ISCTE Business School
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CAPM: AN APPLICATION TO THE PORTUGUESE COMPANIES IN THE RETAIL SECTOR

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Abstract (250 words)

The objective of this study is to estimate the CAPM for the two Portuguese retail companies listed in the PSI-20 (JMT and SON) and assess how the two of them evolve regarding the Portuguese market index.

This study covered sixteen years (pre and post-subprime crisis) and, based on estimation results, we established a comparison between the relation of each company with the PSI-20. We also analysed the differences before and after the 2008 financial crisis. For this purpose, the estimation of α and β coefficients was done by using the OLS method, and the adequacy of the model was checked by verifying the statistical significance of the regression coefficients and the fulfilment of the OLS assumptions.

Finally, the main conclusion is that the two companies tend to behave differently concerning the Portuguese market index. All the beta estimates were statistically significant, meaning that changes in the PSI-20 returns will influence the changes on each company's returns, which is in line with the CAPM. However, except for two periods for JMT, the alpha estimates were statistically significant, meaning that there were additional factors other than the market risk premium that explained the expected value of excess returns. We could also note that the expected returns for JMT went from a negative value (pre-crisis) to a positive value (post-crisis), while for SON there was a decline in the alpha value.

Keywords: Jerónimo Martins (JMT), Sonae (SON), PSI-20, Market risk

JEL codes: C20, G12

Resumo

O objetivo deste estudo é estimar o CAPM para as duas empresas de distribuição portuguesas que estão listadas no PSI-20 (JMT e SON) e avaliarmos como é que elas evoluem em relação ao índice de mercado português.

Este trabalho abrangeu um período de dezasseis anos (pré e pós-crise do subprime) e, com base nos resultados das estimativas, fizemos uma comparação entre a relação de cada empresa com o PSI-20. Posteriormente analisámos as diferenças entre o antes e o após da crise financeira de 2008. Para isso, estimámos os coeficientes α e β através do método OLS e a adequação do modelo foi verificada através da significância estatística dos coeficientes da regressão e do cumprimento das hipóteses do método.

Por fim, a principal conclusão é que as duas empresas tendem a comportar-se de maneira diferente em relação ao índice de mercado português. Todas as estimativas do beta são estatisticamente significativas, o que significa que as mudanças na rendibilidade do PSI-20 influenciam as mudanças nos retornos de cada empresa, o que está alinhado com o CAPM. No entanto, com exceção de dois períodos para a JMT, as estimativas para o alfa são estatisticamente significativas, o que significa que, além do prémio de risco de mercado, há outros fatores que explicam o valor esperado dos retornos em excesso. Também pudemos observar que os retornos esperados para a JMT passaram de um valor negativo (pré-crise) para um valor positivo (pós-crise), enquanto para a SON houve um declínio no valor de alfa.

Palavras-Chave: Jerónimo Martins (JMT), Sonae (SON), PSI-20, Risco sistemático

Códigos JEL: C20, G12

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List of abbreviations

CAPM – Capital Asset Pricing Model

EMH – Efficient Market Hypothesis

Euribor – Euro Interbank Offered Rate

GDP – Gross Domestic Product

JMT – Jerónimo Martins

OLS – Ordinary Least Squares Method

PSI – Portuguese Stock Index

SML – Security Market Line

SON – Sonae

1. Introduction

The objective of this dissertation is to estimate the CAPM (Capital Asset Pricing Model) for the two listed Portuguese companies in the retail sector: Sonae SGPS SA (SON) and Jerónimo Martins SGPS SA (JMT) by using a regression model to estimate and analyse the specific and the systematic risk (beta) of the stocks of these two companies.

The companies that are the subject of the study – Jerónimo Martins and Sonae – are the two largest and more important Portuguese companies in the retail sector and they are listed in the Portuguese stock market (PSI-20 index).

The retail sector encompasses the economic activity that connects producers and consumers by making business transactions through entities like supermarkets and grocery stores, among others. Through these transactions and logistics operations, these entities meet the costumers' needs by providing them products or services in the most convenient and efficient time, place and way (Ferreira, 2011). This sector is also relevant because it is the second widest sector in the PSI-20 index and, together, the two companies have a weight of 14,97%.

Among others, regression analysis is useful and commonly used to forecast future economic conditions; to determine the relationship between two or more variables; and to understand how one variable may change concerning another variable.

Assessing the relationship between risk and return is important when it comes to corporate finance. The CAPM is the most commonly used model to estimate the returns of the assets and to evaluate and predict the market risk of stocks; to evaluate companies by determining the cost of capital; and to help with management functions. Despite the clear limitations of this model, namely being very restrictive, the alternative models do not show higher forecasting ability, they are more complicated to use and require more data.

The research question is: "How does the Portuguese market influence the return of the two stocks of the retail sector?". What is the relation between the Portuguese stock market index and these two companies? Are they related? Do they evolve in the same way as the PSI-20 index or in opposite ways?

This study will cover a time range of 16 years and we will divide it between a before and an after the financial crisis of 2008. The year 2008 was characterized by the subprime mortgage crisis, with the worsening of the macroeconomic environment and volatility of the international financial markets. With the crisis, the confidence in the markets and banks was affected, which generated an environment of uncertainty.

There was a break in the economic growth, which translated into a lowering of the international trade rate, that went from 7.2% in 2007 to 4.6% in 2008. Other impacts of the crisis were the increase in unemployment, lower prices in stock markets, less consumption and less investment, which negatively affected the countries' GDP (Financial report Jerónimo Martins, 2008).

The present study will be an empirical study that might be helpful for parties who are interested in the market, such as investors, by providing some directions and leads. This model also allows company managers to determine the rate of return on investments that the company will need to have to match investors' expectations.

For instance, by looking at the beta estimate, they will know that if the beta is higher than 1, the stock price will be more volatile than the market price; and that, conversely, if the beta is smaller than 1 it means that the stock price is less volatile than the market price. Thus, investors who have risk aversion should invest in stocks with low betas, while investors who prefer taking more risk and possibly win a higher return should invest in stocks with higher betas.

In order to achieve these objectives, this dissertation was divided into five chapters:

In the first one, we began with the introduction of the paper.

In the second chapter, we have a literature review. We started by introducing the two companies that are subject to the study, as well as the Portuguese market index. Then, we introduced the concepts of risk, return and beta, since they are important to understand the CAPM. In this chapter, we also studied important works in finance, such as the

Efficient Market Hypothesis and the Markowitz Portfolio Theory and finally the CAPM model, while describing its assumptions and properties. Since we divided the time length of the period covered in the study into pre and post-subprime crisis, we also explored the crisis in this chapter.

In the third chapter, the data and methodology used throughout our study were described.

In the fourth chapter, we presented the results of the correlation analysis, the estimation and statistical significance of the regression coefficients, the systematic risk, the RESET test, and the tests for the linearity, the normality, the homoscedasticity and no autocorrelation of the errors.

In the fifth chapter, we analysed and discussed the results obtained in the previous chapter and, finally, the main conclusions were presented in the last chapter.

2. Literature review

2.1. PSI-20 index

Euronext is the largest group of stock markets in the world, where more than 100 billion euros per day are traded. It is used in Europe and the United States to trade shares, bonds and commercial paper and it is the leading pan-European operator with the Paris, Amsterdam, Brussels and Lisbon stock exchanges.

The Lisbon Stock Exchange was established in 1769 and more than 200 years later, on 31 December 1992, the PSI-20 (Portuguese Stock Index) was founded, being the main index of Euronext Lisbon. It is vastly used to track the performance of the Portuguese stock market, as it shows how 18 to 20 most actively traded shares listed on Euronext Lisbon behave. Its purpose is to serve as a benchmark of the evolution of the Portuguese stock market (Euronext, 2003).

Due to its characteristics, the market has been selecting the PSI-20 index to help structured products whose profitability depends on the behaviour of the Portuguese stock market (Euronext, 2003).

To calculate the price index, the following formula is used:

$$I_t = \sum_{i=1}^{N} = \frac{Q_{i,t}F_{i,t}f_{i,t}C_{i,t}X_{i,t}}{d_t} \quad \textbf{(1)}$$

Where:

- $\mathbf{I_t}$ is the value of the PSI-20 index on day *t*
- **t** is the time of calculation
- **N** is the number of constituent shares in the index
- $\mathbf{Q_{i,t}}$ is the number of shares of equity of the company *i* on day *t*
- $\mathbf{F_{i,t}}$ is the free Float Factor of share *i*
- $\mathbf{f_{i,t}}$ is the capping factor of equity *i*

- $\mathbf{C_{i,t}}$ is the price of the share *i* on day *t*
- $\mathbf{X_{i,t}}$ is the current exchange rate on day *t*
- $\mathbf{d_t}$ is the index divisor on day *t*

The PSI-20 is comprised by the following companies: EDP, Jerónimo Martins, Banco Comercial Português, Galp Energia, NOS, Redes Energéticas Nacionais, The Navigator Company, Energias de Portugal Renováveis, Sonae, Altri, Semapa, Corticeira Amorim, CTT Correios de Portugal, Mota-Engil, Pharol, Ibersol, Sonae Capital and Ramada.

These companies can be organised by sectors, and the PSI-20 index encompasses the following 12:

- **Banks:** Banco Comercial Português
- **Basic Resources:** The Navigator Company, Semapa, Ramada
- **Construction and Materials:** Mota-Engil
- **Financial Services:** Sonae Capital
- **Food & Beverage:** Corticeira Amorim
- **Industrial Goods and Services:** Altri, CTT Correios de Portugal
- **Media:** NOS
- **Oil and Gas:** Galp Energia
- **Retail:** Jerónimo Martins, Sonae
- **Telecommunications:** Pharol
- **Travel and Leisure:** Ibersol
- **Utilities:** EDP, Redes Energéticas Nacionais, Energias de Portugal Renováveis

The retail sector is the second widest sector in the PSI-20 index, encompassing Sonae and Jerónimo Martins. Together, these companies represent 14,97% of the PSI-20 universe.

2.2. Jerónimo Martins

Jerónimo Martins was established in 1792, weighting 10,18% in the PSI-20 index. It is a group that is mainly focused on food distribution (representing more than 95% of the sales), but also works in specialized retail.

This company is placed in Portugal, Poland, and Colombia, with market leadership positions in the first two countries.

In Portugal, Pingo Doce (with 432 supermarkets) and Recheio (with 39 Cash & Carry and 3 platforms related to Food Service) are leaders in the Supermarket and Cash & Carry segments, respectively. In the specialized retail, Jerónimo Martins is operating Jeronymo, a chain of kiosks and coffee-shops with 22 points of sale and Hussel, with 24 stores, dedicated to chocolates and confectionery. The total sales in Portugal in 2018 were 4,8 billion euros.

Jerónimo Martins also owns Jerónimo Martins Agro-Alimentar (JMA), to ensure there is a supply of some strategic products in the areas of Dairy Products, Livestock (Angus beef) and Aquaculture (sea bass and gilt-head bream).

In Poland, the chain Biedronka operates in 2,900 stores. There is also a chain in the Health and Beauty sector, Hebe, which has 230 stores, and a drugstore chain HebeApteka. In 2018, the total sales in Poland were 11.898 million euros.

In Colombia, the Group owns Ara which has 532 stores, having reached 599 million euros in 2018.

2.3. Sonae

Sonae (Sociedade Nacional de Estratificados) is a multinational company that was founded in 1959, weighing 4,79% in the PSI-20 index.

It is located in 74 countries and operates in retail, financial services, technology, shopping centres, and telecommunications.

In the retail area, Sonae MC is the market leader of food retail, with several brands such as Continente, Continente Modelo and Continente Bom Dia, Meu Super, Bom Bocado, Bagga, Go Natural, Make Notes, Note!, ZU, Well's and Dr. Well's; in the specialized retail in sports and fashion, Sonae S&F is responsible for Sportzone, Berg Outdoor, Berg Cycle, Deeply, Zippy, Losan, MO and Salsa; in the specialized retail in electronics we have Worten and Worten Mobile; and finally, Sonae Retail Properties, that deals with the optimization of the management of its retail real estate portfolio.

Regarding financial services, Sonae FS is responsible for the "Universo" card, "Dá" card, Continente Money Transfer, cross-selling over store credit services and also the insurance broker MDS.

In the field of technology, Sonae IM manages a portfolio of tech-based companies linked to retail and telecommunications: WeDo Technologies, Bizdirect, S21sec, Inovretail, Bright Pixel, and Excellium.

Sonae Sierra also owns of 46 shopping centres spread across 11 countries and responsible for the management and/or leasing of 64 shopping centres.

Finally, in the telecommunications and entertainment area, NOS has a leading position in Pay TV, Next Generation Broadband services and in cinema film exhibition and distribution in Portugal.

2.4. The subprime crisis

Since we are splitting our regression between the period that preceded the collapse of Lehman Brothers and the period right after that happened, it is important to give a background about the subprime crisis.

The financial crisis of 2008 initially began in the United States of America, after the collapse of the speculative bubble in the housing market, and rapidly spread into other segments and countries.

At the beginning of the 2000s, the federal funds rate was lowered, which meant that banks were charging lower interest rates to other banks for lending them money. The result was high liquidity in global financial markets, facilitating mortgage financing (Ackermann, 2008).

With the easing of US monetary policy for a considerable time, more loans were being done, especially for home buyers. The "subprime" mortgages appeared: mortgages made by borrowers who could not really afford the houses, with high credit risk for the lenders. The interest rates for the mortgages were low, which allowed consumers to get big loans while having relatively low monthly payments. This eventually led to home prices rising exponentially, which brought confidence to investors – lenders were relying on the boom in US real estate markets to get bigger revenues.

Back in 2004, the first signs that foreseen what was about to happen started as the interest rates increased and housing prices started to fall. The real estate market began to stagnate: the real estate market was saturated, and with higher interest rates the mortgages became more expensive, so fewer people turned to new mortgages and fewer houses were being bought. Consequently, the prices of houses and real estate began to decline, and mortgages stopped being refinanced (Singh, 2019).

Several US banks linked to the subprime mortgages went bankrupt and investors began losing money. This was due to the rising in the interest rates that led to households with low income not being able to pay the mortgages. As a result, banks hesitated to lend to each other because they could not be sure if they would get the money back (Pritchard, 2019).

The trigger of this crisis, however, was the bankruptcy of the investment bank Lehman Brothers (the fourth-largest investment bank in the US) on September 15, 2008, after the Federal Reserve rejected financial aid to the institution. This had a huge impact since numerous jobs were lost and people were left unemployed, while a scenario of high insecurity and volatility was installed, making people question whether such big financial institutions were reliable and if their money could be trusted in such institutions (Sraders, 2018).

As a consequence, all over the world, the crisis was manifesting itself. In Portugal, there was a significant slowdown in private consumption and a decline in demand that, together with financial difficulties, led to the supply exceeding the demand. The GDP growth then turned negative at the end of 2008 as unemployment increased, which negatively influenced the retail activity.

2.5.Euribor

Euribor (Euro Interbank Offered Rate) is an important reference rate at which twenty panel banks (the ones with the highest volume of business) from Europe borrow funds from one another and it is based on the average interest rates. In total, there are five different Euribor rates that have different maturities, ranging from one week to one year.

Euribor rates are an important benchmark for the price and interest rates of financial products such as interest rate swaps, interest rate futures, saving accounts and mortgages.

2.6. Risk

Risk and return are important aspects to have in consideration when making an investment decision.

For a good definition of risk, we can start by analysing the Chinese symbols for risk: the first, for “danger” and the second, for “opportunity”. That being said, the risk illustrates the relationship between the risk and returns: the higher the risk, “danger” that is taken, the higher the opportunity that might come from it: the returns. So, if an investor is being exposed to risk, he should be rewarded accordingly for taking it (Damodaran, 2015).

Risk can be defined as the standard deviation of the return, the possibility that the actual return from an investment will be different from the expected return (Omisore, Yusuf & Christopher, 2012). This deviation can occur for reasons that are either firm-specific or market-specific, thus, risk can be divided in firm-specific risks (risks that only affect the firm) and market risks (risks that affect all the investments).

To sum up, risk can be defined as the possibility of financial loss, the level of uncertainty that is associated with investment: the bigger the volatility of the returns, the bigger the risk.

2.7. Return

Returns are the main rewards when investing and can be divided into expected returns and realized returns. The expected returns are what the investor is hoping to receive when he invests while the realized returns are what the investor actually receives. Since the expected return is a prediction, it is not certain that it will be the same as the realized return (Omisore, Yusuf & Christopher, 2012).

2.8. Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) is the basis of most financial theories. The EMH started with Paul A. Samuelson but was formalized by Eugene F. Fama in the 1970s and it is still one of the most controversial areas in investment research. The random character of prices is explained as the consequence of rational behaviours. But what is an efficient market?

A capital market is said to be efficient if the actual prices of the assets reflect all the information available at a given moment (Fama, 1970) and if the prices adjust quickly and accordingly to new information (Reilly & Brown, 2012).

For Fama, what matters is the degree of efficiency, not whether the markets are fully efficient. Therefore, financial markets can have three forms of efficiency: weak, semi-strong and strong, depending on the type of information that the prices of assets reflect at any given time.

The weak form is the most restricted set of information and indicates that the current prices reflect all the information given by historical prices, rates of return, trading volume data, among others.

The semi-strong form assumes that the prices adjust to all the public information available in the market, which includes historical data of the asset and relevant public information about the company (announcement of annual earnings, stock splits, etc.), its competitors and the economy in general. The semi-strong hypothesis encompasses the weak form hypothesis.

Finally, the strong form is the set that includes more information and indicates that the prices reflect all the information available that is known and relevant in the market (historical, public and private). This means that no investor has monopolistic access to relevant information in the formation of prices. The strong form encompasses both the weak form and the semi-strong form EMH.

Fama (1970) concluded that there was no relevant evidence against the hypotheses of weak and semi-strong form tests since the prices efficiently adjust to available public information. Regarding the strong form tests, the results are not as conclusive, the evidence is limited, and investors do not seem to have monopolistic access to price information.

Therefore, in an efficient market the assets are always traded at their fair value and their price reflects the information contained in one of the three forms, so, the investors cannot purchase undervalued assets or sell them for higher prices. The only way for an investor to get higher returns on the investments is by incurring in more risk.

2.9. Modern Portfolio Theory

The beginning of the development of theories that relate risk and return was the Modern Portfolio Theory (MPT), also commonly known as mean-variance analysis, which started with Harry Markowitz's article: "*Portfolio selection*", published in 1952 in the *Journal of Finance.*

This theory was formulated to be a tool that would help rational and risk-averse investors to choose optimal portfolios in terms of risk and return based on a given level of market risk. According to the Market Portfolio Theory "an investor selects a portfolio at time *t* - 1 that produces a stochastic return at *t*" (Fama & French, 2004).

One of the assumptions of this model is that investors only care about the mean and variance of their one-period investment return. The intention is to choose mean-variance-efficient portfolios that maximize the expected return on their investments, so they are willing to take more risk until a certain level, depending on their risk aversion to get the desired expected return (Fama & French, 2004).

Another assumption is that investors base their decisions solely on expected return and risk. To estimate the risk, investors use the variability of expected returns. Being risk-averse, when two investments have the same expected returns, investors tend to choose the one with less risk.

Markowitz helped to develop the idea that merely combining various individual securities that have appealing characteristics regarding risk and return does not necessarily lead to an optimal portfolio. In fact, to get a mean-variance efficient portfolio the investor also needs to consider the relationship among the investments (Reilly & Brown, 2012).

According to Markowitz, the risk of the investment could be reduced by diversifying the portfolio, however, it is not enough to simply invest in many securities. In short, the investor should opt by investing in assets with different types of risk or different kinds of industries instead of investing all in the same type of asset. Combining assets or portfolios whose returns are not highly correlated should be preferred to minimize the total variance of the portfolio return, "don't put all your eggs in one basket" (Markowitz, 1952).

By doing this, it is possible to get a mean-variance efficient portfolio – a portfolio which maximizes the expected return on each investment and minimizes the variance. This optimal choice is placed in the efficient frontier, which encompasses all of the best assets' combinations. Here, for each given level of risk, the investor can choose the combination of securities that will maximize the expected return on each investment or, for a given level of expected return, to choose the portfolio that will minimize the risk (Fabozzi, Gupta, & Markowitz, 2002).

Because different investors will have different preferences regarding risk and return, different portfolio choices will occur among investors who, between this set of optimal portfolios, select the one that lies at the point of tangency between the efficient frontier and their highest utility curve. Investors will choose between investment alternatives considering the probability distribution of expected returns and pick the portfolio based on the relation between the expected return and its variance (Reilly & Brown, 2012).

To sum up, if there is no asset or portfolio of assets that give higher expected returns with the same risk (or lower), or lower risk with the same expected return (or higher), an asset or a portfolio of assets is considered to be efficient (Reilly & Brown, 2012).

2.10. Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model (CAPM) is the method that is used to predict how the capital markets behave. This model of Sharpe (1964), Lintner (1965) and Mossin (1966) is based on the Modern Portfolio Theory, developed by Harry Markowitz (1959), and it came out of the necessity to build a market equilibrium theory of asset pricing under an environment of risk. This model explains how the price of an asset and its overall risk are related (Sharpe, 1964) by identifying a portfolio that must be mean-variance-efficient (efficient if asset prices are to clear the market of all assets) (Fama & French, 2004).

With the capital asset pricing model is possible to allow investors to evaluate not only the risk and returns for diversified portfolios, but also individual assets.

There are some assumptions associated with the asset pricing model, in particular:

1. Investors rely on the expected returns and risk to choose among portfolios, which is measured by the standard deviation and expected returns;

2. Investors are rational and risk-averse, which implies that they require more compensation for bearing more risk, and when choosing between two portfolios that are expected to have the same profitability, they opt for the one with the lowest standard deviation. They always try to invest along the efficient frontier (depending on individual risk and return preferences) and the main goal is to minimize the investment risk and to maximize its profitability;

3. If two portfolios have the same level of risk, investors will be more inclined towards the one with the highest expected return;

4. Investors have the same time interval (one month, one year…) for decision-making, in which the interest rate is fixed. That allows us to evaluate the investors' expectations and to establish comparisons between them;

5. Complete agreement: given market-clearing asset prices at $t - 1$, investors agree on the joint distribution of asset returns from $t - 1$ to t. (Fama & French, 2004);

6. Investors can borrow and lend any amount of money at a given riskless rate, which is the same for all investors and independent of the amount borrowed or lent (Fama & French, 2004);

7. Financial markets are perfect, efficient and they are in equilibrium. The investments are properly priced and reflect available information;

8. All assets are infinitely divisible, so investors can buy or sell fractions of any asset;

9. Investors can invest or finance themselves - without amount restrictions - at the risk-free rate, which is the same for all investors. Personal income taxation is assumed to be zero;

10. There are no limits on short-selling, so investors can sell short any number of shares without restrictions;

11. There are no taxation or transaction costs and no taxes on dividends;

12. There is no inflation or any change in interest rates or inflation is fully anticipated;

13. Investors can access all relevant information that may influence the future profitability of a company instantly and at an affordable cost;

14. There is no private information and, therefore, investors cannot find under or overvalued assets in the marketplace;

15. Investors have rational and homogeneous expectations about asset returns, they all have the same assessment about the distribution of the future value of any asset or portfolio.

    Since the information of financial assets is freely accessible and the same to all investors, their homogeneous expectations are explained by their common beliefs about the joint probability distributions of future returns (i.e., means and covariances).

Many of the CAPM's assumptions are difficult to observe under the actual conditions of world economies. As we know, real markets are not characterized by an absolute degree of efficiency, so different investors will have different preferences, and taxes and transaction costs have a significant impact when building a portfolio. For these reasons, several assets that are available in the market are not in a straight line.

However, the assumptions are not sufficiently strict to invalidate the model. In fact, they are useful to describe a financial model and its practical applications.

The CAPM generates the following model:

$$E\ (R_i) = R_f + \beta_i\ [E\ (R_m) - R_f] \qquad \textbf{(2)}$$

Where:

- $E\ (R_i)$ is the expected rate of return on the asset i;
- R_f is the interest rate of a risk-free asset (Risk-free rate);
- βi is the systematic risk of asset i concerning the market, it indicates the relationship between changes in the price of the stock *i* and changes in the general market index;
- $E\ (R_m)$ is the market yield rate of risky assets, the expected return on market portfolio;
- $E\ (R_m) - R_f$ is the market risk premium.

With this equation, one can understand that the expected return on an asset i is equal to the risk-free interest rate, R_f, plus a risk premium (the asset's market beta, β_i, times the premium per unit of beta risk, $E(R_M) - R_f$).

This model shows that the expected return of stocks is equal to the sum of the risk-free rate and risk compensation by measuring the covariance between the rates of return of a security and the market portfolio rates of return.

As we can see, to use the model we need three inputs: the risk-free rate; the expected market risk premium; and the β of the asset under appreciation.

The risk-free rate is the rate of return that a risk-free investment would give, it is the expected return on assets that have market betas equal to zero, which means their returns are uncorrelated with the market return. As for the riskless rate, the Euribor (short for Euro Interbank Offered Rate) 3-month rate will be used.

The market risk premium (the difference between the expected return and the risk-free rate) is the extra return that investors require to invest in the market portfolio with risky assets, instead of investing in a riskless asset (Damodaran, 2015).

According to Sharpe (1970), the total risk of an asset or portfolio can be divided into two parts: the systematic (non-diversifiable or unspecified) and the unsystematic risk (diversifiable or specific).

The CAPM states that to measure the risk we should use only the non-diversifiable part of the variability – which is the systematic risk – instead of considering the total variability (Reilly & Brown, 2012).

The unsystematic risk, also known as specific risk, is the portion that remains unexplained by the regression and which depends exclusively on the characteristics of each asset and on several factors that are company-specific.

This type of risk can be mitigated through diversification. With the process of diversification, where several securities are combined in the same portfolio, investors opt for holding portfolios of assets that are negatively correlated with each other, because the risk is generally lower and, that way, they can reduce risk without losing profitability.

Even though risk can be mitigated, it cannot be fully eliminated, that is, there is a limit, it will only reduce it to a certain extent. The part of the total risk that cannot be eliminated is called the systematic risk.

2.11. Beta coefficient

The last input is the systematic risk (β), the risk that cannot be diversified. It is the market risk that comes from changes in the macroeconomic scenario that generally affect the whole market, and is related to the movement of the stock market and, therefore, it is unpredictable and hard to avoid. Examples of the systematic risk include interest rates, exchange rates, recessions, financial and economic crisis and wars (McClure, 2010).

The CAPM argues that the investor wants to be remunerated only for the market risk to which he is exposed and that this risk can be measured by the beta coefficient, whose value depends on how the returns of the asset vary in conjunction with the returns of the market portfolio.

In the regression equation of CAPM, the beta also represents the slope, it measures the sensitivity of the asset's return concerning variations in the market return (Rossi, 2016). It is widely used to measure systematic risk as well as tracking the performance: it indicates the change that investors expect in the return of the asset (or its portfolio) for every 1% change in the market.

Thus, the expected return on a stock is linearly related to its beta, with the beta being the linearity coefficient. The higher the covariance between the return of an asset and the return of the market, the greater the beta of this asset, the greater the risk and, consequently, the higher the remuneration required by the investor.

As we can see in the following equation, beta is the ratio of the expected excess return of an asset in relation to the overall market's excess return.

$$\beta_{im} = \frac{Cov(Ri,Rm)}{Var(Rm)} \quad \textbf{(3)}$$

Where:

- β_{im} is the beta of the asset i;
- $Cov_{(Ri,\ RM)}$ is the covariance between the return of asset i and the market return;
- $Var_{(RM)}$ is the variance of the market return.

The beta quantifies how much the stock's price moves concerning the market, so:

- When $\beta = 0$ the investment is considered to be risk-free, meaning that the asset has no systematic risk. The expected return on assets with a beta of 0 is equal to the risk-free rate of return. An asset with a beta of 0 means that the asset is uncorrelated with the market return, in the sense that if a 1% change in the market return occurs, it will not affect the return on the asset;

- When $\beta < 1$ it means that the systematic risk is lower than market risk, there is less volatility (W. Mullins, Jr., 1982). A variation of 1% in the market return will translate into a change of less than 1% in the asset return;

- Since the overall market has a beta of 1, when $\beta = 1$ the systematic risk is equal to the market risk. This means that it behaves similarly to a broad market index, such as the PSI-20 index and earns a return equal to the market return. A 1% change in the market return will translate into a 1% change in the asset return;

- When $\beta > 1$ the systematic risk is higher than the market risk, the changes in the asset's price are more accentuated than the changes in the market index and, therefore, it means that it tends to do better in good times and worse in bad times. Being very sensitive to market changes, a 1% change in market return will translate into a change of more than 1% in the asset return.

Indeed, the riskier assets will be the ones that move more according to the market portfolio, while the assets that are not so correlated with the market portfolio will be less risky. This happens because when an asset that is unrelated to the market portfolio is added, it will not affect the overall value of the portfolio.

The risk is therefore measured by the beta coefficient, that calculates the level of a security's systematic risk compared to that of the market portfolio, that is to say, by the covariance of the asset with the variance of the market portfolio (Damodaran, 2015).

In real markets, the beta will not be the only risk measure when investing in an asset. In fact, several other risk factors can affect the rate of return.

To begin with, the perceived risk of the investments can change, the investors can opt for changing the returns required per unit of risk, and inflation may also change and, if it rises, it will increase the risk-free rate of return.

But assuming that beta measures the total risk, the assets that are located above the Security Market Line (SML) are undervalued by the market because investors can get higher returns incurring in lower risk. On the contrary, assets that are located below the SML are overvalued, because their return is lower than it should be regarding the risk level they are bearing.

Consequently, assets at a "fair" price are located exactly on the SML. In this situation, the expected return is entirely consistent with the risk of the investment. In cases where the CAPM conditions are reunited, all assets should be positioned on the SML.

To sum up, the Capital Asset Pricing Model argues that an asset is expected to earn the risk-free rate plus compensation for bearing more risk as measured by that asset’s beta.

3. Data and methodology

Considering the purpose of the dissertation – how the market influences the return of the two stocks of the Portuguese retail sector –, the deductive approach will be followed. Additionally, the data that will be used will be quantitative, more specifically, time-series data from continuous variables, since the values can assume any value in the range of the real numbers set.

The intention is to analyse the risk and returns of Sonae SGPS SA (SON), Jerónimo Martins SGPS SA (JMT) as a function of the return of the PSI-20 index, using a simple linear regression to estimate the beta (systematic risk measure) and to see how the two listed companies in the distribution sector of the Portuguese stock market behave regarding the PSI-20 index.

The simple linear regression is a method that is used to establish the linear relationship between a dependent and an explanatory variable. In this case, the riskless return of each company will be the dependent variable (Y), and the explanatory variable (X) will be the riskless market returns.

The daily closing prices of the stocks of Sonae SGPS SA (SON) and Jerónimo Martins SGPS SA (JMT) were used and obtained from *Euronext*[1] and the study covered a time range of sixteen years (pre and post-crisis). For this reason, the beta was estimated across three different times by following a time series approach. A time series is a set of observations made sequentially over time.

The first step was converting the prices of the stocks to the returns of the stocks. This is relevant because the price of the stocks is in general non-stationary data and, by turning it into stationary data, we eliminate the possibility of having spurious regressions. This transformation was done by computing the logarithmic returns of stocks:

$$r_t = \ln\left(\frac{Pt}{Pt-1}\right) \times 100 \qquad \textbf{(4)}$$

[1] https://www.euronext.com/pt-pt

In this equation:

- *ln* represents the natural logarithm;
- P_t is the price of the stock at a time *t*;
- P_{t-1} is the price of the same stock at time *t-1*.

With the same formula, the logarithmic returns of the PSI-20 index were calculated.

As we saw before, to use the CAPM model we need three inputs: the riskless rate; the expected market risk premium (the extra return in relation to the riskless return required to invest in risky assets); and the beta (β) of the asset under appreciation.

According to the CAPM, the ideal measure for the market should be one that represents the whole economy. Since this measure is hard to obtain, an index that is close to the market portfolio, PSI-20 in this case, was used as a proxy for the market return, as an indicator of the evolution of the Portuguese stock market.

The Euribor 3-month rate (obtained from *Quandl*[2]) was used as a proxy for the riskless rate.

The next step was calculating the market index risk premium, in other words, the difference between the market portfolio return and the risk free rate (R_{mt} - R_{ft}), and calculating the risk premiums of Jerónimo Martins and Sonae's returns, by computing the difference between their returns and the risk free rate (R_{it} - R_{ft}).

Since beta is not an observed variable and cannot be accurately calculated, we needed to estimate it by regressing the riskless returns of each company against the riskless market returns. The goal is to estimate beta, the measure that we will use to quantify the risk and return ratio between the stock and the market.

The values of beta will also depend on the time interval chosen for the calculations of the returns and how many values were used in the regression analysis. This means that a

[2] https://www.quandl.com/

beta that is calculated over 10 years will be different from the one calculated over 15 years.

Despite these changes on the beta value, the regression analysis is the most efficient way of predicting it, and the linear regression will provide us reliable estimates of the true beta values.

In this case, six simple linear regressions were performed on different time ranges. The first period, we will call it "Period 1", was from 28th October 2003 until 15th September 2008; the second period, "Period 2", from 16th September 2008 until 5th June 2019; and lastly, the third period, "Period 3", from 28th October 2003 until 5th June 2019. A comparison of the betas across different times was done.

The estimation of α and β coefficients was done by using the Ordinary Least Squares (OLS) method, assuming that there is a linear relationship between the dependent variable and the explanatory variable. However, it is also important to check if the estimates are the closest to reality.

To that end, the OLS method provides the best linear unbiased estimate of beta, given the fulfilment of the OLS assumptions. To use the OLS method, important assumptions – like the conditional mean value of the errors being zero; homoskedasticity (i.e. the conditional variance of the errors is always constant); no autocorrelation and normality of the errors – must be observed to get reliable results.

As we have already seen, the CAPM equation illustrates the expected return on an investment $[E\ (R_i)]$ as a function of the beta of the investment (β_i), the risk-free rate (R_f), and the expected return on the market portfolio $[E\ (R_m)]$:

$$E\ (R_i) = R_f + \beta_i\ [E\ (R_m) - R_f] \quad \textbf{(5)}$$

This equation can be reformulated to estimate the beta:

$$E\ (R_i) - R_f = \beta_i\ [E\ (R_m) - R_f] \quad \textbf{(6)}$$

$$E\ (R_i) - R_f = \alpha_i + \beta_i\ [E\ (R_m) - R_f] + \varepsilon_i \quad \textbf{(7)}$$

In this equation:

- $E\ (R_i)$ is the return on an asset "i";
- R_f is the riskless rate;
- R_m is the return on the market;
- ε is the error term of the regression equation and it is assumed to be independent of the riskless market return;
- α_i is the intercept of the line with the axis of the dependent variable;
- β_i is the systematic risk of asset i concerning the market, it is the slope.

These last two terms are the coefficients of the regression equation to be estimated.

Let:

$$R_i - R_f = r_i \qquad \textbf{(8)}$$

$$R_m - R_f = r_m \qquad \textbf{(9)}$$

The equation can be re-written as follows:

$$r_i = \hat{\alpha}_i + \hat{\beta}_i\, r_m + \varepsilon_i \qquad \textbf{(10)}$$

The returns of Sonae and Jerónimo Martins were estimated based on the stock prices and related to the returns on a market index (in this case, the PSI-20 index), and we computed an estimate for beta in the CAPM.

Based on the values of the betas obtained through the simple linear regression, we can classify the companies according to their level of systematic risk, forming three categories: $\beta > 1$; $\beta \cong 1$ and $\beta < 1$.

In the regression equation, both the beta and, consequentially, the risk of the stock are measured by the slope of the regression. The intercept is given by α and it is a simple measure of the performance of the stock price relative to the CAPM expectations.

The next step was making some conclusions on the adequacy of the model. According to the CAPM model, the expected value of excess returns on an asset is entirely explained by its market risk premium. Therefore, the intercept (alpha coefficient) in a time series regression model should be zero. The α coefficient will also give us an estimate for the value of the vertical distance between the asset and the SML (Security Market Line), therefore, if:

- $\alpha > 0$: the intercept is positive, meaning that the return is above the SML line, thus earning a higher return than the one suggested by its market risk;

- $\alpha < 0$: the intercept is negative, and it suggests that the return is below the SML line, therefore earning a lower return than the one suggested by its market risk during the regression period.

To analyse the statistical significance of alpha (intercept) and beta (risk factor) estimates in the regression model, we will use the *t*-statistic, whose null and alternative hypotheses are:

$H_0: \alpha = 0$	$H_0: \beta = 0$
$H_1: \alpha \neq 0$	$H_1: \beta \neq 0$

We will have two hypotheses for the intercept and slope coefficients.

In the first case, the null hypothesis states that the intercept is equal to zero, while the alternative hypothesis states that the intercept is different from zero.

In the second case, the null hypothesis states that the slope is equal to zero, while in the alternative hypothesis the slope is different from zero.

The *t* statistic is given by the following formula:

$$t^* = \frac{\hat{\alpha}}{\sigma(\hat{\alpha})} \quad \textbf{(11)}$$

$$t^* = \frac{\hat{\beta}}{\sigma(\hat{\beta})} \quad \textbf{(12)}$$

Where:

- t: statistic value t;
- $\hat{\alpha}$: estimated alpha coefficient;
- $\hat{\beta}$: estimated beta coefficient;
- $\widehat{\sigma(\hat{\alpha})}$: standard error of alpha;
- $\widehat{\sigma(\hat{\beta})}$: standard error of beta.

If $t^* \leq t\ (1- \alpha / 2; n-2)$ we do not reject H_0

If $t^* > t\ (1- \alpha / 2; n-2)$ we reject H_0

Another way to find out if the estimates for alpha and beta are statistically significant or not is by analysing the *p*-value of the test statistic. For this analysis, the significance level considered by default is 0.05.

Therefore, the CAPM is correctly specified if the value of the *t* test is lower than t (1 - α /2; n-2) for the value of alpha to be considered equal to zero. When this situation does not happen and the alpha value is statistically significant at 0.05 significance level, the CAPM fails to predict its risk premium.

On the other side, if the estimate for the beta is statistically equal to zero, it is expected that changes in the explanatory variable do not influence the behaviour of the dependent variable. So, the beta estimate should be statistically significant.

Another conclusion given by the regression model is about the correlation analysis that is helpful to quantify the linear association between two variables. The correlation coefficient is useful to predict how the stocks move concerning the market, and how strong that relationship is by measuring the linear relationship between the dependent and explanatory variable.

The value of the correlation coefficient is always between −1 and +1. When positive, the variables tend to move in the same direction, while a negative value means that they tend to move in opposite directions. A zero value will mean that the variables are not correlated and, therefore, they are linearly independent.

The coefficient of determination is represented by R^2 and ranges between 0 and 1. The R^2 provides a measure of the goodness of fit of the regression but it also provides an estimate of the part of the risk that can be attributed to the market risk. By consequence, the remaining ($1-R^2$) is attributed to firm-specific risk.

The more the value of the coefficient approaches 1, the better the model explains the dependent. It measures the percentage of the total change in the stock return that is attributed to changes in the market and it is given by the following expression:

$$R^2 = \frac{SS_{Regression}}{SS_{Total}} = 1 - \frac{SS_{Residual}}{SS_{Total}} \quad \textbf{(13)}$$

The coefficient of determination can be interpreted as the part of the total variation of the dependent variable that is explained by the variation of the independent variable in the considered sample.

The standard error of the regression represents the standard error of the residuals. The smaller this value is, the better is the fit between the observed and the estimated values of the dependent variable.

Another interesting measure is the weight of the systematic risk and the specific risk in the total risk of the asset. As we know, the total risk of investment of a security is the sum of its systematic risk and its non-systematic risk, and such measures can be obtained through the following expressions:

Weight of Systematic Risk in Total Risk :

$$\frac{\text{Systematic Risk}}{\text{Total Risk}} = \frac{\beta^2 Var(R_M)}{Var\ (R_i)} \quad \textbf{(14)}$$

Weight of Non-Systematic Risk in Total Risk:

$$\frac{\text{Non-Systematic Risk}}{\text{Total Risk}} = \frac{Var(\varepsilon)}{Var\ (R_i)} \quad \textbf{(15)}$$

In statistical terms, the difference between the observed values (in our case observed returns, R_i) and the adjusted values (the returns estimated using CAPM, $\hat{R}$i) is defined as the residual:

$$e_i = R_i - \hat{R}_i \quad \textbf{(16)}$$

By analysing the residuals, it is possible to reach some conclusions over the adequacy of the linear regression model.

One of the ways to analyse the residuals is by representing them against the independent variable. To validate the assumptions of the model, the graphical representation of the residuals should not show any pattern or structure.

Other important steps will include testing the assumptions of the linear regression model. We suspect the violation of the no autocorrelation assumption, a situation that is common in time-series data.

Conclusions about the adequacy of the regression model were drawn based on the analysis of alpha and beta coefficients, the coefficient of determination and residuals.

4. Results

This empirical study aims at estimating and analysing the behaviour of the systematic risk of the riskless Jerónimo Martins and Sonae's returns, collected from Euronext Lisbon and comparing it with the riskless returns of the Portuguese market index, PSI-20.

Our main hypothesis is that both stocks behave in the same way when related to the market. We expect that there is a positive relationship between the returns of the Portuguese companies in the retail sector and the Portuguese market returns.

4.1. Correlation Analysis

First of all, we can start by making a correlation analysis. The main tools that we will use are the scatter diagram, the covariance and the simple linear correlation coefficient.

Figure 1 *Scatter Plot JMT, SON and PSI-20 Period 1*

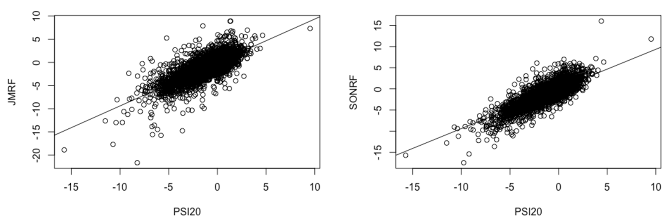


Figure 2 *Scatter Plot JMT, SON and PSI-20 Period 2*

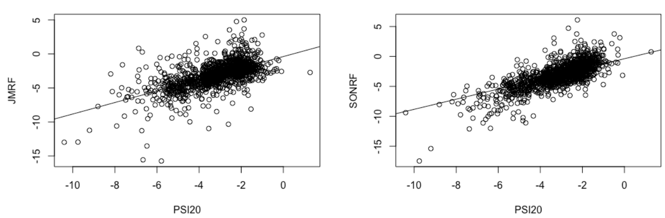
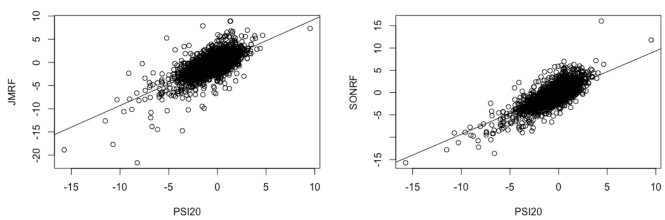


Figure 3 *Scatter Plot JMT, SON and PSI-20 Period 3*



The scatter diagrams suggest a positive linear association between Jerónimo Martins and Sonae's returns and PSI-20 returns: they tend to move in the same direction, meaning that a positive or negative variation of the PSI-20 index returns tends to be accompanied by a positive or negative variation of Jerónimo Martins and Sonae's returns in the sample considered.

Table 1 Linear Correlation Coefficients

	JM	**SON**	**PSI20**
JM	1		
SON	0,62710037	1	
PSI20	0,76177036	0,832950105	1

The value of the linear correlation coefficient confirms the strong positive linear association between the variables. The strongest relation is between the PSI-20 index and Sonae, since it is the closest value to 1.

To test if the sample linear correlation coefficient is statistically significant, we can perform the following test:

H_0: $\rho = 0$

H_1: $\rho \neq 0$

where ρ is the population linear correlation coefficient.

Table 2 Correlation significance test

	***t*-stat**	***p*-value**
SON-JM	50,8151924	0
PSI20-JM	74,2183316	0
PSI20-SON	95,0123867	0

Based on the *p*-value obtained (0) we reject the null hypothesis. In all cases, the probability associated with the test value is always lower than the level of significance considered by default (α = 0.05), rejecting the null hypothesis that $\rho = 0$. Thus, we conclude that the correlation coefficients obtained are statistically significant, considering the sample used and the 0.05 significance level.

4.2. Estimation and statistical significance of the regression coefficients

The betas of each company were estimated through the simple linear regression during three different time periods.

After that, studies on the adequacy of the simple linear regression model were done, namely, checking the statistical significance for the alpha parameter (α) and for the beta parameter (β), analysing the coefficient of determination and the residuals.

Thus, betas were estimated in Period 1 based on 3986 observations of daily returns. After that, we divided this period in a pre-crisis period: Period 2 was based on 1252 observations of daily returns; and post-crisis period: Period 3, based on 2734 observations of daily returns.

The following tables show the estimated values for α, the respective values of the *t* statistic and the *p*-value.

Period 1

Table 3 Estimates and significance tests for alpha coefficient Period 1

Company	Estimated Alpha Coefficient	Std. Error	*t*-stat	*p*-value
JMT	-0,0144	0,3010	-0,4783	0,6325
SON	0,1049	0.0266	3,9501	0,0001

Period 2

Table 4 Estimated alpha coefficients Period 2

Company	Estimated Alpha Coefficient	Std. Error	*t*-stat	*p*-value
JMT	-0,3841	0.1094	-3,5122	0,0005
SON	0,5223	0.0991	5,2711	0

Period 3

Table 5 Estimated alpha coefficients Period 3

Company	Estimated Alpha Coefficient	Std. Error	*t*-stat	*p*-value
JMT	0,0200	0.0316	0,6333	0,5266
SON	0,0632	0.0275	2,3008	0,0215

The *t* statistic and the *p*-value were used to check the statistical significance of the alpha parameter (ordinate at origin) in the simple regression model.

Thus, to test the validity of CAPM, the intercept term should not be statistically significant in the model and the market risk premium term should be statistically significant and positive.

The results show that for Jerónimo Martins the values of the *t*-test for the alpha coefficient in period 1 and period 3 (-0,4783 and 0,6333) are inside the rejection zone: RR =]-∞; -1.961] ∪ [1.961, ∞[, obtained through: *t* (0,975;3984) and *t* (0,975; 2732) respectively) and the respective *p*-values (0,6325 and 0,5266) are higher than the significance level α = 0.05. This means that we do not reject the null hypothesis (H_0: α = 0), so, the estimate for alpha is not statistically significant.

The exception is in period 2, in which the value of the *t*-test (-3,5122) is outside the Rejection zone: RR =]-∞; -1.962] ∪ [1.962, ∞[and the respective *p*-value (0,005) is lower than the significance level α = 0.05. This means that we reject the null hypothesis (H0: α = 0), so, the estimate for alpha is statistically significant.

For Sonae, all the values of the *t*-test for the alpha coefficient in the three different time periods (3,9501; 5,2711 and 2,3008) are outside the rejection zone and the respective *p*-values (0,0001; 0 and 0,0215) are lower than the significance level α = 0.05. Therefore we reject the null hypothesis (H0: α = 0), meaning that the estimate for alpha is statistically significant.

The table below shows the estimates for β, the values of the *t* statistic and the respective *p*-values for the three different time periods.

Period 1

Table 6 Estimated beta coefficients Period 1

Company	Estimated beta coefficient	Std. Error	*t*-stat	*p*-value
JMT	0,9378	0,0126	74,2183	0
SON	1,0594	0.0112	95,0124	0

Period 2

Table 7 Estimated beta coefficients Period 2

Company	Estimated beta coefficient	Std. Error	*t*-stat	*p*-value
JMT	0,8449	0.0319	26,5291	0
SON	1,1596	0.0289	40,1816	0

Period 3

Table 8 Estimated beta coefficients Period 3

Company	Estimated beta coefficient	Std. Error	*t*-stat	*p*-value
JMT	0,9333	0.0186	50,0898	0
SON	1,0726	0.0162	66,1915	0

Regarding the beta estimate for both Jerónimo Martins and Sonae, we reject the null hypothesis in the three different time periods, since the values of the *t*-test are outside the critical regions and the respective *p*-values (0) are lower than the significance level (0.05), meaning that the estimates for the beta coefficients are statistically significant. We can conclude that there is a significant relationship between the independent and dependent variables.

Based on estimates for alpha and beta, the estimated equations are given by:

Table 9 Estimated equations for Jerónimo Martins

Period 1	$\widehat{JM}_i$ = -0,0144 + 0,9378 $PSI20_i$
Period 2	$\widehat{JM}_i$ = -0,3841 + 0,8450 $PSI20_i$
Period 3	$\widehat{JM}_i$ = 0,0200 + 0,9333 PSI20i

Table 10 Estimated equations for Sonae

Period 1	$\widehat{SON}_i$ = 0,1049+ 1,0594 $PSI20_i$
Period 2	$\widehat{SON}_i$ = 0,5223 + 1,1596 $PSI20_i$
Period 3	$\widehat{SON}_i$ = 0,0632 + 1,0726 $PSI20_i$

4.3. Analysing the systematic risk

After that, we analysed the coefficient of determination (R^2), which is used as an indicator of the goodness of fit.

Period 1

Table 11 Coefficient of Determination Period 1

Company	Coefficient of Determination (R^2)
JMT	0,5803
SON	0,6938

Period 2

Table 12 Coefficient of Determination Period 2

Company	Coefficient of Determination (R^2)
JMT	0,3602
SON	0,5636

Period 3

Table 13 Coefficient of Determination Period 3

Company	Coefficient of Determination (R^2)
JMT	0,4787
SON	0,6159

We know that the closer the R^2 value is to 1, the better the model explains the dependent. The R^2 of Sonae is higher in the three different time periods. The highest value of R^2 is in period 1 and it is 0,6938, meaning that 69,38% of the total variability of y (the riskless return of Sonae) is explained by x (the riskless market returns), and the remaining 30.62% are due to other factors.

The lowest R^2 is from Jerónimo Martins, during period 2 and it is 0,3602, meaning that the weight of the systematic risk in the total risk of Jerónimo Martins is 36,02%, and the remaining 63,98% are attributed to firm-specific factors of risk.

In the following charts we can see a comparison of the weights of the systematic and non-systematic risk in total risk.

Figure 4 Weight of the systematic and non-systematic risk in total risk Period 1

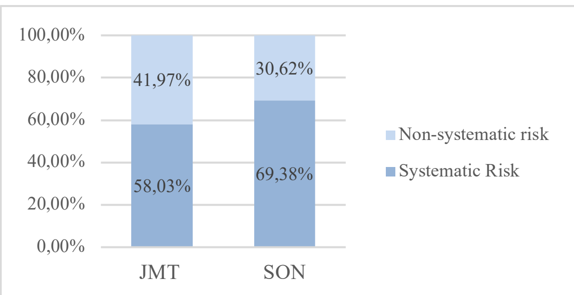


Figure 5 Weight of the systematic and non-systematic risk in total risk Period 2

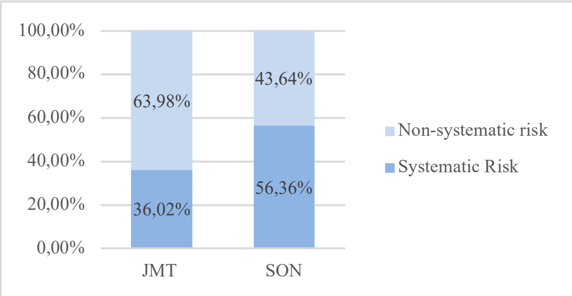
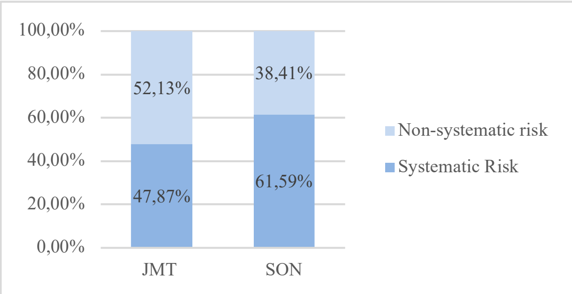


Figure 6 Weight of the systematic and non-systematic risk in total risk Period 3



To calculate the systematic risk of the securities, we used the betas estimated through the regression, the market returns variation and the variation of the returns of each company.

4.4. RESET test

The next step was testing if there was omission of relevant explanatory variables, incorrect functional form and correlation between explanatory variables and the errors of the model. To this end, we started by performing the RESET test (Regression Specification Error Test) to assess if one of the specification errors mentioned above occurred.

Table 14 *P*-values associated to the RESET test

	JM PSI20	SON PSI20
Period 1	0.0017	0.1205
Period 2	0.0156	0.0787
Period 3	1.227e-05	0.39

In all the three periods, for Jerónimo Martins and based on the *p*-value we reject the null hypothesis. This means that at least one of the three assumptions checked by the RESET test is violated. If we have a look at the following plots, we can see that some points are furthest away from the straight line, so one possible cause for the rejection of the null hypothesis could be the omission of variables.

Figure 7 Graphical Representation of the Residuals of JMT and SON against the PSI-20 Period 1

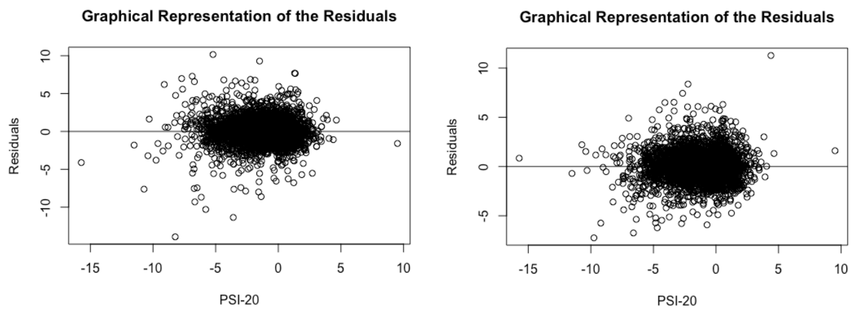


Figure 8 Graphical Representation of the Residuals of JMT and SON against the PSI-20 Period 2

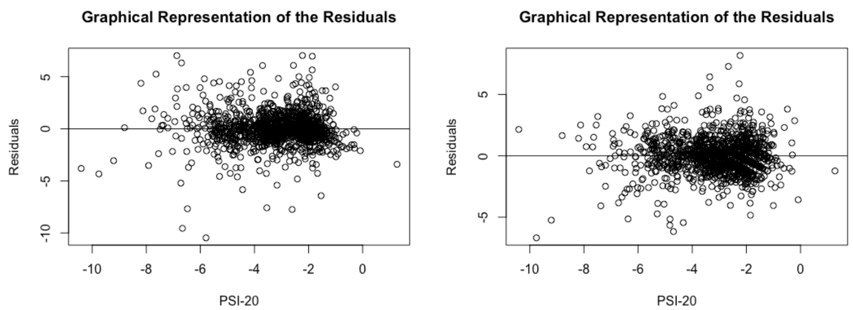
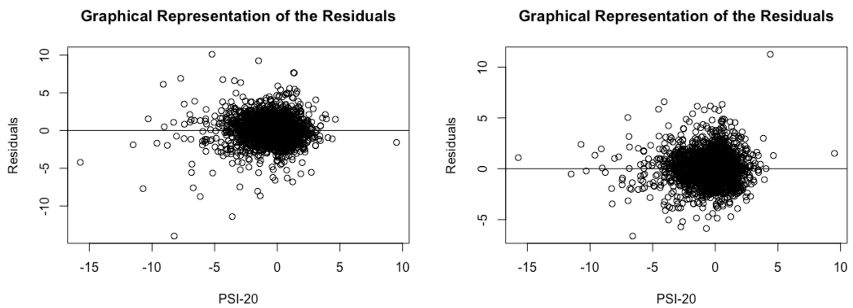


Figure 9 Graphical Representation of the Residuals of JMT and SON against the PSI-20 Period 3



Regarding Sonae, and since the *p*-values are higher than 0.05, we do not reject the null hypothesis, therefore none of the assumptions is violated.

There are several other assumptions that must be checked for the OLS estimators to be fulfilled, such as the linearity of the data, the normality of residuals, homoscedasticity and independence of error terms.

4.5. Linearity

We will start by checking the linearity assumption, that implies that the relationship between the predictor (x) and the outcome (y) is assumed to be linear. To this end, we can have a look in the plots **Residuals vs Fitted**.

Figure 10 Residuals vs Predicted values period 1

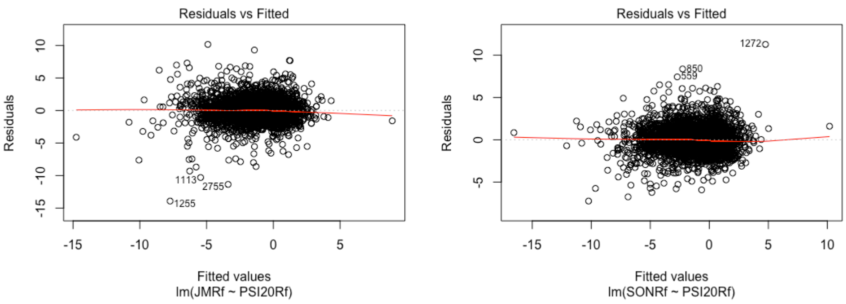


Figure 11 Residuals vs Predicted values period 2

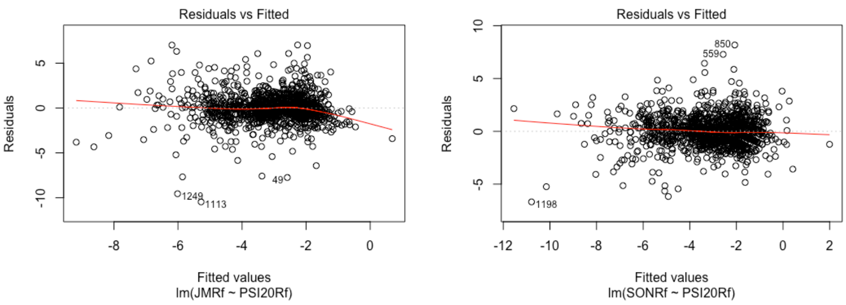
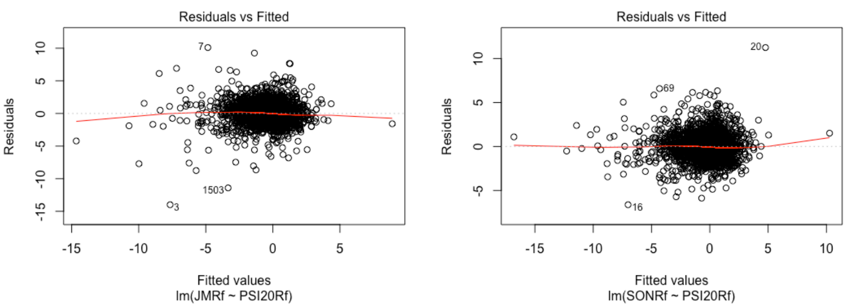


Figure 12 Residuals vs Predicted values period 3



The red line should be approximately horizontal near zero and should not show patterns. In our example, these conditions hold, which suggests that we can assume that there is a linear relationship between our variables.

4.6. Normality of the errors

The next step was checking the errors' normality assumption, which is of utmost importance, since it is the support of all statistical inference in the linear regression model (*F* and the *t*-tests) for the estimated coefficients, especially when we have small samples.

We can have a look in the Normal Q-Q plots to check whether the residuals are normally distributed or not.

Figure 13 Normality Q-Q plot period 1

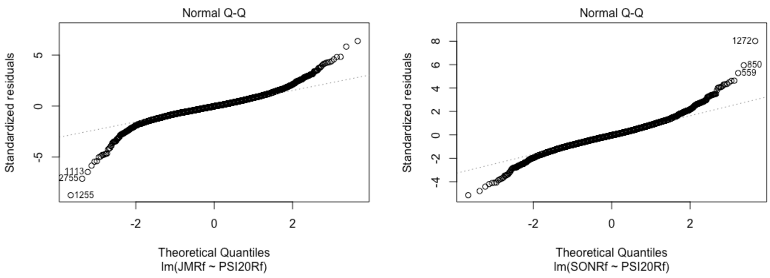


Figure 14 Normality Q-Q plot period 2

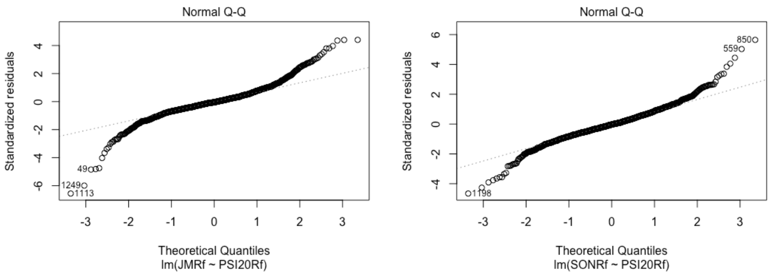
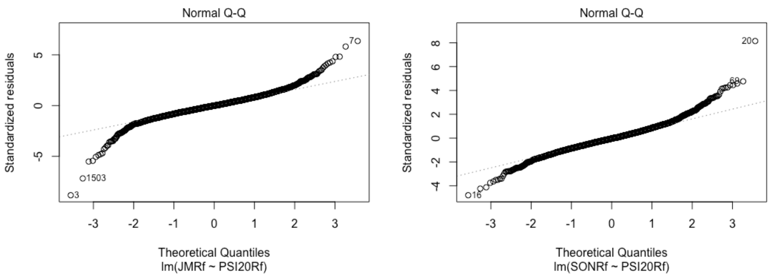


Figure 15 Normality Q-Q plot period 3



The residual errors are assumed to be normally distributed when the points follow the straight line. In our case, the graphs suggest heavy tails as it was expected, so we cannot assume normality.

To be more specific, we can perform a test to prove what we have seen on the normality plots.

In a normal distribution, the values of kurtosis and asymmetry coefficients are 3 and 0, respectively.

Period 1:

Table 15 Kurtosis and Skewness Coefficients Period 1

	JM	SON	PSI20
Kurtosis	4,4648	2,5588	1,5859
Skewness	-0,8756	-0,5041	-0,7233

Period 2:

Table 16 Kurtosis and Skewness Coefficients Period 2

	JM	SON	PSI20
Kurtosis	5,2398	3,5620	1,5180
Skewness	-0,9546	-0,7501	-1,0291

Period 3:

Table 17 Kurtosis and Skewness Coefficients Period 3

	JM	SON	PSI20
Kurtosis	10,007	4,8583	7,5707
Skewness	-1,4608	-0,6031	-1,4962

The kurtosis value represents the excess of kurtosis, the difference between the estimate for the kurtosis coefficient and 3 (the value for the normal distribution).

According to the results obtained, we can conclude that all the variables' distribution is asymmetric negative and leptokurtic, since the estimates for the kurtosis are all positive.

Investors usually prefer positively skewed distributions to negatively skewed ones and distributions with a lower likelihood of jumps (lower kurtosis) over those with a higher likelihood of jumps (higher kurtosis). (Damodaran, 2015)

To verify if the values obtained for the skewness and kurtosis are statistically different from those that characterize a normal distribution (0 and 3), we will use the Jarque-Bera test. The normality Jarque-Bera test is valid for big samples and it is based on the estimates for the coefficients of skewness and kurtosis.

Let X be the random variable that represents the daily risk-free returns of the three variables, the hypotheses being tested are:

H_0: X ~ N (μ, σ)

H_1: X ≠ N (μ, σ)

$$JB = N\left\{\frac{\widehat{S(X)}^2}{6} + \frac{(\widehat{K(X)}-3)^2}{24}\right\} \sim x^2_{(2)} \quad \textbf{(17)}$$

Where:

- N is the sample size;
- $\widehat{S\,(X)}$ is the sample skewness coefficient;
- $\widehat{K(X)}$is the kurtosis coefficient.

We reject the normality hypothesis if JB > $x^2_{(2)}$ (α)

In all the regressions, the *p*-values associated with the values of the Jarque-Bera test are lower than the significance level (α = 0.05), indicating the rejection of the null hypothesis. Therefore, the sample data does not seem to indicate the normality of the errors.

Due to the sample size being large, the rejection of the null hypothesis of errors' normality is not a problem, since the *F* and *t*-tests results are still asymptotically valid.

According to the Gauss-Markov theorem, the errors' conditional distribution has a zero mean, given the explanatory variables; the errors are homoscedastic (constant variance) and there is no autocorrelation (null covariances). If these conditions hold, the OLS estimators are the best linear unbiased estimators.

4.7. Homoscedasticity of the errors

The next step was checking whether the errors were homoscedastic or not. When there is homoscedasticity, the residuals are assumed to have constant variance and when they don't have constant variance, we are in the presence of heteroscedasticity.

If the errors are heteroskedastic, the OLS estimators are no longer the most efficient ones and the t and F tests provide inaccurate results regarding the variances and covariances.

We started by having a look at the Scale-Location plots which are used to check if there is homoscedasticity.

Figure 16 Scale Location Plots Period 1

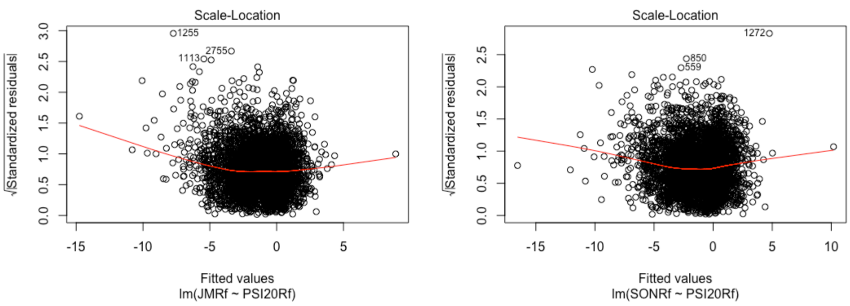


Figure 17 Scale Location Plots Period 2

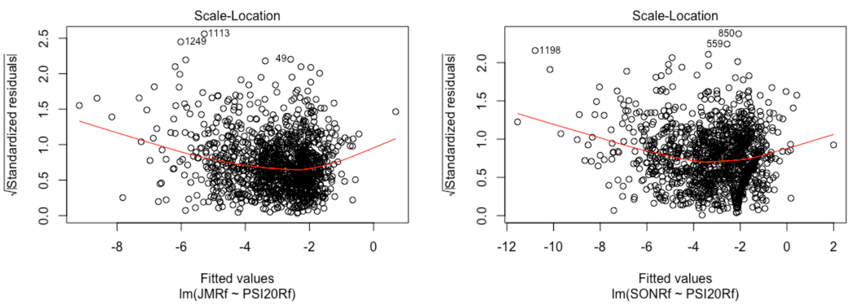
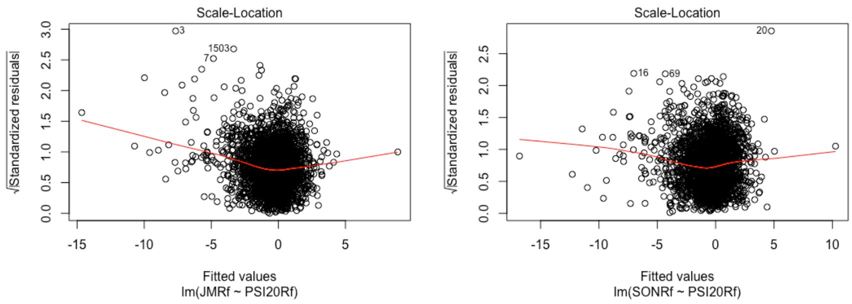


Figure 18 Scale Location Plots Period 3



If the homoscedasticity condition holds, the plots should show a horizontal line with equally spread points. In our case, this does not happen, so it seems like we have a heteroscedasticity problem.

To verify what we have seen in the plots, we used the White test, which was useful to test if the variance around the regression line was equal for all values of the predictor variable.

First, the square of residuals was regressed as a function of the explanatory variable: PSI20 and $PSI20^2$.

The White test is the product of the coefficient of determination R^2 by the number of observations n. The output must be:

Period 1

Table 18 White test period 1

Company	White test	*p*-value
JM	177.3371	0
SON	61.14524	5.273559e-14

Period 2

Table 19 White test period 2

Company	White test	*p*-value
JM	61.14768	5.273559e-14
SON	50.78112	9.397705e-12

Period 3

Table 20 White test period 3

Company	White test	*p*-value
JM	173.1442	0
SON	23.66004	7.282634e-06

Since $X^2_{(5)}(0.05) = 11.0705$ and N x R^2 > 11,0705 and the *p*-values are lower than the significance level (0.05), we reject the null hypothesis, concluding that the errors are heteroskedastic.

As the test decisions point towards the rejection of the homoskedasticity assumption, and due to the big sample size, we corrected the heteroscedasticity by using the White standard errors.

Period 1

Table 21 White Standard Errors Jerónimo Martins Period 1

JM	Estimate	Std. Error*	z value	Pr (>|z|)
Intercept	-0.0144	0.0292	-0.4925	0.6224
Psi20Rf	0.9378	0.0182	51.4216	<2e-16

Table 22 White Standard Errors Sonae Period 1

SON	Estimate	Std. Error*	z value	Pr (>|z|)
Intercept	0.1049	0.0271	3.8729	0.0001
Psi20Rf	1.0594	0.0139	76.1585	<2.2e-16

Period 2

Table 23 White Standard Errors Jerónimo Martins Period 2

JM	Estimate	Std. Error*	z value	Pr (>|z|)
Intercept	-0.3841	0.1372	-2.7985	0.0051
Psi20Rf	0.8449	0.0464	18.2189	<2.2e-16

Table 24 White Standard Errors Sonae Period 2

SON	Estimate	Std. Error*	z value	Pr (>|z|)
Intercept	0.5223	0.1224	4.2667	1.984e-05
Psi20Rf	1.1596	0.0396	29.2672	<2.2e-16

Period 3

Table 25 White Standard Errors Jerónimo Martins Period 3

JM	Estimate	Std. Error*	z value	Pr (>|z|)
Intercept	0.0200	0.0294	0.6785	0.4975
Psi20Rf	0.9333	0.0335	27.8968	<2e-16

Table 26 White Standard Errors Sonae Period 3

SON	Estimate	Std. Error*	z value	Pr (>|z|)
Intercept	0.0632	0.0276	2.2863	0.0224
Psi20Rf	1.0726	0.0210	51.0242	<2e-16

After calculating the White standard errors, we can observe that the estimated coefficients that were statistically significant remain that way, while the ones that were not statistically different from zero also maintain.

4.8. No autocorrelation

Another assumption of the simple linear regression model is that errors are linearly independent, in other words, there should be no autocorrelation. The violation of this assumption occurs more often in time series data, once the errors and residuals must be correlated.

When there is autocorrelation, the OLS estimators are no longer the most efficient ones. The standard errors are underestimated and, consequentially, the value of the significance tests appears to be statistically more significant than their true value.

The value of R^2 is also overestimated, indicating a better fit than it actually should be.

To detect the presence of autocorrelation, we can look at the graphical representation of the residuals already shown (residuals plots) and hypotheses testing.

In the null hypothesis of the tests it is assumed that errors are not autocorrelated and in the alternative hypothesis it is considered that errors show autocorrelation.

The hypotheses are:

- H_0: $\rho = 0$
- H_1: $\rho \neq 0$

Due to the large sample size, we will use the Breusch-Godfrey test to check whether the residuals are autocorrelated or not.

Period 1

Table 27 Breusch-Godfrey test Period 1

Company	Breusch-Godfrey test	*p*-value
JM	4.5708	0.1509
SON	4.8005	0.06549

Period 2

Table 28 Breusch-Godfrey test Period 2

Company	Breusch-Godfrey test	*p*-value
JM	0.14487	0.1509
SON	6.1968	0.06549

Period 3

Table 29 Breusch-Godfrey test Period 3

Company	Breusch-Godfrey test	*p*-value
JM	5.8866	0.2318
SON	21.741	8.624e-05

As we can see, the *p*-values associated to the Breusch-Godfrey statistic are higher than the significance level 0.05, suggesting there is no first-order autocorrelation, except in Period 3, where the *p*-value associated to Sonae is lower than the significance level.

To correct the autocorrelation problem, we will use the Newey-West standard errors.

Table 30 Newey-West standard errors Sonae Period 3

SON	Estimate	Std. Error	z value	Pr (>|z|)
Intercept	0.0632	0.0262	2.4134	0.0158
Psi20Rf	1.0726	0.0201	53.4858	<2e-16

As demonstrated, the estimates for alpha and beta still remain statistically significant.

5. Discussion results

Recalling our main hypothesis that both stocks behave in the same way as the market, we confirm the positive relationship between the returns of the Portuguese companies in the retail sector and the Portuguese market returns.

As expected from the correlation coefficients, the strongest relationship is between Sonae and the PSI-20. This is later confirmed by the coefficient of determination (R^2): in all the three periods the value is higher than for the relationship between Jerónimo Martins and PSI-20 and it is always above 50%.

As shown in the plots below, around the time of the bankruptcy of Lehman Brothers, there is a decrease in the returns of all the three series of returns under analysis: the two companies as well as in the PSI-20.

Figure 19 Jerónimo Martins' returns Period 1

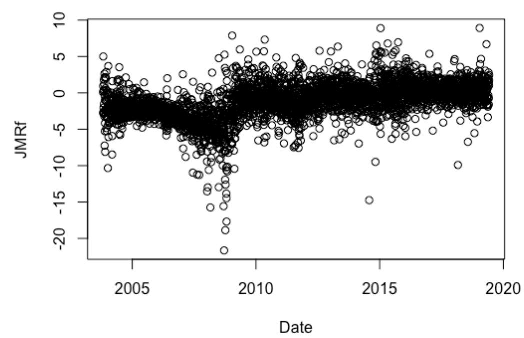


Figure 20 Sonae's returns Period 1

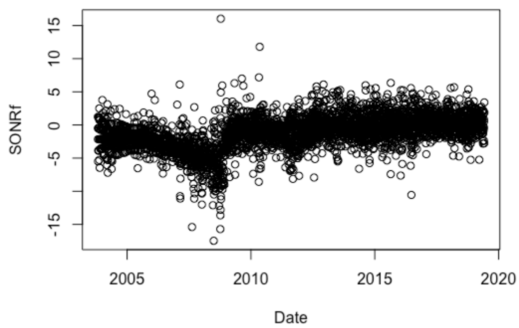


Figure 21 PSI-20' returns Period 1

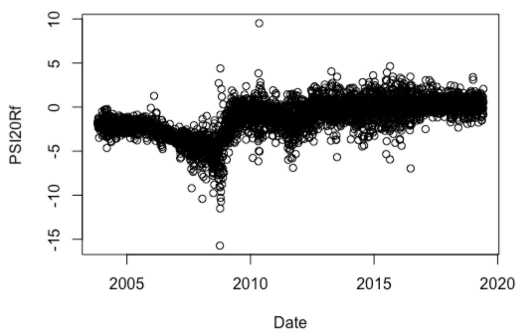


Table 31 Risk and Return before and after the crisis

	Period 2	**Period 3**
Average Returns$_{JM}$	0,1223	0,0330
Std. Dev.$_{JM}$	1,6865	1,9767
Average Returns$_{SON}$	0,0455	0,0127
Std. Dev.$_{SON}$	1,8029	2,0036
Average Returns$_{PSI-20}$	0,0236	-0,0027
Std. Dev.$_{PSI-20}$	0,8340	1,3112

By having a look at the average returns of each variable, we can see that in all of them there was also a decline between the pre and post-crisis period. Indeed, the one that suffered the biggest decrease was the PSI-20 index, with a decline of 111,44% in its returns, followed by Jerónimo Martins, with a drop of 73,02% in its average return, and finally Sonae with a decline of 72,08% in its returns.

To see whether the means of returns are statistically different or not before and after the crisis, we performed a *t*-test. In the null hypothesis, we assume the equality of means and in the alternative the difference of the means. For Jerónimo Martins, Sonae and PSI-20, we got a *p*-value higher than the significance level considered (0.05), so we do not reject the null hypothesis, meaning that they are not statistically different from each other.

Conversely, if we check the standard deviations of the returns, we can see that there is an increase from the pre-crisis to the post-crisis period, that is, the risk to which these companies and the market index are exposed, increased.

In order to test if the difference is statistically significant, we computed the *F*-test. The results point for the rejection of the null (the p-value for all the three series is approximately 0), therefore the increase in risk is statistically significant. There are several factors that can influence this, namely the fact that investors are more sensitive to information about markets and economies, generating a feeling of mistrust and fear.

As we know, if the CAPM holds, the alpha value should not be statistically different from zero (it is expected that the estimated α coefficient should be equal to zero), since the expected value of excess returns on an asset is entirely explained by its market risk premium. If it is 0, it indicates that the stock is moving perfectly with the general market, so an alpha that differs from 0 represents the return on an investment that is not resulting completely from the movement in the overall market.

In our case, alpha not being statistically significant only holds for the regression between Jerónimo Martins and PSI-20 in the 1st and 3rd periods. The remaining estimated alpha coefficients are statistically significant, meaning that there are factors other than the market risk premium that explain the expected value of excess returns.

The intercept or alpha indicates the excess return of the company when compared to the expected return resulting from the overall market. It is useful to determine how much the realized returns differ from the expected returns. Thus, it measures the extra performance during the period of the regression.

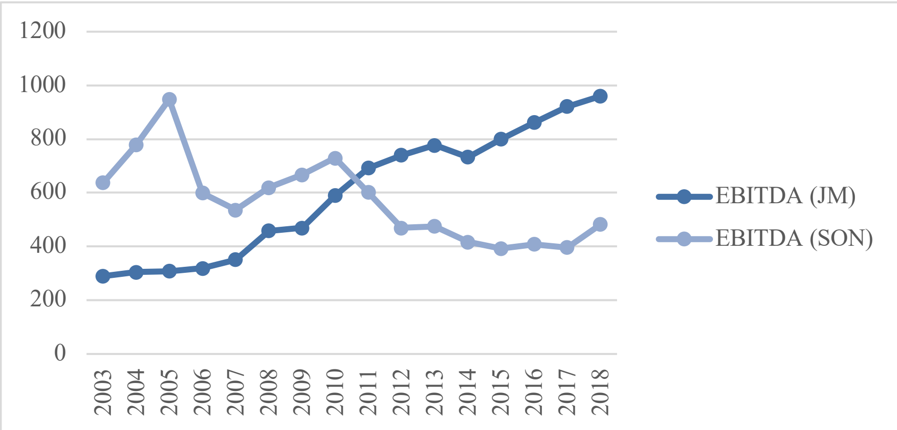
According to the results, in the second period we have a negative value, meaning that Jerónimo Martins' returns were worse than expected by the CAPM and in period 3 the value turns positive, but still very close to 0. Taking Period 2 as an example, -0,3841 is the expected value for the return of Jerónimo Martins if the PSI-20 return is 0. Jerónimo Martins did 0,3841 worse than expected, per day, in the pre-crisis period and 0,0200 better than expected in the post-crisis period. As we can see, we went from a negative value to a positive value.

The retail sector has numerous opportunities for expansion. The results of Jerónimo Martins demonstrate a good performance of the company in relation to the sector, as well as a good response to the crisis, with restructuring processes that included, for example, the Pingo Doce brand retail activity, always keeping a positive sales growth.

In the early 2000s, the overall results for Jerónimo Martins were not so high as stockholders expected. At the time, financial problems were aggravated by the poor performance of the food distribution business in Portugal. As competition increased, the sales of Pingo Doce supermarkets continued to decline, also due to Pingo Doce being considered an expensive supermarket.

To counteract this, the company began a financial restructuring plan, by selling several stakes in various companies and concentrating most of the retail activity under the Pingo Doce insignia. They repositioned the brand by praising their product's quality, promoting their own brand and practicing low prices. This restructuring was successful with the number of sales increasing noticeably (Ferreira, 2011).

Figure 22 EBIDTA for JMT and SON (source: values obtained from the financial reports of JMT and SON)



In the pre-crisis Sonae did 0,5223% better than expected, and in the post-crisis did 0,0632% better than expected. Despite still being positive, in the post-crisis period Sonae suffered a decline in the alpha value.

The year 2011 was characterized by the significant decrease in the private consumption of the Portuguese market and the difficulties of the banking system (the rise of the interest rates required by the banks, lower volume of sales on real estate, etc.). Rather than focusing on international growth, Sonae chose to protect the returns and to reduce debt (Financial Report Sonae, 2011).

In 2012, Sonae SR's profitability was highly penalized by the adverse market environment. Together with the economic recession, the rising of the unemployment and a significant reduction in the purchasing power of the households, there was a restructuring of the sports and fashion business.

Besides that, the consolidated net profit decreased when compared to the previous year, due to the increase in the net financial costs and the impacts of depreciation of Sonae Sierra's shopping center portfolio in Europe. (Financial Report Sonae, 2012)

For Jerónimo Martins there is an increase in the estimated alpha from the pre-crisis period and the post-crisis period, while for Sonae we are able to verify that the opposite happens, the estimated alpha value decreases.

Despite this decrease, the estimated alpha is positive in the three different time periods which means that Sonae's returns did better than the CAPM predicted. Besides, it is still higher for Sonae in the post-crisis period and investors generally prefer investments with a higher alpha for the same risk.

On the other side, the estimates for beta should be statistically different from zero. We can confirm that all beta estimates are statistically significant, so we know that changes in the explanatory variable will influence the behaviour of the dependent variable.

Having a look into Jerónimo Martins' three different estimated equations, the beta is the coefficient that seems more stable over the three time periods and it is always lower than 1. This means that the systematic risk is lower than market risk, and a variation of 1% in the PSI-20 returns will translate into an expected change of less than 1% in Jerónimo Martins' returns. As the estimate for beta before the crisis was 0,8450 and after the crisis was 0,9333, we can see that the value got closer to one, reflecting more the market behaviour.

Regarding Sonae's estimated results, we can see that we have a higher estimate for the beta, which means more volatility in Sonae's returns. In the three different time periods, the beta estimate is always higher than 1, meaning that the systematic risk is higher than the market risk, it is more sensitive to the changes in the PSI-20 returns, so it tends to do better in good times and worse in bad times. A 1% change in Sonae's returns will translate into an expected change of more than 1% in the PSI-20' returns.

In the pre-crisis Sonae was 15,96% more volatile than the PSI-20, while in the post-crisis it was 7,26% more volatile. Just as Jerónimo Martins, the value of the beta estimate also got closer to one, approaching the movement of the market.

According to the estimated beta values, we can see that Sonae shows higher changes when compared with the movements of the PSI-20 index since the betas are higher, thus meaning that when one changes, the other changes in a bigger scale.

Since the estimates for the betas are all statistically significant, we can conclude that at least statistically the variation in the PSI-20 index is positively related to the variation in Jerónimo Martins and Sonae's returns. The higher the beta is, the greater the impact of the explanatory variable on the dependent one.

Usually, a positive alpha is the most desirable over a negative one. However, beta will depend on the risk aversion of investors. A lower beta like Jerónimo Martins would probably be more attractive to risk-averse investors, while a higher beta like Sonae would be more interesting for investors that are willing to bear some risk in exchange for a possible higher return.

To check whether the estimated coefficients are stable over time or not, we can perform the Chow test. The Chow test will show us if we are in the presence of a structural break at a specific time – in our case, the day of the collapse of Lehman Brothers – and it will allow us to see if the estimated regression coefficients are equal for the split data sets.

We will perform two Chow tests. In the first one, the null hypothesis of the test states that there is no breakpoint after the 2008 crash in the relationship between Jerónimo Martins and PSI-20, while the alternative hypothesis states that there is a breakpoint.

In the second one, the null hypothesis states that there is no structural break after the 2008 crash in the relationship between Sonae and PSI-20, while the alternative hypothesis states that there is a structural break.

Regarding Jerónimo Martins, we obtained a *p*-value higher than the significance level 0.05, thus we did not reject the null hypothesis, so we cannot assume that there was a structural break in the relationship between Jerónimo Martins and PSI-20 before and after the bankruptcy of Lehman Brothers.

For Sonae, we obtained a *p*-value lower than the significance level 0.05, meaning that we reject the null hypothesis, so there was a structural break in the relationship between Sonae and PSI-20 before and after the bankruptcy of Lehman Brothers.

Therefore, only the changes in the estimates for Sonae are statistically significant.

6. Conclusions

Considering that the purpose of this work is to analyse how Jerónimo Martins and Sonae behave regarding the PSI-20 index, this study aimed at estimating the CAPM for the two Portuguese companies in the retail sector by examining their daily returns.

A simple linear regression was estimated by regressing the dependent variables (the daily riskless returns of the companies) against the explanatory variable (the riskless market returns) in three different periods and the ordinary least squares (OLS) method was applied in this research to find results.

Initially, the beta and alpha coefficients of the two companies were estimated, as well as other important statistics such as the coefficient of determination. According to the coefficient of determination values, we could see what part of the total variation in the dependent variable could be explained by the independent variable (the market).

After that, we analysed the adequacy of the simple linear regression models using statistical tools and checking if the assumptions of the OLS estimators were fulfilled, namely the conditional mean value of the errors being zero; the homoskedasticity of the errors; no autocorrelation and normality of the errors. If the assumptions didn't hold, corrective measures have been adopted.

The weight of the systematic and non-systematic risks in the total risk was evaluated and the estimated betas were compared in the three different time periods as well as between the two companies.

We confirmed the positive relationship between each company with the Portuguese market index, and by analysing the beta estimate we could see that they move differently according to the PSI-20. Sonae has an estimate for beta higher than 1, meaning that it has more volatility, it moves more than the market while for Jerónimo Martins the opposite happens.

By analysing the average returns and the standard deviations of the returns in the pre and post-crisis period we can see that the returns decreased while the risk increased.

However, by testing the statistical significance of these changes, only the increase in risk was statistically significant.

When checking the statistical significance of the regression coefficients, we could observe that all the beta estimates were statistically significant, meaning that changes in the Portuguese market returns will influence the changes on each company's returns. However, except for two periods for Jerónimo Martins, the alpha estimates were statistically significant, meaning that there were other factors explaining the expected value of excess returns other than the market risk premium, which is not in line with the CAPM.

We could also observe that the expected returns for Jerónimo Martins went from a negative value in the pre-crisis period to a positive value in the post-crisis period, while for Sonae there was a decline in the alpha value between the two periods.

Shortly, this could be explained by the restructuring of Jerónimo Martins, which translated into positive results, while Sonae was more affected by the effects of the financial crisis as well as by the restructuring of the sports and fashion business and the depreciation of the shopping centre portfolio in Europe.

In spite of all my efforts, the study still has some limitations: we only compared two Portuguese companies in the retail sector (only the ones that were listed on the Portuguese market index) and we are lacking the exact factors that affected the changes in the estimates for the CAPM coefficients.

In further studies, it would be interesting to compare the retail sector with another sector and analyse how the estimated coefficients of one compare with the others.

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