

- μ is the mean
- ϵ_t is the residue
- γ is the cointegration coefficient

The regression parameters will be estimated by the Ordinary Least Squares (OLS) method. And finally, to check if the two actions are co-integrated, it will be done through the Augmented Dicey Fuller test, in order to check if the ϵ_t residue is stationary or not.

2.4. Hurst Exponent

Ramos-Requena et al. [56] introduced Hurst exponent as a management tool for statistical arbitrage strategies based on the concept of reversion to the mean. The work that has been done on Pairs Trading, selects pairs looking for stocks that are correlated or co-integrated so that the pair meets the property of mean reversion.

To meet the property of mean reversion the most logical thing to do is to look for pairs with a low H value.

Of the different approaches that have been developed to calculate the Hurst exponent, this paper uses the Generalized Hurst Exponent (GHE) because it is a methodology of relative simplicity and also shows precision with relatively short time series, as is the case with financial series ([65]).

To calculate the Generalized Hurst Exponent (GHE), it will be done as follows:

We consider the following statistic:

$$K_q(\tau) = \frac{<|X(t+\tau) - X(t)|^q>}{<|X(t)|^q>} \tag{4}$$

where X is the time series, τ varies between values 1 and τ_{max} and $< \cdot >$ represents the average of the sample during the time window. Choose τ_{max} as a quarter of the length of the series.

Therefore, the GHE model can be defined through the behavior of the statistic $K_q(\tau)$ given by the power-law:

$$K_q(\tau) \propto \tau^{qH(q)}. \tag{5}$$

It can be said that GHE is calculated by linear regression by taking logarithms in the expressions contained in Equation (5) [66,67].

2.5. Pairs Trading Strategy

In this section, it is shown how the Pairs Trading strategy is calculated:

1. **Price Normalization**. If two assets *A* and *B*, their price is given by P_A and P_B respectively, the series of the pair *AB* will be:

$$log(P_A) - b * log(P_B)$$

where *b* is a constant factor, used to normalize the logarithm of the prices of *A* and *B*.

To calculate the value of *b*, we will use a method introduced in [56,68] that is based on the volatility of stock returns. This factor is calculated as:

$$b = \frac{\sigma(R_A)}{\sigma(R_A)}$$

where R_A is the (logarithmic) return of stock A, R_B is the (logarithmic) return of stock B and σ is the standard deviation.

Once you have the value of factor b, you can say that the volatility of *A* and *B* stocks are the same, therefore both stocks are normalized.

2. **Pair selection**. To select the pairs, it will be done through the methods defined in Section 2 (distancie, correlation, cointegration and Hurst exponent). The study period is one year (250 trading days).

3. **Trading strategy**. Once the values of the pair have been selected, the trading strategy will be carried out. If *s* is the pair series, *m* is the moving average of *s* and σ is the standard deviation of $m - s$, then:

   - If $s > m + \sigma$ the pair will be sold. The position will be closed when $s < m$ or $s > m + 2\sigma$.
   - If $s < m - \sigma$ the pair will be bought. The position will be closed when $s > m$ or $s < m - 2\sigma$.

   The duration of the trading strategy will be 6 months (120 trading days).

3. Experimental Results

In this section, we will apply the statistical arbitrage strategy by taking the daily values of the components of the FTSE100 (see Tables A1 and A2) and FTSE4GOOD indices (see Table A3), for the period from 1 January 2000 to 3 December 2018. The values of these indices are taken from the Yahoo Finance website. To this end, 3 scenarios will be studied. First, the Pairs Trading strategy will be applied by taking values from the FTSE4GOOD index. In the second scenario we will use the stocks of the FTSE100 index and to conclude we will use a similar strategy than Ziegler et al. [47], buying securities from the FTSE4GOOD index and selling those that make up the FTSE100 index.

3.1. Ftse4good Index

The FTSE4Good Index was launched in 2001 by the FTSE Group. The inclusion of a company in the index is based on a range of corporate social responsibility criteria. The index is designed to measure the performance of companies demonstrating strong Environmental, Social and Governance (ESG) practices.

This indicator is revised twice a year, in March and September, to accept new companies and exclude those that are part of the index and no longer meet the sustainability requirements demanded. This indicator was created with the collaboration of UNICEF, the UN children's fund, and uses information provided by EIRIS, the Ethical Investment Research Service.

Table A4 presents the results obtained comparing the 4 most popular methods to select pairs (Distance, Correlation, Cointegration, Hurst) limiting the selection to the stocks of the FTSE4GOOD index, for different portfolios during the period 1 January 2000 until 31 December 2018.

This Table A4 shows that the best option is to select the pairs through the Hurst exponent method, introduced by Ramos-Requena et al. [56]. In this case, according to the sharpe ratio (1.66) and the maximum drawdon (3.20% and 2.80%) the best option is to create a portfolio composed of 40 and 50 pairs. However, the 2 pairs portfolio has the highest average annualized return (6.50%).
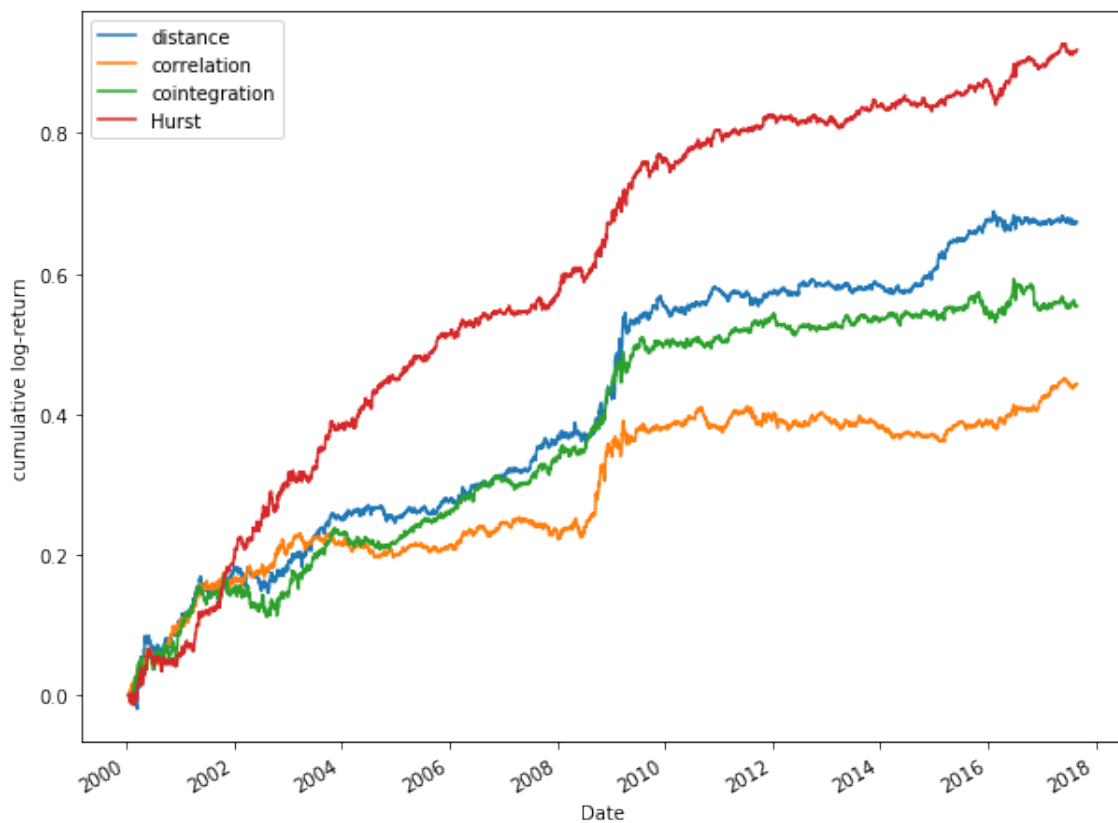

Figure 1. Comparative of accumulated logarithmic returns, for a portfolio of 30 pairs, with FTSE4GOOD stocks, over the period 2000–2018.

Figure 1 shows a comparison of the cumulative returns according to the selection method used, for a portfolio composed of 30 pairs using FTSE4GOOD index values. It can be seen that the best option is to select the pairs through the Hurst exponent method, which is through which greater accumulated logarithmic returns are obtained. The other approaches move in a very similar way, especially the distance and cointegration methods, the worst option being the correlation method.

3.2. Ftse100 Index

Table A5 shows the results obtained for different portfolios, taking the values that make up the FTSE100 index during the period 2000–2018, using different methodologies to select the pairs and for portfolios composed of different pairs.

Table A5 shows the main results obtained. It can be seen that among the different methods used, the best option is to select them through the Hurst exponent method. If it is decided to create a portfolio, the best option would be to have a portfolio composed of 20 pairs, which would obtain an accumulated yield after transaction constants of 124.36%. Looking at the values of the sharpe ratios tells us that the highest return is achieved by investing in the portfolio of 30 pairs (2.01), using Hursts exponent method to select the pairs.
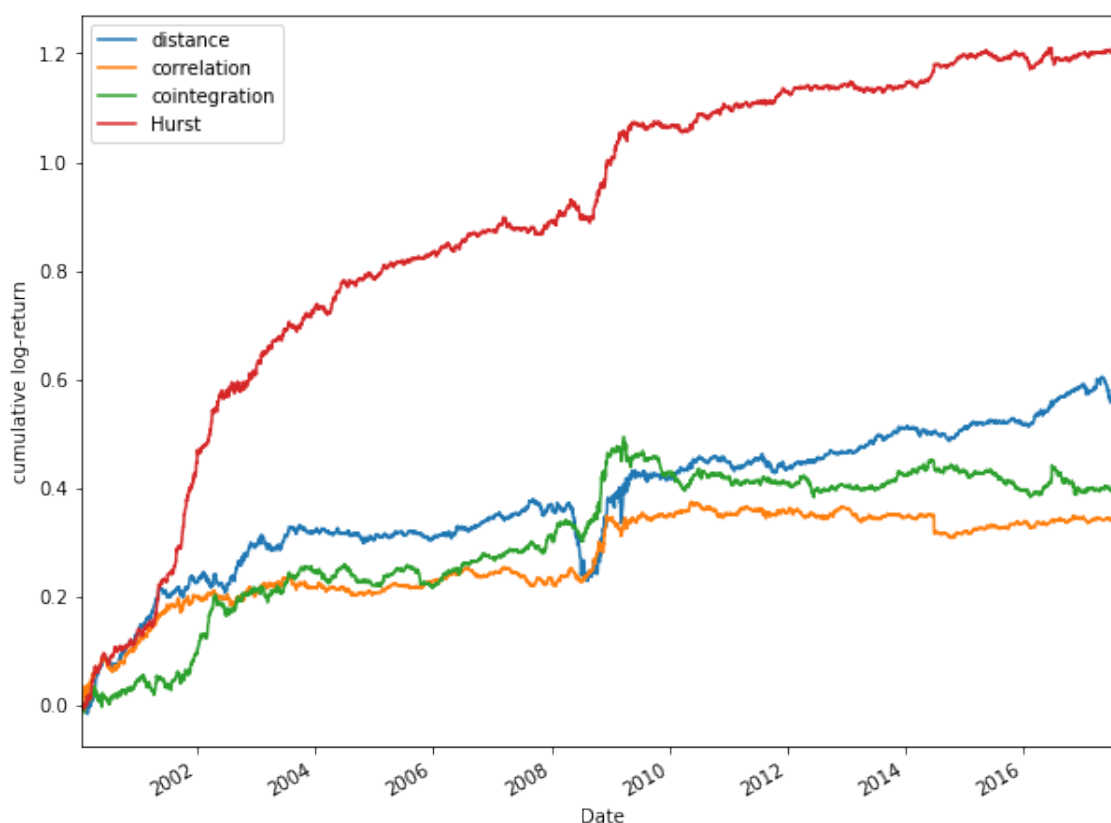
Figure 2. Comparative of accumulated logarithmic returns, for a portfolio of 30 pairs, with FTSE100 stocks, over the period 2000–2008.

Figure 2 shows a comparison between the cumulative logarithmic returns obtained for the different selection methods using the stocks of the FTSE100 index. As in Figure 1, the results obtained by the method based on the Hurst exponent are significant, where a large difference can be observed with respect to the other models.

3.3. Buy Ftse4good Index and Sell Ftse100 Index

In this case, we consider all pairs of stocks that belongs to both FTSE4GOOD and FTSE100 index, but only take a position in a pair when a stock of the FTSE4GOOD index is bought and a stock which belongs to FTSE100 but not to FTSE4GOOD is sold. The rationale of this strategy is that if we consider that stocks in the FTSE4GOOD index will perform better than the stocks that are not in the index, then we will only buy stocks from the FTSE4GOOD index, and we will only sell stocks that does not belong to the FTSE4GOOD index, since the hypothesis is that they will do worse in the long run.

Table A6 below shows the results obtained in the case of purchasing shares that are part of the socially responsible index and selling shares that does not belong to it. For this purpose, different portfolios have been formed, made up of different pairs and for the period from January 2000 to December 2018.

As shown in Table A6, it can be seen that the best option for most of the data is to select the pairs through the Hurst exponent method as in the previous data. If we focus on some of the indicators shown in Table A6 , the best value of the Sharpe ratio is obtained for the portfolio composed of 30 pairs (1.01) and selecting this method. In relation to the maximum Drawdown, we can see that the best option is the portfolio composed of 50 pairs if they are selected through the distance approach (2.60%), it is significant that as the number of pairs that compose the portfolios increases, the best results are obtained for this indicator. Finally, if the results of R^2 are analysed, it indicates that the greatest

robustness is obtained for the portfolios composed of 30 and 50 pairs and selecting them through the distance focus (0.92)

Figure 3. Comparative of accumulated logarithmic returns, for a portfolio composed of 30 pairs, if FTSE4GOOD index securities are bought and FTSE100 securities not in FTSE4GOOD are sold, over the period 2000–2018.

Figure 3 shows the cumulative logarithmic return for a portfolio of 30 pairs, in the event that a decision is made to buy FTSE4GOOD index shares and sell FTSE100 index shares that are not in FTSE4GOOD. When we also consider Figures 1 and 2, it can be seen that the best option is to select the pairs through the Hurst exponent, since it obtains much better results than the rest of the models compared.

Therefore, Tables A4–A6 prove that our arbitrage strategy does not performance better in the case of the generic index (FTSE100) versus the socially responsible index (FTSE4GOOD). Best results obtained for FTSE4GOOD index is when a portfolio of 10 pairs is used while for the the FTSE100 index is 20. In all cases the best methodology is the based on Hurst Exponent.

If the investor decides to buy shares of the FTSE4GOOD index and sell shares of the FTSE100 index (Not included in FTSE4GOOD), it behaves very similar to the traditional Pairs Trading strategy, although the accumulated returns are lower than in the first case. However, this is due to the fact that less transactions occur, so we should focus better in the Sharpe ratio in this case.

On the contrary, no significant differences can be observed in the case of deciding to buy only shares of the sustainable index and sell shares of the generic index, since for all of them the highest profitability is achieved through the Hurst exponent method and with significant differences to the other methods.

Focusing on the values obtained through the Sharpe ratio, it is shown that the best results are obtained for the sustainability index for the portfolio composed of 10 pairs and selecting them through the Hurst exponent (1.44) and for the rest of the portfolios analyzed the best results are for the results obtained through the FTSE100 index (1.89 (20 pairs), 2.01 (30 pairs), 2 (40 pairs) and 1.96 (50 pairs)) selecting the pairs through the same method.

4. Conclusions

This paper tries to provide new evidences of the profitability of investment strategies based on CSR criteria through a statistical arbitrage technique known as pairs trading. We compare the results of a strategy developed exclusively with the companies of the FTSE4GOOD index and a similar one using companies of the FTSE100 index. In addition, we perform a strategy similar to the one proposed by Ziegler et al. [47] consisting in purchasing socially responsible shares and selling not socially responsible ones.

Results show that the arbitrage strategy is profitable in all cases, but surprisingly the best results are obtained in the case of social CSR companies. This finding are similar to the results obtained by Ameer and Othman [22], Katsikides et al. [23], Derwall et al. [36], Statman [34] or Lins et al. [26]. However, the strategy consisting in buying socially sustainable shares and selling those that are not performs worse which is also in accordance with the results obtained by Ziegler et al. [47].

Our results allow us to conclude that investment strategies such as statistical arbitrage are suitable with CSR companies. This also provide evidence that social responsibility does not affect negatively to the market performance. However, it is also risky to conclude that this relationship is positive. We are more in the line of Zhang and Guo [9], Lee [28], Becchetti et al. [29] and McWilliams and Siegel [30] considering that the relationship between market performance and social performance is neither strictly negative nor strictly positive, but difficult to determine. Therefore, it can be seen from the results obtained that a great advantage cannot be obtained by applying the strategy of pairs trading with values from socially responsible companies as opposed to those that are not.

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Abbreviations

The following abbreviations are used in this manuscript:

SRI	Socially Responsible Investment
CSR	Corporate Social Responsibility
DJSI	Dow Jones Sustainability Index
UK	United Kingdom
S&P 500	Standard and Poor's 500 index
US	United States
EDD	Distance squared of the standard stocks prices
GHE	Generalized Hurst Exponent

Appendix A. Stocks Portfolio Componets

Table A1. FTSE100 index.

Ticker	Company
AAL.L	Anglo American
ABF.L	Associated British Foods
ADM.L	Admiral Group
AHT.L	Ashtead Group
ANTO.L	Antofagasta
AV.L	Aviva
AZN.L	AstraZeneca
BA.L	BAE Systems
BAB.L	Babcock International Group PLC
BARC.L	Barclays
BATS.L	British American Tabaco
BDEV.L	Barratt Developments
BKG.L	Berkeley Group Holdings
BLND.L	British Land
BLT.L	Bunzl
BNZL.L	Bunzl plc
BP.L	BP
BRBY.L	Burberry
BT-A.L	BT Group
CCH.L	Coca-Cola HBC
CCL.L	Carnival Corporation & plc
CNA.L	Centrica
CPG.L	Compass Group
CPI.L	Capita plc
CRH.L	CRH plc
DC.L	Dixons Carphone plc
DCC.L	DCC plc
DGE.L	Diageo
DLG.L	Direct Line Insurance Group plc
EXPN.L	Experian
EZJ.L	EasyJet
FRES.L	Fresnillo Plc
GLEN.L	Glencore
GSK.L	GlaxoSmithKline
HIK.L	Hikma Pharmaceuticals
HL.L	Hargreaves Lansdown
HMSO.L	Hammerson plc
HSBA.L	HSBC
IAG.L	International Airlines Group
III.L	3i
IMB.L	Imperial Brands
INF.L	Informa
INTU.L	intu properties plc
ITRK.L	Intertek
ITV.L	ITV plc
JMAT.L	Johnson Matthey

Table A2. FTSE100 index.

Ticker	Company
KGF.L	Kingfisher plc
LAND.L	Land Securities
LGEN.L	Legal & General
LLOY.L	Lloyds Banking Group
LSE.L	London Stock Exchange Group
MDC.L	Mediclinic International plc
MKS.L	Marks and Spencer Group plc
MNDI.L	Mondi
MRW.L	Morrisons
NG.L	National Grid plc
NXT.L	Next plc
PFG.L	Provident Financial plc
PRU.L	Prudential plc
PSN.L	Persimmon plc
PSON.L	Pearson plc
RB.L	Reckitt Benckiser
RBS.L	Royal Bank of Scotland Group
RDSA.L	Royal Dutch Shell
RDSB.L	Royal Dutch Shell plc
REL.L	RELX
RIO.L	Rio Tinto Group
RMG.L	Royal Mail plc
RR.L	Rolls-Royce Holdings
RSA.L	RSA Insurance Group
SBRY.L	Sainsbury's
SDR.L	Schroders
SGE.L	Sage Group
SKY.L	Smurfit Kappa
SN.L	Smith & Nephew
SSE.L	SSE plc
STAN.L	Standard Chartered
STJ.L	St. James's Place plc
SVT.L	Severn Trent
TPK.L	Travis Perkins plc
TSCO.L	Tesco
TUI.L	TUI Group
TW.L	Taylor Wimpey
ULVR.L	Unilever
UU.L	United Utilities
VOD.L	Vodafone Group
WPP.L	WPP plc
WTB.L	Whitbread

Table A3. FTSE4GOOD index.

Ticker	Company
AAL.L	Anglo American
ABF.L	Associated British Foods
AHT.L	Ashtead Group
ANTO.L	Antofagasta
AV.L	Aviva
AZN.L	AstraZeneca
BARC.L	Barclays
BLT.L	Bunzl
BNZL.L	Bunzl plc
BT-A.L	BT Group
CCL.L	Carnival Corporation & plc
CNA.L	Centrica
CPG.L	Compass Group
CRH.L	CRH plc
DGE.L	Diageo
EXPN.L	Experian
FRES.L	Fresnillo Plc
GSK.L	GlaxoSmithKline
HSBA.L	HSBC
IAG.L	International Airlines Group
IHG.L	InterContinental Hotels Group PLC
KGF.L	Kingfisher plc
LAND.L	Land Securities
LGEN.L	Legal & General
LLOY.L	Lloyds Banking Group
LSE.L	London Stock Exchange Group
NFC.L	Next Fifteen Communications Group plc
MCRO.L	Micro Focus International plc
NG.L	National Grid plc
PRU.L	Prudential plc
RB.L	Reckitt Benckiser
RBS.L	Royal Bank of Scotland Group
RDSA.L	Royal Dutch Shell
RDSB.L	Royal Dutch Shell plc
REL.L	RELX
RIO.L	Rio Tinto Group
SLA.L	Standard Life Aberdeen plc
SDR.L	Schroders
SGE.L	Sage Group
SKY.L	Smurfit Kappa
SN.L	Smith & Nephew
SSE.L	SSE plc
STAN.L	Standard Chartered
TSCO.L	Tesco
ULVR.L	Unilever
VOD.L	Vodafone Group
WTB.L	WPP plc
WPP.L	Whitbread

Appendix B. Empirical Results

Appendix B.1. Ftse4good Index

Table A4. Results obtained for the period 2000–2018 for FTSE4GOOD securities; where N is the number of pairs, OP. number of transactions, AAV annualized average profit, $Profit$, profits considering transaction costs of 0.01%.

Method	N	Op.	AAV	Sharpe Ratio [a]	%Max Drawdown [b]	R^2	%Profit
Distance	10	4962	2.60%	0.58	11.50%	0.92	41.14%
Correlation	10	4969	1.90%	0.52	10.90%	0.71	28.83%
Cointegration	10	5005	2.70%	0.57	8.70%	0.91	43.19%
Hurst	10	4993	6.50%	1.44	6.20%	0.96	111.61%
Distance	20	9843	2.80%	0.74	7.10%	0.96	45.98%
Correlation	20	9911	2.10%	0.65	7.50%	0.77	32.34%
Cointegration	20	9861	3.60%	1.01	5.80%	0.95	60.67%
Hurst	20	10,009	5.70%	1.59	3.50%	0.94	97.50%
Distance	30	14,850	3.70%	1.05	4.00%	0.95	61.45%
Correlation	30	14,921	2.50%	0.84	4.10%	0.88	39.33%
Cointegration	30	14,896	3.10%	0.91	5.70%	0.93	50.43%
Hurst	30	15,070	5.00%	1.56	4.00%	0.93	85.68%
Distance	40	19,884	3.50%	1.06	3.60%	0.96	58.63%
Correlation	40	19,957	2.50%	0.92	6.40%	0.84	40.11%
Cointegration	40	19,887	3.20%	0.99	4.30%	0.93	51.83%
Hurst	40	19,962	5.00%	1.66	3.20%	0.93	84.91%
Distance	50	24,968	3.20%	1.02	3.50%	0.96	52.81%
Correlation	50	24.932	2.60%	0.99	7.20%	0.84	42.11%
Cointegration	50	24,681	2.90%	0.95	4.40%	0.94	47.36%
Hurst	50	25,049	4.80%	1.66	2.80%	0.93	81.29%

[a] The Sharpe ratio is a measure of the excess return per unit of risk of an investment. [b] The maximum drawdown measures the difference between the maximum and minimum recorded by the stock between one maximum and the next.

Appendix B.2. Ftse100 Index

Table A5. Results obtained for the period 2000–2018 for FTSE100 stocks; where N is the number of pairs, OP. number of transactions, AAV annualized average profit, $Profit$, profits considering transaction costs of 0.01%.

Method	N	Op.	AAV	Sharpe Ratio	%Max Drawdown	R^2	%Profit
Distance	10	5058	2.30%	0.50	16.90%	0.83	35.74%
Correlation	10	5093	1.70%	0.54	10.90%	0.75	25.51%
Cointegration	10	4935	2.20%	0.45	17.90%	0.62	34.06%
Hurst	10	4863	6.30%	1.23	9.90%	0.65	108.94%
Distance	20	10,051	2.30%	0.58	12.00%	0.84	36.87%
Correlation	20	10,068	1.20%	0.46	9.00%	0.63	16.87%
Cointegration	20	9794	2.20%	0.56	12.60%	0.82	35.10%
Hurst	20	9673	7.20%	1.89	5.20%	0.79	124.36%
Distance	30	14,988	2.80%	0.76	13.60%	0.92	45.00%
Correlation	30	15,146	1.90%	0.79	4.80%	0.73	29.75%
Cointegration	30	14,743	2.70%	0.79	9.90%	0.84	43.39%
Hurst	30	14,622	6.50%	2.01	4.40%	0.81	112.33%

Table A5. *Cont.*

Method	N	Op.	AAV	Sharpe Ratio	%Max Drawdown	R^2	%Profit
Distance	40	19,945	2.90%	0.88	11.90%	0.93	47.91%
Correlation	40	20,099	2.20%	0.95	5.50%	0.82	35.18%
Cointegration	40	19,720	2.50%	0.80	9.30%	0.86	39.27%
Hurst	40	19,615	5.90%	2.00	3.80%	0.84	101.90%
Distance	50	24,878	3.10%	0.97	10.90%	0.95	50.52%
Correlation	50	25,020	2.20%	0.99	4.80%	0.83	35.20%
Cointegration	50	24,566	2.40%	0.84	9.40%	0.87	39.19%
Hurst	50	24,581	5.50%	1.96	4.00%	0.84	93.78%

Appendix B.3. Buy Ftse4good Index and Sell Ftse100 Index

Table A6. Results obtained for the period 2000–2018, if we buy FTSE4GOOD securities and sell FTSE100 securities that are not in FTSE4GOOD; where *N* is the number of pairs, *OP*. number of transactions, *AAV* annualized average profit, *Profit*, profits considering transaction costs of 0.01%.

Method	N	Op.	AAV	Sharpe Ratio	%Max Drawdown	R^2	%Profit
Distance	10	1038	0.60%	0.23	8.80%	0.34	8.46%
Correlation	10	697	−0.30%	−0.19	7.90%	0.41	−5.90%
Cointegration	10	1310	1.00%	0.36	7.10%	0.57	16.49%
Hurst	10	1243	1.60%	0.61	7.30%	0.71	26.66%
Distance	20	2225	0.60%	0.32	3.40%	0.89	9.99%
Correlation	20	1408	0.10%	0.05	3.50%	0.01	0.30%
Cointegration	20	2490	0.30%	0.15	8.10%	0.16	4.65%
Hurst	20	2514	1.60%	0.85	4.30%	0.74	28.34%
Distance	30	3336	0.80%	0.47	2.90%	0.92	12.49%
Correlation	30	2148	0.20%	0.22	3.00%	0.08	2.78%
Cointegration	30	3867	0.40%	0.19	7.80%	0.17	5.81%
Hurst	30	3826	1.60%	1.01	4.10%	0.79	27.92%
Distance	40	4572	0.90%	0.51	2.70%	0.91	13.56%
Correlation	40	3039	0.30%	0.31	2.70%	0.30	3.84%
Cointegration	40	5067	0.40%	0.21	8.00%	0.23	5.83%
Hurst	40	4956	1.30%	0.93	3.90%	0.82	22.86%
Distance	50	5798	0.60%	0.40	2.60%	0.92	9.94%
Correlation	50	4033	0.30%	0.34	2.90%	0.30	4.59%
Cointegration	50	6315	0.30%	0.18	7.20%	0.18	4.44%
Hurst	50	6320	1.00%	0.78	3.80%	0.80	17.54%

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