
Financial ratios applied to portfolio selection: Electre III methodology in buy-and-hold strategy

Indicadores financeiros aplicados à seleção de carteiras: Metodologia Electre III numa estratégia de buy-and-hold

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ABSTRACT

The scope of this paper is to explore and analyze the multi-criteria models, in particular the application of ELECTRE III method, in order to construct defensive portfolios, in a buy-and-hold strategy, where all criteria and alternatives are equally weighed, using financial ratios (ROA, ROE, FA, GL and RL). So being, we firstly selected shares trading in PSI-Geral, from 1999 to 2011, and then defined an initial/historical period, where eight portfolios were established (one for each period), and a follow-up period considering one, two and three-years holdings. We conducted statistical analysis, in particular, parametric (*t-Student*) and non-parametric tests (Kruskal-Wallis and Mann-Whitney tests) tests, subdivided into two analyses: a unit sample analysis from 2005 to 2011; and a two sample analysis, one from 2005 to 2007, and another one from 2008 to 2011. Statistical tests results, for a unit sample and for two samples, lead us to conclude generally that in every follow-up period we cannot infer that one way of calculating portfolio's average profitability and portfolio's Sharpe's index is better than the other statistically, although Mann-Whitney test differentiated certain means.

Keywords: financial ratios; Portuguese index; portfolio management; Electre III

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RESUMO

O objetivo deste artigo é explorar e analisar os modelos multicritério, em especial a aplicação da metodologia ELECTRE III, a fim de construir carteiras defensivas, em uma estratégia de *buy-and-hold*, em que todos os critérios e alternativas são igualmente ponderados, utilizando-se indicadores financeiros (ROA, ROE, FA, GL e RL). Assim sendo, nós primeiro selecionamos ações negociadas no PSI-Geral, de 1999 a 2011, e depois definimos um período inicial / histórico, no qual oito carteiras foram estabelecidas (uma para cada período), e um período de *follow-up*, considerando um, dois e de três anos de espera. Realizamos análises estatísticas, particularmente testes paramétricos (t-Student) e não paramétricos (Mann-Whitney e Kruskal-Wallis), subdivididos em duas análises: uma de amostra única de 2005-2011; e outra de duas amostras, de 2005 a 2007 e de 2008-2011. Os resultados dos testes estatísticos, para uma amostra e para duas amostras, levam-nos a concluir, de modo geral, que, em todo período de *follow-up*, não podemos inferir que uma forma de cálculo da rentabilidade média e do índice de Sharpe da carteira seja estatisticamente melhor que a outra, embora o teste de Mann-Whitney tenha diferenciado certas médias.

Palavras-chave: indicadores financeiros, índice português, gestão de carteira, Electre III

INTRODUCTION

Over the last decades the financial market has been changing tremendously specially due to globalization. So, when the time comes to define which investment(s) to undertake, or in what asset(s) to invest, the decision is often not clear given a set of alternatives. Furthermore, the investment decision may be influenced by all kinds of constraints, both explicit and implicit, generating a multi-criteria decision problem. In this sense and as we all know, for decision-makers the expected returns on various asset classes are key inputs in portfolio decisions. Unfortunately, to determine the best method to estimate expected returns, in a more rigorous and assertive way is a difficult task.

So, by transforming the portfolio management into a multi-criteria problem, and using the ELECTRE III method, we explored

the application of financial theory (financial ratios) to select what assets should be chosen to form a certain portfolio, in a buy-and-hold strategy, and test if it outperforms the market (PSI-20TR).

As referred by Yap, Yong and Poon (2010), financial theory has been very successful in distinguishing the weak companies from the healthy ones. In this sense, supported by the company's financial statements, financial theory provides information about its solvency position and its borrowing power, and whether it is a suitable investment to consider, through financial ratios and studies of trends. This idea is enhanced by several studies, for instance, Beaver (1966), Altman (1968), Ohlson (1990), Taffler (1983), Wood and Piesse (1987), Inman (1991), Ganelasingam and Kumar (2001), Cybinski (2001), and Sori and Jalil (2009) among many others.

Within the different available models, financial ratios are of particular importance: they have long been regarded as barometers of corporate health, and have been used for reporting liquidity, leverage, activity and profitability, and an investor may use them to assess a company's performance and its future prospect of success (Green, 1978; Gibson, 1982; Chen & Shimerda, 1981; Gardiner, 1995; Yap, Yong and Poon, 2010).

Thus, this paper is organized as follows: first, the multi-criteria decision-making problem and the ELECTRE III method's main features are presented. Then, the linkage between financial ratios and portfolio management is explored. Subsequently, empirical tests are performed, followed by the analysis of results. Finally, the main conclusions are drawn.

THE RELEVANCE OF PORTFOLIO CONSTRUCTION AND MONITORING, AND THE ELECTRE III METHOD

THE BASIS OF MULTI-CRITERIA DECISION-MAKING MODELS

A decision problem, according to Roy (1991), is a representation of an element of a global decision. Zbigniew and Watróbski (2008) divide the decision alternatives into realistic alternatives (corresponding to a project whose implementation is feasible) and unrealistic ones (which can include contradictory goals and can be used only for the debate). When solving multi-criteria decision problems, the

difficulty is in the requirement to include alternatives judgments (choice alternatives) from various points of view, which refers to multi-criteria judgments (Escobar-Toledo & López-García, 2005).

To do so, Zbigniew and Watróbski (2008) consider that the definition of a decision problem consists of a two-element process, (C, θ) , where C represents a set of criteria, describing relations between properties of decision alternatives and preference levels of considered alternatives; and θ represents a set of meta-data of a decision situation, consisting of the decision-maker's expectations about a decision situation. The fundamental element of the meta-data set θ is the choice of a problematic situation according to the following (Roy, 1991):

- problem α – the choice problem (finding a subset of the set A which includes only the best solutions);
- problem β – the sorting problem (assigning alternatives to defined categories);
- problem γ – the ordering problem (constructing a ranking of alternatives in the set A from the best one to the worst one).

Such an approach considers only a part of the decision process. Applying multi-criteria methods to analyze a decision situation requires the deliberate choice of a method suitable for a given decision situation, for instance the ELECTRE method. The goal of the mentioned choice is to find the multi-criteria transformation F which fulfils, $F(C, \theta) \rightarrow \max u$, where u is an indicator of a decision-maker's satisfaction, measured by his preferences.

THE ELECTRE III METHOD'S MAIN FEATURES

ELECTRE methods, from the "European school", are considered relevant methods when speaking about multi-criteria decision problems, as stated by Buchanan, Sheppard and Vanderpooten (1999), Kangas, A., Kangas, J. and Pykäläinen (2001), Figueira, Mousseau and Roy (2005) (following the studies of Roy, 1991, Roy & Bouyssou, 1993, and Schärflig, 1985), Tervonen et al. (2005), Hanandeh and El-Zein (2006), Wang (2007), and Afshari, Mojahedet al. (2010), among many others.

So, ELECTRE methods are developed in two main phases. Firstly the *construction of the outranking relations*, and secondly the

exploitation of those relations to get the final ranking of the alternatives. In the *exploitation procedure*, recommendations are elaborated from the results obtained in the first phase.

Being ELECTRE method based on criteria, it is important to distinguish two sets of parameters: the *importance coefficients* and the *veto thresholds*. The *importance coefficients* in ELECTRE methods refer to intrinsic “weights”: for a given criteria the weight, w_j , reflects its voting power when it contributes to the majority which is in favor of an outranking. The *veto thresholds* express the power attributed to a given criteria to be against the assertion “ a outranks b ”, when the difference in the evaluation between $g(b)$ and $g(a)$ is greater than this threshold. These thresholds can be constant along a scale or it can also vary.

In *ELECTRE methods*, an indifference threshold q , a preference threshold p , and an additional binary relation Q are introduced. So, the above relations are redefined to:

$$\begin{aligned} aPb_h \text{ (} a \text{ is strongly preferred to } b_h) & \Leftrightarrow g(a) - g(b_h) > p \\ aQb_h \text{ (} a \text{ is weakly preferred to } b_h) & \Leftrightarrow q < g(a) - g(b_h) \leq p \\ aIb_h \text{ (} a \text{ is indifferent to } b_h \text{, and } b_h \text{ to } a) & \Leftrightarrow |g(a) - g(b_h)| \leq q \end{aligned}$$

The definition of these thresholds will allow the testing of all the alternatives that outrank the relation aSb_h “ a is at least as good as b_h ” or “ a is not worse than b_h ”. So, this gives rise to one of the following four situations:

- [aSb_h and not(b_hSa)] ó aPb (a is strictly preferred to b);
- [not(aSb_h) and b_hSa] ó aRb (a is incomparable to b);
- [aSb_h and b_hSa] ó aIb (a is indifferent to b);
- [not(aSb_h) and not(b_hSa)] ó aRb (a is incomparable to b).

In ELECTRE III, the outranking relation requires the definition of a *credibility index*, which characterizes the credibility of the assertion aSb_h - “ a outranks b ” - being defined by using the *concordance index* and a *discordance index* for each criterion g_j in F^1 .

The concordance index $c_j(a, b)$ is calculated for each pair of alternatives (a, b) in terms of each decision criterion. The comprehensive

¹ To test the assertion aSb_h (or b_hSa), two conditions should be verified: -*Concordance condition*: for an outranking aSb_h (or b_hSa) to be accepted, a “sufficient” majority of criteria should be in favor of this assertion; and -*Non-Discordance condition*: when the concordance condition holds, none of the criteria in the minority should oppose to the assertion aSb_h (or b_hSa) in a “too strong way”.

concordance index $c(a, b)$ is the sum of the concordance indexes $c_j(a, b)$ on each criterion weighed by the weights of each criterion. Thus,

- if the performance of a is greater or equal to that of b , or if the performance of a is smaller to that of b but a staying indifferent to b then $c_j(a, b) = 1$;
- if b is weakly preferred to a : $c_j(a, b)$ is obtained with an linear interpolation and is between 0 and 1;
- if b is strictly preferred to a then $c_j(a, b) = 0$.

So, the formula comes as,

$$c_j(a, b) = \begin{cases} 1 & \text{if } g_j(a) + q_j(g_j(a)) \geq g_j(b) \\ 0 & \text{if } g_j(a) + p_j(g_j(a)) \leq g_j(b) \\ g_j(a) + q_j(g_j(a)) < g_j(b) < g_j(a) + p_j(g_j(a)), & \text{otherwise} \end{cases} \quad [01]$$

where, $q_j(.)$ and $p_j(.)$ are the indifference and preference threshold values for criteria c_j (Belton & Stewart, 2001).

The next step is to calculate the discordance index $d_j(a, b)$ for all the alternatives in terms of each decision criterion according to the following formula:

$$d_j(a, b) = \begin{cases} 1 & \text{if } g_j(b) \geq g_j(a) + v_j(g_j(a)) \\ 0 & \text{if } g_j(b) \leq g_j(a) + p_j(g_j(a)) \\ g_j(a) + p_j(g_j(a)) < g_j(b) < g_j(a) + v_j(g_j(a)), & \text{otherwise} \end{cases} \quad [02]$$

where, $v_j(.)$ is the veto threshold for criteria c_j (Belton & Stewart, 2001). If no veto threshold is specified, then $d_j(a, b) = 0$ for all pairs of alternatives.

Finally, the credibility index $\rho(a, b)$ is defined as follows,

$$\rho(a, b) = \begin{cases} c(a, b), & \text{if } d_j(a, b) \leq c(a, b), j = 1, \dots, n \\ c(a, b), & \prod_{j \in J(a,b)} \frac{1 - d_j(a, b)}{1 - c_j(a, b)} \text{ otherwise} \end{cases} \quad [03]$$

where,

$$c(a, b) = (\sum_{j=1}^m w_j c_j(a, b)) / (\sum_{j=1}^m w_j)$$

$J(a, b)$ is the set of criteria for which $d_j(a, b) > c(a, b)$. The credibility index is a measure of the strength of the claim that “alternative a is at least as good as alternative b ” - aSb .

To notice that, when $d_j(a, b) = 1$, it implies that $\rho(a, b) = 0$, since $c(a, b) < 1$.

Next, the descending and ascending distillation procedures (Belton & Stewart, 2001; Rogers et al., 1999) must be applied based on the credibility index, in order to construct the two pre-orders for the alternatives. Being defined the two pre-orders, they are combined to get the final overall ranking of alternatives.

THE IMPORTANCE OF FINANCIAL THEORY

When considering financial theory, and financial ratios in particular, it is inevitable to reflect on how financial data can add knowledge to our understanding of why some firms cease to grow, discontinue, fail, or go into bankruptcy – the worst nightmares of investors. That’s why research on default prediction has been conducted for many decades and a very large number of empirical studies have been published since the pioneering work of Beaver (1966, 1968) and Altman (1968).

More recently, Romacho and Cidrais (2007) studied how and to what extent the announcement of accounting results influence the behavior of investors in capital markets. They concluded, on the one hand, that the most liquid assets have increased profitability, mainly in the pre-announcement of results. On the other hand, in less liquid assets, an increase in profit variability was verified, before and after the announcement of results (although investors have anticipated the results, they continued to feel the need to adjust their behavior after the disclosure of results). In short, investors attribute value to the publication of results, and that reflects on the price of assets and the variability of equity returns, but also in the number of transacted assets. So, the announcement of companies’ results affects the liquidity of these assets, being this idea supported by Beaver’s study (1968).

Jagric et al. (2007) tell us that, historically, just about a decade ago, investors were almost exclusively interested in assets having large annual returns or, in other words, assets capable of beating the market. But, seeing many portfolios with outstanding profits collapse, investors became more and more interested in another dimension of the asset's performance: risk. So, there are several statistical measures to assess risk, for instance, Coefficient Beta (β), Sharpe's, Treynor's and Jensen's measures.

2. METHODOLOGY

EMPIRICAL WORK OBJECTIVES AND RESEARCH QUESTIONS

The scope of this work is to give to portfolio management a new perspective in an effort to support the decision-maker in his investment decision. So, the main idea is to transform portfolio management into a multi-criteria problem and use the ELECTRE III method to explore the application of financial theory (financial ratios equally weighed) to select what assets (equally weighed) choose to form a certain portfolio, and test if it outperforms the market (PSI-20TR). So, procedures were initially conducted for a certain (historical) period, and then monitored for a three-years holding period or follow-up period.

In concrete, our empirical tests to ELECTRE behavior face to market measured by PSI-20 TR are:

– Test 1 (*T1*): Is the portfolio average profitability higher than market profitability with ELECTRE III?

– Test 2 (*T2*): Does the portfolio have greater profitability by unit of risk than the market (Sharpe's index) with ELECTRE III?

In order to answer such questions, we conducted a statistic analysis to the follow-up period, in terms of average profitability and risk, through parametric and nonparametric tests: on one hand, a follow-up period as a unit sample; on the other hand, a follow-up period divided into two sub periods (two samples).

METHODOLOGY, DATA , SOFTWARE USED IN EMPIRICAL WORK

Based on Spronk and Hallerbach (1997), our empirical work is characterized as a step-by-step process, where we first selected, from

PSI-Geral, companies' shares traded from 1999 to 2011, expressed as *alternatives* to the model. Within this period from 1999 to 2011, eight historical/initial periods were defined, each one corresponding to a portfolio P_x , being x the portfolio number. Also, for each one of these historical periods, follow-up periods were defined. This procedure allowed us to see how the portfolio behaved over time, as already mentioned, in a buy-and-hold strategy.

Secondly, the decision-maker's preferences are described, reflecting the decision context and comprising the investment objectives the investor wishes to obtain, as well as the imposed constraints (thresholds). In addition, based on financial ratios, decision-makers wish to invest only in a certain class of assets, so the threshold must be defined for each criterion, according to the periods/portfolios previously defined. The preference structure of decision-makers, being based on a multi-criteria problem, is more complex than the mean-variance approach. The decision-maker may have other objectives than financial value maximization, for instance, he may want to achieve a stable growth rate. So, based on an optimization process, processed with ELECTRE III method, possible portfolios were defined, and their performances were monitored across the years, from 2000 to 2011.

As *criteria* we used five financial ratios previously calculated from 1999 to 2011, in order to assess profitability, leverage and liquidity, all of them having the same weight in the model, that is, 20%. In order to analyze each portfolio, we calculated their average for each period defined in table 1.

As *thresholds*, we defined a q , the indifference threshold, and a p , the preference threshold, for each criterion, from 2000 to 2011. Since we followed a buy-and-hold strategy, and constructed defensive portfolios, threshold q corresponds to the annual average of assets without risks – interest treasury bonds 3M – for the periods expressed in table 1; p threshold corresponds to q threshold plus 30% (historically, in average, the market gave us a greater profitability than the assets without risk plus 30%) being applied to ROA and ROE criteria. As to Financial Autonomy, General Liquidity and Reduced Liquidity, thresholds were defined based on the rules applied in the allocation of government subsidies (for instance, Opera-

tional Programme of Human Potential Organization for Enrichment Evaluations [POPH], and National Strategic Reference Framework [QREN]) among others.

Thirdly, variables of the model were previously treated, particularly the closing prices. Concerning the shares' weekly closing prices, from 1999 to 2011, they were adjusted considering splits. Then, respective monthly and annual averages were calculated. The same procedure was applied to PSI-20 TR closing prices.

Fourthly, noticing that not all selected shares were interesting for investment, ELECTRE III software gave us the Ranking Matrix. This information gave us, through an optimization process already described in Section 1, the best to the worst shares according to criteria and thresholds defined, for each portfolio/period. Seeing that ELECTRE III ranks all shares from the best to the worst, it was necessary to select the shares to use in our work. To do so, we selected only those share(s) with at least 50% preference to the others, represented in ranking matrix by the letter "P".

In fifth place, and in order to test our hypothesis, we calculated the profitability and Sharpe's index of each portfolio, and checked their market performance (PSI-20TR) across time. Profitability and Sharpe's index for both portfolio and market are calculated to all periods defined in table 1: first to the historical period, and then to the follow-up periods.

Finally, the average profitability and Sharpe's index were calculated for each follow-up period, one year, two years and three years, for market and ELECTRE, and then parametric tests (*t-Student* test) and nonparametric tests (Mann-Whitney test) were conducted.

So, we started by determining the profitability by share (including dividends), according to the formula,

$$SP_{jt} = \left(\frac{C_{fjt}}{C_{0jt}} \right)^{\frac{1}{n^{\circ} \text{ periodinvested}}} - 1 \quad [04]$$

where,

SP_{jt} is the profitability of share j selected by ELECTRE for period t ;

C_{fjt} is the final capital obtained with certain investment in share j in time t ;

C_{0jt} is the initial capital invested in share j in time t .

and,

$$C_{fjt} = C_0 * [1 + (\frac{CP_t}{CP_{t-1}} - 1)] + Divid_t * n^o \text{ shares}_{t-1} \quad [05]$$

where,

C_{fjt} is the final capital obtained with certain investment in share j in time t ;

C_{0jt} is the initial capital invested in share j in time t ;

CP_t is the share j closing prices for a certain year, from 1999 to 2011. Closing prices were determined by calculating annual average of weekly data for portfolio/period in study;

$Divid_t * n^o \text{ shares}_{t-1}$ are the dividends paid in a certain year, concerning the results obtained in previous year, reinvested by the investor, by purchasing more shares from that company.

Then, portfolio's profitability (P_{pt}) was defined as the share profit average. One must notice that all selected shares had the same weight in the portfolio. Mathematically,

$$P_{pt} = \sum_{j=1}^n r_{jt} * w_{jt} \quad [06]$$

where,

r_{jt} is the profitability of share j in period t , selected by ELECTRE;

n is the number of shares in portfolio;

w_{jt} is the weight of share j in the portfolio.

And, market profitability is calculated according to the formula,

$$MP_t = \frac{CP_t}{CP_{t-1}} - 1 \quad [07]$$

where,

MP_t is the market profitability for period t ;

CP_t is the PSI-20TR closing prices for a certain year, from 1999 to 2011. Closing prices were determined by calculating the annual average of weekly data.

To carry out the empirical work proposed and test the enunciated hypothesis, we defined what companies were traded in the Portuguese Stock Index (PSI-Geral), between 1999 and 2011, defined the portfolio dates, the alternatives of the empirical model, criteria and respective thresholds, all the assumptions expressed in tables above, and collected the following data:

- from PSI-Geral, we selected the companies' shares traded from 1999 to 2011, also named as alternatives of the model (see table 2);
- weekly closing prices relative to shares selected from 1999 to 2011. This data was collected from the Euronext site²;
- weekly closing prices from PSI-20TR from 1999 to 2011. This data was collected from the Euronext site;
- monthly data from interest treasury bonds, 3M, from 1999 to 2011. This data was collected from the Institute for the Management of Treasury and Public Credit, IP (IGCP, IP);
- annual financial data from financial statements (balance sheet, income statement and annex for each company previously selected) from 1999 to 2011. This data was used to calculate financial ratios. Data was collected from the companies' electronic address. Specifically we collected: total asset, equity, net income, current liabilities, cash, clients and inventories;
- gross dividends paid by each company selected, from 2000 to 2011. This information was based on the companies' annual report.

To perform the ELECTRE estimation and construct Ranking Matrix that gives us the best to the worst alternative, we used ELECTRE III software, kindly provided by *Université Paris Dauphine*³.

Table 1 – Portfolios dates

Portfolio n°	Initial / Historical Period	Follow-up Period		
P 1	2000 – 2004	Jan05-Dec05	Jan05-Dec06	Jan05-Dec07
P 2	2001 – 2005	Jan06-Dec06	Jan06-Dec07	Jan06-Dec08
P 3	2002 – 2006	Jan07-Dec07	Jan07-Dec08	Jan07-Dec09
P 4	2003 – 2007	Jan08-Dec08	Jan08-Dec09	Jan08-Dec10
P 5	2004 – 2008	Jan09-Dec09	Jan10-Dec10	Jan10-Dec11
P 6	2005 – 2009	Jan10-Dec10	Jan11-Dec11	
P 7	2006 – 2010	Jan11-Dec11		
P 8	2007 – 2011			

Source: Created by the authors, May, 2012.

² www.euronext.com

³ A note of special thanks to Professor Luis Pacheco, from DCEE, for his prompt cooperation.

Table 2 – Model Alternatives

ALTERNATIVE	TICKER	SECTOR OF ACTIVITY
Banco Comercial Português	BCP	Financial services
Banco Espírito Santo e Comercial de Lisboa	BES	Financial services
Banco Português Investimento	BPI	Financial services
BRISA - Auto-estradas de Portugal, S.A.	BRI	Transportation, construction
CIMPOR - Cimentos de Portugal	CPR	Building materials
COFINA	CFN	Media segment
COMPTA	COMAE	Information Technology and Communication
Corticeira Amorim S.G.P.S., S.A.	COR	Cork industry
EDP - Energias de Portugal	EDP	Energy
ESTORIL SOL, S.G.P.S., S.A.	ESO	Game and related areas such as hospitality
FISIPE	FSP	Textile fibre producer
GRAO-PARA	GPA	Construction industry
IBERSOL	IBS	Food chain management area
INAPA - IPG, SA	INA	Paper
Jerónimo Martins SGPS, SA	JMT	Retail, manufacturing
LISGRAFICA	LIG	Printing and graphic arts
Mota-Engil	EGL	Construction industry
OREY ANTUNES	ORE	Ship industry
Portucel S.A.	PTI	Pulp and paper
Portugal Telecom	PTC	Telecommunications
REDITUS	RED	Business Consulting
Salvador Caetano	TMC	Automotive and Robotics
SEMAPA - Sociedade de Investimento e Gestão	SEM	Conglomerate
Soares da Costa SGPS, S.A.	SCOAE	Civil engineering and construction
SONAE	SON	Conglomerate holding company
SONAE Indústria	SONI	Manufacturing
SUMOL-COMPAL	SUCO	Beverage distributor
Teixeira Duarte	TDSA	Construction industry
Zon Multimédia	ZON	Media holding

Source: Created by the authors, May, 2012.

Table 3 – Definition of criteria and thresholds

Financial Ratios (Models Criteria)		Models Thresholds
		Value
Return on Assets (ROA): Net Income _N / Total Assets _{N-1}	Profitability	P 1 ($p > 3.42\%$; $q \leq 2.63\%$)
		P 2 ($p > 2.88\%$; $q \leq 2.21\%$)
		P 3 ($p > 2.80\%$; $q \leq 2.15\%$)
		P 4 ($p > 2.79\%$; $q \leq 2.14\%$)
		P 5 ($p > 3.14\%$; $q \leq 2.41\%$)
		P 6 ($p > 3.24\%$; $q \leq 2.50\%$)
		P 7 ($p > 3.07\%$; $q \leq 2.36\%$)
		P 8 ($p > 2.90\%$; $q \leq 2.23\%$)
Return on Equity (ROE): Net Income _N / Equity _{N-1}	Profitability	P 1 ($p > 3.42\%$; $q \leq 2.63\%$)
		P 2 ($p > 2.88\%$; $q \leq 2.21\%$)
		P 3 ($p > 2.80\%$; $q \leq 2.15\%$)
		P 4 ($p > 2.79\%$; $q \leq 2.14\%$)
		P 5 ($p > 3.14\%$; $q \leq 2.41\%$)
		P 6 ($p > 3.24\%$; $q \leq 2.50\%$)
		P 7 ($p > 3.07\%$; $q \leq 2.36\%$)
		P 8 ($p > 2.90\%$; $q \leq 2.23\%$)
Financial Autonomy (FA): Equity _N / Total Assets _N	Leverage	$p > 30\%$; $q \leq 25\%$
General Liquidity (GL): (Clients + Stocks + Cash) _N / Current liabilities _N	Liquidity	$p > 1.50$; $q \leq 1.00$
Reduced Liquidity (RL): (Clients + Cash) _N / Current liabilities _N	Liquidity	$p > 1.50$; $q \leq 1.00$

Notes: Concerning ROE and ROA,

- q is the indifference threshold, corresponding to the interest treasury bonds, 3M, annual average, for the defined periods;

- p is the preference threshold, corresponding to q threshold plus 30%.

Source: Created by the authors, May, 2012.

FINANCIAL RATIOS APPLIED TO EMPIRICAL WORK

To define which financial ratios, among the so many found in literature, were useful to evaluate the financial performance and financial condition of a company, we based ourselves on the studies by Beaver (1966), Altman (1968, 2000), Yap, Yong and Poon (2010), and Chen and Shimerda (1981). These authors' searches indicate which ratios are the best predictors of business failures, and conclude that there is no need for many ratios. For instance, Taffler's study (1983) started with eighty potentially useful ratios, and ended up with just four. Thereafter, in our study, five ratios (table 4) were chosen among the many that had been used in previous studies with financial theory. They assess profitability, leverage, and liquidity.

The choice of ratios was based on two main criteria: their popularity, as evidenced by their frequent use in the finance and accounting literature, and their good performance as showed in bankruptcy studies. They are:

a) Return on Assets (ROA): This ratio expresses how much profit a company generated compared to its assets. It is expected to increase over the years. Concerning the established thresholds, we considered the annual average interest rates on treasury bonds, three months. So, q , or indifference threshold, is equal to this value, considering each period (see table 1), and p , or preference threshold, is equal to q plus 30%. In the model, there is a 20% weighting. The formula used was:

$$ROA_N = \text{Net Income}_N / \text{Total Assets}_{N-1} \quad [08]$$

b) Return on Equity (ROE): ROE gives us the ratio between profits and shareholders' equity, and it is expected to have a rate of return higher than the rate of return on treasury bonds to be able to say that the company is really profitable. The amount expected to increase over the years is at least equal to profits minus dividends paid. Concerning the established thresholds, we considered the annual average interest rates on treasury bonds, three months. So, q , or indifference threshold, is equal to this value, considering each period (see table 1), and p , or preference threshold, is equal to q plus 30%. In the model, there is a 20% weighting. The formula used was:

$$ROE_N = \text{Net Income}_N / \text{Equity}_{N-1} \quad [09]$$

c) Financial Autonomy (FA): This ratio, which is related to the company's financial structure, expresses the extent to which the asset is being financed by equity and debt capital. This ratio is expected to increase every year or, at least, to remain stable. The

threshold q was defined based on criteria required by investment projects subsidized by the government. In the model, there is a 20% weighting. The formula used was:

$$FA_N = \text{Equity}_N / \text{Total Assets}_N \quad [10]$$

d) General Liquidity (GL): Liquidity refers to the ability to convert the asset into cash, being some items more liquid than others. So, this ratio measures the extent to which a company has cash to meet immediate and short-term obligations, or assets that can be quickly converted to do so. It is desirable that the ratio exceeds at least the value of 1, meaning that the company has at least liquid assets to meet liabilities in the short term, even without the liquidation of stocks. Threshold q was defined based on criteria required by investment projects subsidized by the government. In the model, there is a 20% weighting. The formula used was:

$$GL_N = (\text{Clients} + \text{Stocks} + \text{Cash})_N / \text{Current liabilities}_N \quad [11]$$

e) Reduced Liquidity (RL): RL measures a company's ability to meet its short-term liabilities with cash provided by its net assets, but in a more demanding way than in the general liquidity ratio, assuming that stocks (stocks of raw materials and intermediate and finished products) will hardly be quickly converted into cash. It is expected to exceed at least the value of 1. Threshold q was defined based on criteria required by investment projects subsidized by the government. In the model, there is a 20% weighting. The formula used was:

$$RL_N = (\text{Clients} + \text{Cash})_N / \text{Current liabilities}_N \quad [12]$$

RESULTS

RESULTS OBTAINED BY HOLDING PERIOD

With the ELECTRE method, we process alternatives, criteria and thresholds, with ELECTRE III software, being the results obtained with a distillation process based on the Credibility Matrix and Ranking Matrix. So, the main results are displayed in table 4, following a descending distillation, that is, from the best alternatives to the worst ones according to their financial performance measured by financial ratios,. Notice that the results are presented by portfolio, and each of them represents a specific period, as explained previously.

Table 4 – Shares selected by ELECTRE

	P1 (00-04)		P2 (01-05)		P3 (02-06)		P4 (03-07)		P5 (04-08)		P6 (05-09)		P7 (06-10)		P8 (07-11)				
1	Orey	1	Cimpor	1	Cimpor	1	Cimpor	1	Cimpor	1	Cimpor	1	Cimpor	1	PT	1	PT	Jerónimo	
2	Ibersol	2	Orey	2	Ibersol	2	Zon	2	Zon	2	PT	2	Brisa	2	Brisa	2	Martins	Martins	
3	Brisa	3	Ibersol	3	PT	3	Ibersol	3	PT	3	Jerónimo	3	Jerónimo	3	Jerónimo	3	Martins	Martins	
4	Cimpor	4	Brisa	4	Semapa	4	PT	4	Reditus	4	Zon	4	Ibersol	4	Ibersol	4	Ibersol	4	Ibersol
5	Semapa	5	Semapa	5	Teixeira Duarte	5	Teixeira Duarte	5	BPI	5	BPI	5	BPI	5	Zon	5	Zon	5	Portucel
6	BPI	6	BPI	6	Orey	6	Sonae	6	Ibersol	6	Portucel	6	Portucel	6	Portucel	6	Portucel	6	Zon
7	PT	7	Cofina	7	Cofina	7	Reditus	7	Jerónimo	7	Jerónimo	7	Ibersol	7	Cimpor	7	Cimpor	7	Cimpor
8	Portucel	8	Teixeira Duarte	8	Brisa	8	Semapa	8	Orey	8	Reditus	8	Reditus	8	Mota Engil	8	Mota Engil	8	EDP
9	Reditus	9	PT	9	Zon	9	Cofina	9	Semapa	9	Semapa	9	Mota Engil	9	EDP	9	EDP	9	Mota Engil
10	Toyota	10	BCP	10	BPI	10	BPI	10	Sonae	10	EDP	10	Semapa	10	Semapa	10	Semapa	10	Semapa
11	BES	11	Mota Engil	11	Sonae	11	Orey	11	Portucel	11	Teixeira Duarte	11	BPI	11	BPI	11	BPI	11	BPI
12	BES	12	Portucel	12	Portucel	12	Jerónimo	12	Brisa	12	Brisa	12	Reditus	12	Reditus	12	Reditus	12	Orey
13	BES	13	Reditus	13	BCP	13	Portucel	13	Mota Engil	13	Semapa	13	Semapa	13	Semapa	13	Semapa	13	Amorim
14	BES	14	Jerónimo	14	Jerónimo	14	Portucel	14	Soares da Costa	14	Soares da Costa	14	Soares da Costa	14	Soares da Costa	14	Soares da Costa	14	Cofina
15	BES	15	Martins	15	Martins	15	Brisa	15	Brisa	15	Brisa	15	Soares da Costa	15	Soares da Costa	15	Soares da Costa	15	Cofina
16	BES	16	BES	16	BES	16	Mota Engil	16	Mota Engil	16	Mota Engil	16	Mota Engil	16	Mota Engil	16	Mota Engil	16	Soane

Source: From ELECTRE III software output estimation, May 2012

From tables 5, 6 and 7 jointly interpreted, we can easily see that in all follow-up holding periods ELECTRE III had better Sharpe's index results than the market. So, monitoring a holding period of 1 year, ELECTRE III behaved much better than PSI-20 TR (-1.27% face to -6.77%), and the average profitability confirms that. In a holding period of 2 years, results are very similar, once again in favor of ELECTRE III (0.6226% for ELECTRE and -6.8551% to PSI). Concerning the average profitability, there is also a big difference in favor of ELECTRE. But the big difference remains in a holding period of 3 years, where ELECTRE III is clearly able to obtain a differential return per unit of risk much high than the market: 3.0272% for ELECTRE III and -6,9733% for PSI. Average profitability confirms these conclusions. These results showed beyond doubt that, in the long run, selecting assets to invest using ELECTRE III method, allow us to obtain better results than the market (PSI-20TR).

Table 5 – Follow-up results, by group (1 year)

Follow-up Results - 1 y		
	PSI	ELECTRE
MEAN	-0.2060%	0.1093%
SHARPE'S INDEX	-6.77%	-1.27%
NUMBER OF OBSERVATIONS	84	84

Source: Created by the authors, September 2012

Table 6 – Follow-up results, by group (2 years)

Follow-up - 2 y		
	PSI	ELECTRE
MEAN	-0.2060%	0.2264%
SHARPE'S INDEX	-6.8551%	0.6226%
NUMBER OF OBSERVATIONS	84	144

Source: Created by the authors, September 2012.

Table 7 – Follow-up results, by group (3 years)

Follow-up - 3 y		
	PSI	ELECTRE
MEAN	-0.2060%	0.3902%
SHARPE'S INDEX	-6.9733%	3.0272%
NUMBER OF OBSERVATIONS	84	180

Source: Created by the authors, September 2012.

RESULTS OBTAINED BY HOLDING PERIOD – PARAMETRIC AND NON-PARAMETRIC TESTS RESULTS

Parametric and non-parametric testes are useful to test the significance of assumptions or factors that may influence the behavior of a variable of reference, where the intent is to test whether or not such assumptions or factors had a significant effect. To do so, we have two methods: *parametric tests* (requiring that the shape of the sampling distribution is known, usually Normal distribution), and *nonparametric tests* (the knowledge of sampling distribution is not required). Whenever possible, one should use parametric tests in place of nonparametric tests, because first tests allow us to obtain more robust results (Maroco, 2007).

In our empirical work, we started by defining a few portfolios, constructed under ELECTRE assumptions, and the behavior of each portfolio was analyzed for a certain period of time. We then observed, in each follow-up period, which performed better: PSI (as market) or ELECTRE. The results would allow us to conclude on the best way to form a portfolio.

Concerning *parametric tests*, two conditions must be verified: (1) if dependent variables have normal distribution, and (2) if population variances are homogeneous, when comparing two or more variables.

To test normality, the most used test is the Kolmogorov-Smirnov test⁴, or alternatively, Shapiro-Wilk test (Shapiro & Wilk, 1965). Levene test is usually used to test variance homogeneity (Levene, 1969). We started by testing if PSI-20 TR and ELECTRE followed, or not, a normal distribution.

T-Student tests whether the mean of a single variable differs from a specified constant one, assuming data are normally distributed. However, this test is fairly robust to departures from normal-

⁴ Usually referred as K-S test.

ity. So, we wanted to test if the average profitability for PSI and ELECTRE differed from zero, at a 95% confidence level, for each follow-up/holding period. Our test hypotheses were:

H_0 : $\mu = 0\%$ (average profitability of Method_i is not significantly different from zero, with $i = \text{PSI}$ and ELECTRE).

H_1 : $\mu \neq, <, > 0\%$ (p average profitability of Method_i is significantly different from zero, with $i = \text{PSI}$ and ELECTRE).

As already stated, nonparametric tests are an alternative to parametric tests, because they do not require a normal variable and variance homogeneity: nonparametric tests are distribution-free tests. One of the alternatives is to use a Wilcoxon-Mann Whitney test (Mann & Whitney, 1947), which is the nonparametric test analog to *t*-Student for independent samples. According to Maroco (2007), this test has a 95.5% level of efficiency (using *t*-Student test as reference). So, having calculated the average profitability for all portfolios (PSI and ELECTRE) and for each follow-up period (1. 2 and 3 years), we wanted to test is if one's distribution was higher than the other, with an error probability of 5%. So, our test hypotheses were:

H_0 : $F(X_i) \geq F(X_j)$ ($F(X_i)$ and $F(X_j)$) is the distribution function, with $i, j = \text{PSI}$ and ELECTRE).

H_1 : $F(X_i) < F(X_j)$ ($i, j = \text{PSI}$ and ELECTRE)

We also used the Kruskal-Wallis test (Kruskal & Wallis, 1952), which is similar to ANOVA one-way test. Our hypotheses were,

H_0 : $F(X_i) = F(X_j) = F(X_k)$ (distributions of dependent variables are identical in k populations).

H_1 : $F(X_i) \neq F(X_j)$ (there is at least one population where the dependent variable distribution is different from the distributions of other populations).

Parametric test results - one sample

From normality test results for the first follow-up period we can conclude that only ELECTRE has a normal distribution for average profitability, according to K-S test with Lilliefors correction, both

with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, they all have homogenous variances, with $p\text{-value} > \alpha = 0.05$. As to the average Sharpe's index, we can conclude that they all have a normal distribution, according to K-S test, with Lilliefors correction, with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, none of them have homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

Concerning *t-Student* test results to average profitability, we can conclude that to first follow-up period, ELECTRE $p\text{-value} = 0.863 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average profitability is not significantly different from 0%. To PSI, $p\text{-value} = 0.745 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average profitability is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $0.173 < 1.96$ and for PSI $-1.96 < -0.327$. Generally, we conclude that none of the ways of determining profitability are significantly different from 0%.

Concerning *t-Student* test results to average Sharpe's index, we can conclude that to first follow-up period, ELECTRE $p\text{-value} = 0.904 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average Sharpe's index is not significantly different from 0%. For PSI, $p\text{-value} = 0.353 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average Sharpe's index is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $-1.96 < -0.121$ and for PSI $0.934 < 1.96$. Generally, we conclude that none of the ways of determining Sharpe's index are significantly different from 0%.

As to the estimation of normality in the second follow-up period, only ELECTRE showed a normal distribution for average profitability, according to K-S test with Lilliefors correction, with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, all have homogenous variances, seeing all $p\text{-value} > \alpha = 0.05$. Concerning average Sharpe's index, only ELECTRE has a normal distribution, according to K-S test with Lilliefors correction, with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, no one have homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

Now, looking to *t-Student* results to second follow-up period, to average profitability, ELECTRE $p\text{-value} = 0.661 > \alpha = 0.05$, meaning

that we cannot reject H_0 . So, with an error probability of 5%, average profitability is not significantly different from 0%. To PSI, $p\text{-value} = 0.745 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average profitability is not significantly different from 0%. All these results are confirmed by t value: for ELECTRE $0.439 < 1.96$ and for PSI $-1.96 < -0.327$. Generally, we conclude that every way of calculating average profitability is not significantly different from 0%.

Analyzing t -Student results to average Sharpe's index, ELECTRE $p\text{-value} = 0.652 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average Sharpe's index is not significantly different from 0%. For PSI, $p\text{-value} = 0.857 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average Sharpe's index is not significantly different from 0%. All these results are confirmed by t value: for ELECTRE $-1.96 < -0.453$ and for PSI $-1.96 < -0.180$. So we conclude that none of the ways of calculating the average Sharpe's index is significantly different from 0%.

As to the estimation of normality in the third follow-up period results show that all the ways present a normal distribution for average profitability, according to K-S test with Lilliefors correction, because all $p\text{-value} < \alpha = 0.05$. Concerning variance homogeneity, all have homogenous variances, seeing all $p\text{-value} > \alpha = 0.05$. Relatively to average Sharpe's index, estimation results reveals that only ELECTRE has a normal distribution, according to K-S test with Lilliefors correction, because $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, none of the ways have homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

As to the average profitability, t -Student results to third follow-up period, ELECTRE had a $p\text{-value} = 0.419 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average profitability is not significantly different from 0%. To PSI, $p\text{-value} = 0.745 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average profitability is not significantly different from 0%. All these results are confirmed by t value: for ELECTRE $0.810 < 1.96$ and for PSI $-1.96 < -0.327$. Generally, we conclude that none of the ways of determining the average profitability are significantly different from 0%.

Concerning the average Sharpe's index, *t-Student* results obtained to third follow-up period, ELECTRE had a $p\text{-value} = 0.761 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, ELECTRE average Sharpe's index is not significantly different from 0%. For PSI, $p\text{-value} = 0.120 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, average Sharpe's index is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE, $0.304 < 1.96$, and for PSI, $-1.96 < -1.563$. So, we conclude that none of the ways of determining the average Sharpe's index are significantly different from 0%.

Nonparametric tests results – one sample

In the first follow-up period, after analyzing Kruskal-Wallis' test results to the average profitability, and based on a $p\text{-value} = 0.902 > \alpha = 0.10$, we cannot reject H_0 , meaning that one way of calculating the portfolio's average profitability is not greater than the other. Now, analyzing the results obtained for the average Sharpe's index, and based on a $p\text{-value} = 0.346 > \alpha = 0.10$, we cannot reject H_0 , meaning that one way of calculating the portfolio's average Sharpe's index is not greater than the other.

Now, Mann-Whitney's test results allow us to conclude that, based on a $p\text{-value} = 0.452 > \alpha = 0.10$, we cannot reject H_0 . So, the average profitability of PSI is greater than the average profitability obtained with ELECTRE, being these conclusions consistent with the observed data: the mean rank is higher for PSI (84,96) than to ELECTRE (84,04), answering to *T1*. For Sharpe's index, results allow us to conclude that, based on a $p\text{-value} = 0.174 > \alpha = 0.10$, we cannot reject H_0 . So, the average Sharpe's index of PSI is greater than average Sharpe's index obtained with ELECTRE, being these conclusions consistent with observed data: the mean rank is higher for PSI (88.04) than to ELECTRE (80.96), answering to *T2*.

In the second follow-up period, after analyzing Kruskal-Wallis' test results to the average profitability, and based on a $p\text{-value} = 0.792 > \alpha = 0.10$, we cannot reject H_0 , meaning that one way of calculating the portfolio's average profitability is not greater than the other way. Analyzing results obtained for the average Sharpe's index, and based on a $p\text{-value} = 0.484 > \alpha = 0.10$, we cannot reject H_0 ,

meaning that one way of calculating the portfolio's average Sharpe's index is not greater than the other way.

Mann-Whitney's test results to average profitability allow us to conclude that, based on a p-value = $0.396 > \alpha = 0.10$, we cannot reject H_0 . So, the average profitability of PSI is greater than the average profitability obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (115.38) than for PSI (112.99), answering to T1. For the average Sharpe's index, results allow us to conclude that, based on a p-value = $0.243 > \alpha = 0.10$, we cannot reject H_0 . So, the average Sharpe's index of PSI is greater than the average Sharpe's index obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (115.38) than for PSI (112.99), answering to T2.

In the final follow-up period, the third, after analyzing Kruskal-Wallis' test results to the average profitability, and based on a p-value = $0.596 > \alpha = 0.10$, we cannot reject H_0 , meaning that one way of calculating the portfolio's average profitability is not greater than the other way. Concerning Sharpe's index, and based on a p-value = $0.829 > \alpha = 0.10$, we cannot reject H_0 , meaning that one way of calculating the portfolio's average Sharpe's index is not greater than the other way.

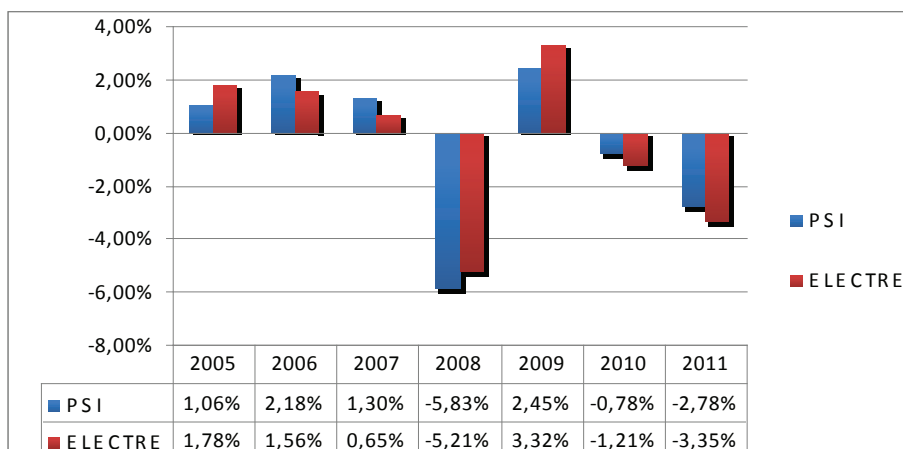
Mann-Whitney's test results to the average profitability allow us to conclude that, based on a p-value = $0.299 > \alpha = 0.10$, we cannot reject H_0 . So, the average profitability of PSI is greater than the average profitability obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (134,20) than for PSI (128.86), answering to T1. To the average Sharpe's index, results allow us to conclude that, based on a p-value = $0.415 > \alpha = 0.10$, we cannot reject H_0 . So, the average Sharpe's index of PSI is greater than average Sharpe's index obtained with ELECTRE, being these conclusions consistent with the observed data: the mean rank is higher for PSI (133.99) than to ELECTRE (131.81), answering to T2.

RESULTS OBTAINED BY HOLDING PERIOD – PARAMETRIC AND NON-PARAMETRIC TESTS RESULTS (TWO SAMPLES)

From charts 1 and 2, we clearly see that there is a big difference in average profitability and Sharpe's indexes between 2005-2007,

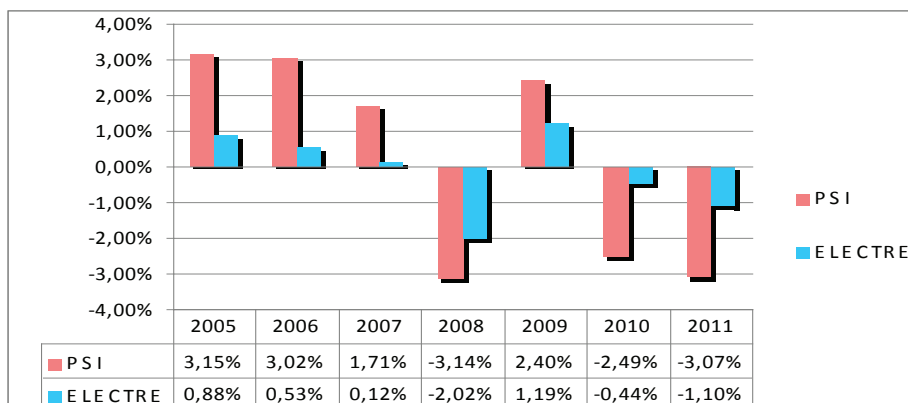
where all average profitability and Sharpe's indexes are positive, and 2008-2011, were all average profitability and Sharpe's indexes are negative (being very negative in 2008), except for 2009. The reason for such behavior lies in subprime crises that affected the Portuguese stock market in 2008.

Chart 1 – Average profitability obtained, by year, in follow-up periods



Source: Created by the authors, September 2012.

Chart 2 – Sharpe's Index obtained, by year, in follow-up periods



Source: Created by the authors, September 2012.

With all this, we subdivided the whole period into two sub-periods, the first occurring before the subprime crises (2005-2007), and the second, after the subprime crises (2008-2011). We then compared if there were significant differences between both means (average profitability and Sharpe's index).

Concerning parametric tests to test normality, as mentioned previously, the most used test is the Kolmogorov-Smirnov test, or alternatively, Shapiro-Wilk test (Shapiro and Wilk, 1965). For variance homogeneity, Levene test (Levene, 1969) is usually the most used. Then, *t-Student* test was conducted for the individual method.

Relatively to nonparametric tests, we conduct a Wilcoxon-Mann Whitney test (Mann & Whitney, 1947) and Kruskal-Wallis tests (Kruskal and Wallis, 1952).

First follow-up sub-period

Regarding the normality test results for the first follow-up of the first sub-period, we can conclude that, for the average profitability, PSI and ELECTRE showed a normal distribution, according to K-S test with Lilliefors correction, all with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, all variances were homogenous, seeing all $p\text{-value} > \alpha = 0.05$. Relatively to Sharpe's index, we can conclude that only ELECTRE had a normal distribution, according to K-S test with Lilliefors correction, all with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, no one had homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

Results obtained with *t-Student* test for the average profitability, with a 95% confidence interval, for ELECTRE subprime $0.013 < \alpha = 0.05$, meaning that we can reject H_0 in favor of H_1 , meaning our average profitability is significant different from 0% with an error probability of 5%. To PSI, $p\text{-value} = 0.059 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, PSI average profitability is not significantly different from 0% despite, to an error probability of 10%, we can reject H_0 meaning average profitability is significantly different from 0% ($p\text{-value} = 0.059 < \alpha = 0.10$). All these results are confirmed by *t* value: for ELECTRE, $1.96 < 2.619$, and for PSI, $1.96 < 2.543$. So, we conclude that all the ways of calculating average profitability are significantly different from 0%, to $\alpha = 0.10$.

Regarding results obtained for the average Sharpe's index, with *t-Student* test, with a 95% confidence interval, ELECTRE showed a *p-value* = 0.007 < α = 0.05, meaning that we can reject H_0 in favor of H_1 , meaning our average Sharpe's index is significantly different from 0% with an error probability of 5%. PSI showed *p-value* = 0.015 < α = 0.05, meaning that we can reject H_0 . So, with an error probability of 5%, all the ways of calculating the average Sharpe's index are significantly different from 0%. All these results are confirmed by *t* value: ELECTRE showed 1.96 < 2.863 and PSI showed 1.96 < 2.546. Thus, we conclude all the ways of calculating the average Sharpe's index are significantly different from 0%.

Based on Kruskal-Wallis estimation results, to average profitability, and based on a *p-value* = 0.770 > α = 0.10, we cannot reject H_0 , meaning that no way of calculating portfolio's average profitability is greater than the other way. Analyzing results obtained to Sharpe's index, and based on a *p-value* = 0.207 > α = 0.10, we cannot reject H_0 , meaning that no way of calculating portfolio's average Sharpe's index is greater than the others.

Regarding Mann-Whitney results for the average profitability, they allow us to conclude that based on a *p-value* = 0.387 > α = 0.10, we cannot reject H_0 . So, the average profitability obtained with PSI is greater than average profitability obtained with ELECTRE, being these conclusions not consistent with observed data: the mean rank is higher for ELECTRE (37.22) than for PSI (35.78), answering to T1. Results to average Sharpe's index allow us to conclude that, based on a *p-value* = 0.105 > α = 0.10, we cannot reject H_0 . So, the average Sharpe's index of PSI is greater than the average Sharpe's index obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (39.61) than for PSI (33.39), answering to T2.

Looking for normality estimation results for the second follow-up period, none of the ways of calculating average profitability have a normal distribution, according to K-S test with Lilliefors correction, with *p-value* < α = 0.05. Concerning variance homogeneity, all variances are homogenous, seeing all *p-value* > α = 0.05. Now looking for estimation results for average Sharpe's index, only ELECTRE has a normal distribution, according to K-S test with Lilliefors correction,

with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, none of the ways have homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

Relative to *t-Student* test results obtained for the average profitability, with a 95% confidence interval, ELECTRE showed a $p\text{-value} = 0.669 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average profitability for ELECTRE is not significantly different from 0%. PSI showed a $p\text{-value} = 0.852 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, PSI average profitability is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $0.429 < 1.96$ and for PSI $-1.96 < -0.187$. Thus, we conclude that all the ways of calculating average profitability are not significantly different from 0%. Now looking to *t-Student* results to average Sharpe's index, ELECTRE had a $p\text{-value} = 0.051 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average Sharpe's index for ELECTRE is not significantly different from 0%. But, to a error probability of 10%, we can reject H_0 , meaning that average Sharpe's index is significantly different from 0% ($p\text{-value} = 0.051 < \alpha = 0.10$). To PSI, $p\text{-value} = 1.320 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, no way of determining the average Sharpe's index is significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $1.96 < 1.984$ and for PSI $1.532 < 1.96$. Thus, we conclude that none of the ways of calculating the average Sharpe's index are significantly different from 0%, except for ELECTRE, with $\alpha = 0.10$.

Analyzing results obtained for the average profitability with Kruskal-Wallis, and based on a $p\text{-value} = 0.405 > \alpha = 0.10$, we cannot reject H_0 , meaning that no way of determining portfolio's average profitability is greater than the others. Considering the results obtained for the average Sharpe's index, and based on a $p\text{-value} = 0.301 > \alpha = 0.10$, we cannot reject H_0 , meaning that no way of determining portfolio's average Sharpe's index is greater than the others.

Results obtained in Mann-Whitney test to find the average profitability allow us to conclude that, based on a $p\text{-value} = 0.204 > \alpha = 0.10$, we cannot reject H_0 . So, the average profitability of PSI is greater than the average profitability obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean

rank is higher for ELECTRE (62.66) than for PSI (57.26), answering to T1. Observing the results obtained for the average Sharpe's index, and based on a $p\text{-value} = 0.152 > \alpha = 0.10$, we cannot reject H_0 . So, the average Sharpe's index with PSI is greater than the average Sharpe's index obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (63.18) than for PSI (56.48), answering to T2.

Relatively to the third follow-up of first sub-period, results of the normality test reveal that only ELECTRE has a normal distribution to the average profitability, according to K-S test with Lilliefors correction, based on a $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, all variances are homogenous, seeing all $p\text{-value} > \alpha = 0.05$. Results estimation for the average Sharpe's index, once again reveal that only ELECTRE has a normal distribution, according to K-S test with Lilliefors correction, based on a $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, there were no homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

Referring to results obtained with *t-Student* for the average profitability, with a 95% confidence interval, ELECTRE showed $p\text{-value} = 0.378 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average profitability for ELECTRE is not significantly different from 0%. PSI showed $p\text{-value} = 0.629 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, PSI average profitability is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $0.885 < 1.96$ and for PSI $0.486 < 1.96$. Thus, we conclude that none of the ways of calculating average profitability are significantly different from 0%.

Results obtained with *t-Student* for the average Sharpe's index in the third follow-up period, with a 95% confidence interval, for ELECTRE $p\text{-value} = 0.077 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average Sharpe's index for ELECTRE is not significantly different from 0%. But, to a error probability of 10%, we can reject H_0 , meaning average Sharpe's index is significantly different from 0% ($p\text{-value} = 0.077 < \alpha = 0.10$). To PSI, $p\text{-value} = 0.042 < \alpha = 0.05$, meaning that we can reject H_0 . So, with an error probability of 5%, the average Sharpe's for PSI index

is significantly different from 0%. All these results are confirmed by t value: for ELECTRE $1.787 < 1.96$ and for PSI $1.96 < 2.081$. Thus, we conclude that none of the ways of calculating average Sharpe's index are significantly different from 0%, except for the market.

With Kruskal-Wallis estimation results to average profitability, and based on a p -value = $0.859 > \alpha = 0.10$, we cannot reject H_0 , meaning that no one way of calculating the portfolio's average profitability is greater than another. Looking to results obtained to Sharpe's index and based on a p -value = $0.583 > \alpha = 0.10$, we cannot reject H_0 , meaning that no one way of calculating portfolio's average Sharpe's index is greater than another.

Relatively to results obtained through Mann-Whitney test for the average profitability, based on a p -value = $0.430 > \alpha = 0.10$, we cannot reject H_0 . So, the average profitability of PSI is greater than the average profitability obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (85.00) than for PSI (83.61), answering to $T1$. To the average Sharpe's index, and based on a p -value = $0.292 > \alpha = 0.10$, we cannot reject H_0 . So, the average Sharpe's index of PSI is greater than average Sharpe's index obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (86.04) than for PSI (81.73), answering to $T2$.

Second follow-up sub-period

Regarding the normality test results for the first follow-up of the second sub-period, for the average profitability we can conclude that all the ways of determining average profitability follow a normal distribution, according to K-S test with Lilliefors correction, both with p -value $> \alpha = 0.05$. Concerning variance homogeneity, all variances are homogenous, seeing all p -value $> \alpha = 0.05$. Concerning the average Sharpe's index, we can conclude that all the ways of determining it follow a normal distribution, according to K-S test with Lilliefors correction, both with p -value $> \alpha = 0.05$.

From results obtained with t -Student test for the average profitability, we can conclude that, with a 95% confidence interval, ELECTRE showed a p -value = $0.359 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, ELECTRE average

profitability is not significantly different from 0%. PSI showed a p -value = 0.114 > α = 0.05, meaning that we cannot reject H_0 . So, with an error probability of 5%, PSI average profitability is not significantly different from 0%. All these results are confirmed by t value: for ELECTRE $-1.96 < -0.923$ and for PSI $-1.96 < -1.609$. Thus, we conclude that none of the ways of calculating average profitability are significantly different from 0%.

For the average Sharpe's index, t -Student results lead us to conclude that, with a 95% confidence interval, ELECTRE showed p -value = 0.026 < α = 0.05, meaning that we can reject H_0 . So, with an error probability of 5%, ELECTRE average Sharpe's index is significantly different from 0%. PSI showed p -value = 0.433 > α = 0.05, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average Sharpe's index calculated to PSI is significantly different from 0%. All these results are confirmed by t value: for ELECTRE $-2.301 < -1.96$ and for PSI $-1.96 < -0.791$. Thus, we conclude that none of the ways of calculating average Sharpe's index are significantly different from 0%, except for ELECTRE.

Considering the Kruskal-Wallis results for the average profitability, and based on a p -value = 0.971 > α = 0.10, we cannot reject H_0 , meaning that no one way of calculating portfolio's average profitability is greater than another. Analyzing results obtained to Sharpe's index, and based on a p -value = 0.012 < α = 0.10, we can reject H_0 , meaning that one way of calculating portfolio's average Sharpe's index is greater than the other.

Results to Mann-Whitney test concerning average profitability allow us to conclude that, based on a p -value = 0.486 > α = 0.10, we cannot reject H_0 . So, the average profitability of PSI is greater than the average profitability obtained with ELECTRE, being these conclusions consistent with the observed data: the mean rank is higher for PSI (48.60) than for ELECTRE (48.40), answering to $T1$. Results to the average Sharpe's index allow us to conclude that, based on a p -value = 0.006 < α = 0.10, we can reject H_0 . So, the average Sharpe's index of PSI is not greater than the average Sharpe's index obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for PSI (55.65) than for ELECTRE (41.35), answering to $T2$.

To second follow-up period, normality results to average profitability also tell us that all the ways of calculating average profitability have a normal distribution, according to K-S test with Lilliefors correction, with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, all variances are homogenous, seeing all $p\text{-value} > \alpha = 0.05$. To average Sharpe's index, estimation results to normality indicate that only ELECTRE has a normal distribution, according to K-S test with Lilliefors correction, with $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, none of the ways have homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

Now, observing the results obtained for the average profitability with *t-Student* test, with a 95% confidence interval, ELECTRE showed $p\text{-value} = 0.705 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, ELECTRE average profitability is not significantly different from 0%. PSI showed $p\text{-value} = 0.114 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, PSI average profitability is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $-1.96 < -0.380$ and for PSI $-1.96 < -1.609$. Thus, we conclude that none of the ways of determining average profitability are significantly different from 0%.

Relative to Sharpe's index, *t-Student* results obtained a $p\text{-value} = 0.052 > \alpha = 0.05$ for ELECTRE, with a 95% confidence interval, meaning that we cannot reject H_0 . So, with an error probability of 5%, ELECTRE average Sharpe's index is not significantly different from 0%. But, to a error probability of 10%, we can reject H_0 , meaning average Sharpe's index is significantly different from 0% ($p\text{-value} = 0.052 < \alpha = 0.10$). For PSI, $p\text{-value} = 0.132 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average Sharpe's index for PSI is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $-1.977 < -1.96$ and for PSI $1.532 < 1.96$. Thus, we conclude that none of the ways of determining the average Sharpe's index are significantly different from 0%, except for ELECTRE, with $\alpha = 0.10$.

Analyzing results obtained with Kruskal-Wallis test to average profitability, and based on a $p\text{-value} = 0.585 > \alpha = 0.10$, we cannot reject H_0 , meaning that no one way of calculating the portfolio's average profitability is greater than another. Regarding results ob-

tained to Sharpe's index, and based on a $p\text{-value} = 0.009 < \alpha = 0.10$, we can reject H_0 , meaning that one way of calculating the portfolio's average Sharpe's index is greater than the other.

Results obtained by Mann-Whitney to the average profitability allow us to conclude that, based on a $p\text{-value} = 0.294 > \alpha = 0.10$, we cannot reject H_0 . So, the average profitability for PSI is greater than the average profitability obtained for ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for ELECTRE (61.92) than for PSI (58.38), answering to T1. To average Sharpe's index, based on a $p\text{-value} = 0.004 < \alpha = 0.10$, we can reject H_0 . So, the average Sharpe's index for PSI is not greater than the average Sharpe's index obtained with ELECTRE, being these conclusions not consistent with the observed data: the mean rank is higher for PSI (70.62) than to ELECTRE (53.75), answering to T2.

Results from normality estimation for the third follow-up period, to average profitability reveal that all the ways of calculating it have a normal distribution, according to K-S test with Lilliefors correction, because all $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, all variances are homogenous, seeing all $p\text{-value} > \alpha = 0.05$. Results estimation to average Sharpe's index also reveal that all the ways of calculating it have a normal distribution, according to K-S test with Lilliefors correction, because all $p\text{-value} > \alpha = 0.05$. Concerning variance homogeneity, there are no homogenous variances, seeing all $p\text{-value} < \alpha = 0.05$.

As to the average profitability, *t-Student* test results obtained a $p\text{-value} = 0.695 > \alpha = 0.05$ with for ELECTRE, with a 95% confidence interval, meaning that we cannot reject H_0 . So, with an error probability of 5%, average profitability for ELECTRE is not significantly different from 0%. For PSI, $p\text{-value} = 0.114 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, PSI average profitability is not significantly different from 0%. All these results are confirmed by *t* value: for ELECTRE $-1.96 < -0.393$ and for PSI $-1.96 < -1.609$. Thus, we conclude that none of the ways of determining average profitability are significantly different from 0%.

Concerning average Sharpe's index, *t-Student* test obtained a $p\text{-value} = 0.165 > \alpha = 0.05$ for ELECTRE, with a 95% confidence interval, meaning that we cannot reject H_0 . So, with an error probability

of 5%, the average Sharpe's index for ELECTRE is not significantly different from 0%. For PSI, $p\text{-value} = 0.433 > \alpha = 0.05$, meaning that we cannot reject H_0 . So, with an error probability of 5%, the average Sharpe's index for PSI is not significantly different from 0%. All these results are confirmed by t value: for ELECTRE $-1.96 < -1.404$ and for PSI $-1.96 < -0.791$. Thus, we conclude that every way of determining average Sharpe's index is not significantly different from 0%.

Analyzing results obtained for the average profitability, with Kruskal-Wallis test, and based on a $p\text{-value} = 0.543 > \alpha = 0.10$, we cannot reject H_0 , meaning that no one way of calculating portfolio's average profitability is greater than another. To Sharpe's index, and based on a $p\text{-value} = 0.224 > \alpha = 0.10$, we cannot reject H_0 , meaning that no one way of calculating portfolio's average Sharpe's index is not greater than the other.

Results to Mann-Whitney estimation, express that based on a $p\text{-value} = 0.273 > \alpha = 0.10$, we cannot reject H_0 . So, average profitability of PSI is greater than average profitability obtained with ELECTRE, being these conclusions not consistent with observed data: the mean rank is higher for ELECTRE (62.08) than for PSI (58.14), answering to $T1$. To Sharpe's index, results allow us to conclude that, based on a $p\text{-value} = 0.113 > \alpha = 0.10$, we cannot reject H_0 . So, the average Sharpe's index of PSI is greater than average Sharpe's index obtained with ELECTRE, being these conclusions consistent with observed data: the mean rank is higher for PSI (65.230) than to ELECTRE (57.35), answering to $T2$.

CONCLUSIONS

The scope of this article is to propose a form to improve estimates on expected returns or portfolio selection, and help investors to decide which the best assets to invest in are. So, transforming this problem into a multi-criteria problem, and using ELECTRE III method, we explored the use of financial theory – financial ratios – in a buy-and-hold perspective and built defensive portfolios, where financial ratios and shares are equally weighed.

Regarding ELECTRE III results, descriptive analysis tell us that for certain portfolios this method behaved better than market (PSI) besides being more efficient (Sharpe's index). Thus, in order to be able to draw an overall conclusion, average profitability and

Sharpe's Index, by holding periods, was calculated for ELECTRE III and PSI. Considering statistical results to a unit sample, non-parametric test (Kruskal-Wallis and Mann-Whitney tests), we can also say that, generally, we cannot reject H_0 , meaning that no way of calculating portfolio's average profitability (empirical hypothesis $T1$) and portfolio's Sharpe's index (empirical hypothesis $T2$) is greater than the other way. But, Mann-Whitney test allow us to differentiate statistically certain means, for instance, to average profitability: PSI vs. ELECTRE (1 year); to Sharpe's index: PSI vs. ELECTRE (1 year), and PSI vs. ELECTRE (3 years).

For two samples, conclusions are different in the second sub-period. Results obtained to the first sub-period, with the *t-Student* parametric test, indicate that for an error probability of 5% and 10%, all the ways of calculating the portfolio's average profitability in a one year holding are different from 0%, except for PSI, when considering an error of 5%. To portfolio's average Sharpe's index, results for one year holding tell that every mean is statistically different from 0%, with an error probability of 10%. In two and three-year holdings, only ELECTRE is statistically different from 0% with an error probability of 10%. Nonparametric tests (Kruskal-Wallis and Mann-Whitney tests) generally failed to demonstrate that, statistically, portfolio's average profitability and the average Sharpe's index can be differentiated for PSI and ELECTRE.

Results obtained in the second sub-period, the parametric test (t-Student) indicates that for an error probability of 5% and 10%, for average Sharpe's Index, only ELECTRE to a one year holding is statistically significant from 0%. All the others are statistically significant from 0%, but only to an error probability of 10%. In a two-year holding, Sharpe's Index means calculated with ELECTRE are significantly different from 0% to an error probability of 10%. Nonparametric tests (Kruskal-Wallis and Mann-Whitney tests) tell us that certain means could be differentiated based on Kruskal-Wallis results, for instance, the average Sharpe's index for one and two-year holdings, to an error probability of 10%. Also with the Mann-Whitney test some means could be differentiated, in particular, to average profitability, PSI vs. ELECTRE (1 year); to average Sharpe's index, PSI vs. ELECTRE (3 years).

With all this, we can say that in a certain sense and attending to sample limitations, the ELECTRE III method proved to be a good tool to select assets to invest in a buy-and-hold perspective, and form defensive portfolios, within shares traded in the Portuguese stock index (PSI). However, the findings left by this empirical work leave us open other lines for future research, for instance, to explore other stock markets, other alternatives as investment funds, use another multi-criteria method as PROMETHEE, or even enunciate other assumptions (criteria and thresholds).

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