Low Price Anomaly in European Stock Markets

by

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To My Parents

Biographic Note

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The author was awarded with his bachelor degree in Economics at Universidade da Beira Interior, Covilhã during the academic year of 2014/2015. After the bachelor, the author began to pursue a master degree in Finance at FEP.

At the time this dissertation was published, the author was working with EY (formerly Ernst & Young) as an auditor.

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Abstract

The low-price effect is the idea that low-priced stocks tend to produce higher returns than high-priced stocks in a risk-adjusted basis. Although an old anomaly, there is a lack of studies, especially for markets outside the United States.

By sorting portfolios according to their nominal prices for the period 1996-2016, we aimed at studying whether the low-price anomaly is present in the main European stock markets, namely Austria, Belgium, France, Ireland, Italy, Netherlands, Portugal, and the United Kingdom. We also provide evidence on the seasonality and performance during bull and bear markets of the low-price anomaly.

Our results suggest that high-priced portfolios produce higher and statistically different returns from low-priced portfolios for all European stock markets under study. Furthermore, we found evidence that a strategy based on alpha seeking for most of the markets is not robust for both low-priced and high-priced portfolios. We also provide evidence that high-priced stocks have a lower level of total risk and a higher level of systematic risk compared with low-priced stocks.

We also found evidence of statistically significant returns robust to transaction costs for high-priced portfolios in January and that high-priced portfolios seem to have a better performance both during bull and bear markets. These results have implications for investors and professional which have biased preferences towards low-priced stocks.

Keywords: nominal price, portfolio, stocks, market efficiency, anomaly

JEL codes: G11, G12, G14, G15

Resumo

O efeito de baixo preço consiste na observação de que as ações com baixo valor nominal tendem a produzir retornos maiores que as ações com alto valor nominal depois de considerado o risco. Apesar de ser uma anomalia antiga, existem poucos estudos, especialmente para mercados que não os Estados Unidos.

Através do método de dividir as ações em diferentes portfolios tendo em conta o seu valor nominal para os períodos 1996-2016, iremos investigar se a anomalia de baixo preço está presente nos principais mercados de ações Europeu, nomeadamente Áustria, Bélgica, França, Irlanda, Itália, Holanda, Portugal e Reino Unido. Também apresentamos evidência sobre a sazonalidade do efeito de baixo preço e o seu comportamento durante mercados *bull* e *bear*.

Os nossos resultados sugerem que os portfolios de ações com preço nominal mais elevado geram retornos mais altos e estatisticamente significativos para todos os mercados de ações Europeus em estudo. Mais ainda, uma estratégia baseada em obtenção de alfa não é robusta depois de considerar os custos de transação para ambos portfolios de alto preço e baixo preço. Encontrámos, ainda, evidência que as ações de alto preço nominal têm um nível mais baixo de risco total e um nível mais alto de risco sistemático comparadas com ações de baixo preço nominal.

Também encontramos evidência a favor de retornos estatisticamente significativos e robustos a custos de transação para os portfolios de alto preço nominal em janeiro e que portfolios de alto preço nominal parecem ter melhor performance durante fases de mercado *bull* e *bear*. Estes resultados trazem implicações para investidores e profissionais que têm preferência por ações de baixo valor nominal.

Palavras-chave: preço nominal, portfolio, ações, eficiência de mercado, anomalia

Códigos-JEL: G11, G12, G14, G15

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Introduction

Anomalies in financial markets have been fascinating researchers and practitioners for a very long time. The main reason is that market anomalies are a breach to the efficient market hypothesis. In the very end, this might mean that abnormal returns could be extracted. Thus, it comes as no surprise that so much literature exists on the topic of market anomalies.

The low-price anomaly is the idea that low-priced stocks tend to produce abnormal returns compared with high-priced stocks in a risk-adjusted basis. Perhaps this is one of the oldest anomalies observed, since the first literature goes back to 1936. (Fritzmeier, 1936) Although an old anomaly, a lot is still to be done in this topic. Hence, we perceive the study of this anomaly as an opportunity, which will contribute to further increase the knowledge of this anomaly and the mechanisms of financial markets.

Like any other study in market anomalies, this study aims to bring to the knowledge of investors, researchers, and practitioners some peculiarities of the low-price effect in stock markets. Although there is no certainty that this anomaly will disappear, bringing it to the knowledge of investors may be a first step in making them look at their own biases related to low-priced stocks and eventually correct them. If this aim is successful, it will represent an enhancement in market efficiency. Furthermore, this effect is not very well developed in terms of literature for markets outside the United States, which means that extending it to European markets will contribute to the improvement of our understanding on this specific anomaly for these markets. The study on the low-price anomaly is also important because it contributes to our understanding of the mechanisms through which financial markets operate.

The main purpose of this work is to capitalize in the lack of studies for other relevant markets outside the United States. By using well established techniques in the literature such as the four-factor model and the GARCH model, this dissertation will explore whether the low-price anomaly is valid for the main unstudied European markets, namely Austria, Belgium, France, Ireland, Italy, Netherlands, Portugal, Spain, and the UK. Furthermore, we will present two extensions to the main study. The first will consist in the extension to the markets above of existing studies for the United States which connect the low-price anomaly with seasonality. The idea is to understand whether the low-price effect is stronger in certain months of the year and possibly connect it with some known temporal anomalies, such as the January effect in the study of Bhardwaj & Brooks (1992). The second extension will consist of a study of the low-price anomaly during different market phases, namely bull and bear markets. As far as it came to our knowledge, this will be the first study to connect the low-price effect with uptrend and downtrend phases of the market.

We will begin by implementing the traditional technique of building portfolios with stocks of low and high prices and analyze their return and risk characteristics. This first approach will allow us to have a rough idea of the presence of the low-price anomaly. We will further advance the study by adjusting the returns for the main market effects through a four-factor model.

The part of the study aimed at studying the seasonality of the effect, will be performed by splitting the returns of the portfolios by months, using a dummy variable, and observing whether the returns are particularly high or low in different months. The extension of the study aimed at analyzing the low-price effect during bull and bear markets will be performed by using a framework developed by Pagan & Sussounov (2003) to distinguish between bull and bear markets and compare the returns on the portfolios in the two phases of the market.

We found evidence in favor of a high-price anomaly in all the European markets under study in line with the study of Hammerich et al. (2016) for Germany. Furthermore, we present some evidence that the high-price effect present on these markets is in most of the cases not statistically significant after accounting for the size effect, value effect, momentum and transaction costs.

This dissertation unveils as follows. The next chapter presents a literature review with the main conclusions of the most important studies in the field. Chapter 2 presents the methodology, data and results for the study of the low-price anomaly. Chapter 3 discusses the methodology and the results for the study on the seasonality of the anomaly. Chapter 4 discusses the methodology and results of the low-price anomaly during bull and bear markets. The dissertation ends with a conclusion of the main results and suggestions of future investigation.

Chapter 1

Literature review

This first chapter intends to revise the current body of literature published in the low-price anomaly. Despite being an old anomaly, the literature on the low-price effect is not abundant. A recent interest in this topic has arisen since many papers have been published in 2016.

This literature review has been divided into 7 sections. The first settles the definition of the low-price effect and relevant terms in the dissertation. The second explores the literature on the preference of investors for low-priced stocks. The third section presents the first contributions for the literature of the low-price effect. The fourth, all the studies presenting evidence for the United States. The fifth section presents the studies for international markets. The sixth, presents studies specialized in the study of the riskiness of low-priced stocks. Lastly, we review the literature linking the low-price effect with its seasonality across different months.

1.1. Literature definition of low-price effect

All literature seems to agree with the definition of low-price effect as the empirical finding that low-priced stocks seem to produce higher returns than high-priced stocks in a risk-adjusted basis. Recently, some authors, mainly Singal & Tayal (2015), found that the low-price anomaly is no longer observed in the US market, but instead it seems to have been replaced by a high-price anomaly. Throughout the dissertation, we will continue to refer generically to the low-price anomaly as the name of this phenomenon. Furthermore, low-price anomaly and low-price effect are two terms used interchangeably.

1.2. The preference of investors for low-priced stocks

The preference of investors for low-priced stocks, known as nominal price illusion or share price puzzle, is well documented in the literature of stock splits. This body of literature seems to agree that the decisions of managers to produce stock splits to keep stock prices in an "acceptable range" is influenced by the preference of investors for low-priced stocks. Two studies presenting evidence on this relationship are the ones by Baker et al. (2009) and Jiang et al. (2013). According to these authors, there is a catering through the nominal share price. In other words, when the value of a stock increases considerably, managers will supply more low-priced stocks to investors. The explanation for this phenomenon is that managers recognize the preference of investors for low-priced stocks.

Weld et al. (2009) present evidence that since the great depression, the average share price has been remaining approximately constant around $36. The main reason pointed by these authors is that this price range was purposely achieved by stock splits due to the preference of investors for stocks with lower prices. Dyl & Elliot (2006) found direct evidence that managers manage the price of their firms' stocks using stock splits. More evidence on this finding was advanced by Schultz (2000), who finds that the number of investors on a certain share increases after stock splits. Green & Hwang (2009) find that similarly priced stocks commove together. After stock splits, the co-movement between low-priced stocks and the split stocks increases.

As for the explanations regarding the preference of investors for low-priced stocks, Kumar (2009) suggests that investors like low-priced stocks because they are perceived as a lottery. According to this author, lotteries have small prices compared with the big premiums, hence, it is possible that investors perceive low-priced stocks in the same sense. Birru & Wang (2016) provide evidence, by studying the options markets, that investors tend to overestimate the growth potential of low-priced stocks. According to these authors, investors perceive low-priced stocks as being more distance from infinity, which leads them to a believe that these stocks have more potential to grow. Bae et al. (2016) suggest that investors prefer low-priced stocks because they are anchored to the IPO price, which tends to be low.

1.3. First contributions

The studies presented in the above section focused in providing evidence in favor of the preference of investors for low-priced stocks in detriment of high-priced stocks. Other authors focused in providing empirical evidence showing that low-priced stocks can generate higher returns than higher-priced stocks.

The first work that came to our knowledge suggesting that low-priced stocks produced higher returns compared with high-priced stocks was the one by Fritzmeier (1936). In his paper, the author grouped the NYSE industrial stocks according to their prices into portfolios and analyzed graphically the performance of those portfolios. His results suggested clearly that the portfolios with low-priced stocks outperformed the portfolios with high-priced stocks. This author has not, however, presented a more robust statistical analysis, which was introduced latter by other authors.

Clendenin (1951) was the first to show some evidence regarding the volatility of low-priced stocks. According to this author, the anecdotal argument that low-priced stocks present higher volatility than high-priced stocks is not accurate. He analyzes different priced stocks with different degrees of quality[1] and he concluded that the variability that low-priced stocks observe is a consequence of speculation by investors and not the mere fact that low-priced stocks itself are riskier. Also, Allison & Heins (1966) presented evidence in favor of speculation as the explanation for the low-priced stocks high volatility.

1.4. Studies for the United States stock market

After the first contributions of the authors presented above, some other authors presented evidence in favor of the low-price effect, mainly for the US market. This new evidence, which I consider to be the main body of literature on this topic, used statistical analysis to draw conclusions from the data. The statistical analysis was mainly performed to provide evidence that in fact low-priced stocks have superior returns than high-priced stocks.

The first study to analyze statistically the low-price effect was the one by Pinches & Simon (1972). Their approach consisted in building different portfolios with low-priced stocks for a buy-and-hold strategy and for a fixed proportion strategy. Their findings suggest clearly that the portfolios with low-priced stocks have higher returns. They also found that the low-priced portfolios have higher returns after transaction costs when hold for longer periods of time.

The study by Blume & Husic (1973) was the first to apply modern portfolio theory to the low-price effect. By constructing indices for different stock prices, these authors found that the results obtained by Fritzmeier (1936) were correct. This study was of absolute importance, because Fritzmeier (1936) used only graphical analysis to derive the

[1] The notion of quality here is related to the rating assigned to stocks. On those days of the author, stocks were rated much like bonds today.

low-price effect, but Blume & Husic (1973) derived the effect analytically. Furthermore, these authors found that the beta changes as a function of the price level.

Another study that confirms the previous results is the one by Bachrach & Galai (1979). These authors arranged the stocks into two portfolios. One containing the stocks priced below $20 and the other containing stocks above $20. Then, the authors used regression analysis to test for the risk-return relationship. Their findings suggests that low-priced stocks produce higher risk adjusted returns and that systematic risk does not fully explain the superior returns of the low-priced stocks.

Perhaps the most important study on the low-price anomaly is the one developed by Edmister & Greene (1980) because these authors were the first to use risk-adjusted measures, namely the Sharpe and Treynor. In their study, the authors picked up all the stocks of the COMPUSTAT database and organized them into 61 portfolios. Edmister & Greene (1980) provide evidence that the portfolios with super-low-priced stocks[2] have higher average returns and higher total risk, but still they can produce higher risk-adjusted returns. They also found that the correlation between the portfolios of super-low-priced stocks and the market is lower than the correlation between high-priced stocks and the market.

Goodman and Peavy (1986) produced a study confirming the low-price effect. However, their study introduced an innovation, which consisted in analyzing the effect of size effect and earnings yields in the low-price effect. Their results suggest that low-price effect is present on the top of the size effect and the earnings yields.

Tseng (1988) was the first author to adjust the returns on the different portfolios for a market factor through the Capital Asset Pricing Model. The results of this author suggest that low-priced portfolios are able to produce returns in excess of the market. Furthermore, this author constructed two sets of portfolios, one sorted on price and price-to-earnings and the other sorted on price and market value. Their results suggest that stocks with lower prices still produced higher returns after controlling for price-to-earnings and market value.

Hwang & Lu (2008) also approached the low-price anomaly and by constructing several portfolios, they found that the low-priced stocks outperformed the high-priced stocks even after transaction costs. These authors were the first to incorporate a three and

[2] The authors define super-low-priced stocks as those with nominal prices less than $10.

four-factor model in their analysis to account for other factors such as size. These authors also accounted for illiquidity by using the factor of Amihud (2002). Their results suggest that low-priced stock returns are robust after accounting for these factors.

A recent study by Singal & Tayal (2015) analyses the traditional raw returns from organizing the stocks into portfolios according to their prices, but they also used the Fama and French (1992) three factor model and the Cahart (1997) momentum factor. Their findings suggest that high-priced stocks outperformed low-priced stocks. Furthermore, they also found that high-priced stocks are less sensitive to market movements, and display lower idiosyncratic volatility, idiosyncratic skewness, and illiquidity.

Another recent study is the one by Birru & Wang (2015). These authors use Ohlson (1995) model with accounting variables to adjust the price of stocks before sorting. This adjustment is used so that a nominal price premium can be reliably estimated, since price and return are mechanically linked. The evidence by these authors suggests that there is a low-price anomaly able to generate an abnormal return of 85 basis points based in value-weighted portfolios and in a four-factor model.

In summary, all the studies produced so far for the United States market seem to agree on the presence of a low-price anomaly, except the one by Singal & Tayal (2015). Our results for European stock markets are not in line with the results provided by most of the authors, since we provide evidence that high-priced stocks can outperform low-priced stocks in a risk-adjusted basis.

1.5. Literature for other international stock markets

Although the biggest body of literature is for the US market, some studies have been produced for other markets around the world.

Waelkens & Ward (1997) studied the low-price effect in the Johannesburg Stock Exchange and found that the low-price anomaly is not present in this market. Muthoni (2013) produced a study for the Nairobi stock exchange and concluded that a low-price anomaly is present in this market.

Elfakhani & Wei (2003) studied the existence of the low-price effect in the Canadian market alongside with the small firm effect. Furthermore, they controlled for the survivorship bias by examining the three groups of stocks: the survivor stocks, the delisted stocks, and the overall stocks. Their results suggest that high-priced stocks outperformed low-priced stocks both for small, medium, and large firms, and also for the survivor, delisted, and overall stocks.

Zaremba & Zmudzinski (2014) studied the Polish market and found that the low-price effect is observed in this market, but that it becomes insignificant after accounting for transaction costs. Zaremba et al. (2016) also studied the low-price anomaly in Poland, however, these authors found evidence in favor of a high-price effect.

The most recent study for a market outside the United States is the one by Hammerich et al. (2016) for Germany. These authors find robust evidence in favor of a high-price effect in Germany.

1.6. Studies on the riskiness of low-priced stocks

Alongside with the studies presented above, which focused mainly in gathering evidence of the existence of a low-price anomaly, other studies focused on the riskiness of low-priced and high-priced stocks. These studies were all performed for the United States.

Previously, it was said that Bachrach & Galai (1979) provided evidence that the systematic risk was not enough to explain the superior return of low-priced stocks. These results were contradicted by Christie (1982) and Dubofsky & French (1988). These later authors used new risk measures and found that in fact low-priced stocks are riskier than high-priced stocks. One of the explanations given by these authors to this fact is that low-priced stocks tend to be acquired with a higher degree of leverage.

Another study in the riskiness of low-priced stocks is the one by Bar-Yosef & Brown (1979), which by using only systematic risk instead of total risk found that there is a negative relationship between share price level and beta for non-splitting shares. For the group of splitting shares, the authors found no significant correlation. Another study that confirmed these results was the one by Strong (1983).

1.7. Studies on the seasonality of the low-price effect

The investigation of whether the low-price anomaly is more prominent in certain months of the year has attracted some attention. Special attention has been paid to the month of January, since this month exhibits the famous January effect.

Branch & Chang (1990) studied low-priced and high-priced stocks in December and January. Their results suggest that both low-priced and high-priced stocks that underperform in December, tend to outperform in January. They also found that this effect is particularly prominent for low-priced stocks. Thus, the authors conclude that the January effect is mainly a low-priced stocks effect.

Bhardwaj & Brooks (1992) found that the January effect is mainly observed for the low-priced stocks. According to them, the size effect was one of the main explanations for the January effect, however, their findings suggest that in fact the low-price effect is the main reason for the January effect. Furthermore, they found that after transaction costs, low-priced stocks do not earn abnormal returns in January. In addition to this study, the results of Jaffe, Keim &Westerfield (1989) and Kross (1985) also seem to confirm that the January effect is more a cause of the price effect than the size effect.

Hwang & Lu (2008) extended the previous studies by analyzing the different priced portfolios in every month of the year. Their results suggest that the most significant returns appear in January, November and December. January presents an average positive abnormal return and November and December present an average negative abnormal return. The other months of the year are not very relevant in terms of abnormal returns.

Singal & Tayal (2015) also analyzed the effect of January in the low-price effect by studying what happens to the portfolios returns when January is included and when it is excluded. Their results suggest that by excluding January, the returns of both low-priced and high-priced portfolios are higher than when January was included.

Except for Singal & Tayal (2015), all the authors found that the January effect in the United States is linked to the low-price effect. Although some studies on the low-price effect have been produced for markets outside the United States, no studies on the seasonality of this effect have been produced. Hence, this dissertation intends to capitalize on this opportunity. We hope that this study will help us understand whether the January effect in European markets can be explained in part by the low-price effect.

Chapter 2

Analysis of the low-price effect in European stock markets

2.1. Data and methodology

2.1.1. Data

All the data for Austria, Belgium, France, Ireland, Italy, Netherlands, Portugal, Spain, and the United Kingdom used in this study was retrieved from Datastream Thomson Reuters for the period between 1996 and 2016. The choice of this sample period is related with the data availability from the database. As for the frequency of the data, we retrieved monthly observations in alignment with all the studies in the literature of this effect.

The assignment of stocks into portfolios requires unadjusted prices (prices not incorporating the effect of corporate events). The choice of unadjusted prices is related with the fact that this would be the true price observed in the market and the one used to assign the stocks into the different portfolios.

The calculation of the returns of individual stocks and portfolios requires the use of returns. Datastream Thomson Reuters provides a measure of return know as return index, which is constructed as follows.

$$RI_{t+1} = RI_t \times \frac{P_{t+1}}{P_t} \qquad (2.1)$$

Although the index is defined in terms of prices, it includes the effect of all corporate events, such as dividends. The return index was retrieved also for 1995 because it is needed to compute the momentum factor in the four-factor model.

The final stocks included in the study had to meet cumulatively four criteria: 1) Being ordinary shares. Shares from REITs and mutual funds were excluded from the study. 2) Being quoted in the currency of the country in analysis. 3) Having available data on unadjusted price and return index in Datastream Thomson Reuters. This means that stocks with missing data or limited data are erased from the study. 4) Having at least 24 months (2 years) of observations

Survivorship bias is one important consideration in studies which deal with performance assessment. Hence, in addition to active stocks as of the last trading day of 2016, we also collected dead and suspended stocks. This way, we intend to perform the study free from any survivorship bias. When retrieved from Datastream Thomson Reuters, dead stocks present the last price available for all the months after its death. We clean this price after the death of the stock so the final selection of the stock is not affected by these prices.

A challenge that arises in the study of European markets for the sample period selected (1996 to 2016) is the change in 2000 of the national currency to the Euro. Datastream Thomson Reuters accounts for this change in the unadjusted prices and return index for periods before 2000.

We also retrieved the price-to-book ratio of each company and the total market capitalization of shares traded. As a proxy for the risk-free rate, we gathered the annualized monthly yields on treasury bills for each country. All this data will be useful for computing the factors in the factor models.

2.1.2. Portfolios construction

It seems unanimous in the literature that the best way to study the presence of the low-price effect is by constructing portfolios considering the prices of the stocks. This widespread approach will also be adopted in this dissertation.

The process begins by assigning the stocks into portfolios according to their unadjusted price. As stated above, the unadjusted price is used because that would be the real price observed in the market by investors.

The exact number of portfolios that should be constructed is not consensual. Some authors propose the construction of up to 60 portfolios, such as Edmister & Greene (1980), and others, such as Bachrach & Galai (1979), propose to split the shares into two portfolios. Most of the authors, such as Hwang and Lu (2008), Bhardwaj & Brooks (1992), and Singal and Tayal (2015) adopt a 5-portfolio approach. This work will follow these authors and will adopt 5 portfolios.

Another issue in the construction of the portfolios is the interval of stock prices that should be included in each portfolio. Most of the studies to the United States apply specific intervals to the stocks based in what the author believes is a low-priced and high-priced stock. The definition for the United States is not replicable to Europe because of three main factors: 1) The currency is different. 2) The notion of low price or high price depends on the market, since a low-priced stock in one market may be considered high-priced in another. 3) The existence of fixed stock price intervals may lead to certain portfolios having many stocks and others having few stocks. This might be an issue if diversification is a concern.

In order to address the three factors above, we have decided to implement the approach of Bhardwaj & Brooks (1992) and Zaremba et al. (2016) to define the stock price intervals. This approach divides the stocks into quintiles according to their unadjusted prices, allowing for an even distribution of stocks among portfolios.

The relevant price for assigning a stock into a portfolio is based on the price on the last trading day of the year before the one of the portfolio construction. This is consistent with most of the approaches adopted in the literature. The rebalancing of the portfolios will be made yearly and the stocks will change portfolio if their unadjusted prices in the last trading day of the previous year is no longer framed in the previous period portfolio price range. In order to avoid look-ahead bias, portfolios are only rebalanced in the end of the year for stocks listed or delisted during the year. All the literature in the low-price effect agrees in an equal-weighting and market capitalization weighting schemes for each stock in the portfolio. We will use both approaches. Due to missing data regarding market capitalization, we did not consider the stocks which miss this data, so the portfolios are directly comparable.

Once the portfolios are constructed, the monthly return for each stock is obtained from the following formula.

$$r_{i,t} = \ln\left(\frac{RI_{i,t+1}}{RI_{i,t}}\right) \times 100 \qquad (2.2)$$

Where $RI_{i,t}$ is the return index of stock i in week t. After the construction of these returns for each stock, we clean all outlier returns so we obtain results free from abnormal observations. We define outliers as extreme observations that lie below the 1% percentile and above the 99% percentile. The return of a portfolio in a certain month t is as follows.

$$R_{p,t} = \sum_{i=1}^{n} w_i \times r_{i,t} \qquad (2.3)$$

Where w_i is the weight of stock i. After computing the weighted average return for each portfolio based in the previous formula, the monthly returns of the portfolios are annualized as follows.

$$R_{p,a} = \left[\prod_{t=1}^{252}\left(1 + R_{p,t}\right)\right]^{\frac{1}{21}} - 1 \tag{2.4}$$

The risk of each portfolio will be given by the annualized monthly standard deviation of the portfolio returns as follows.

$$\sigma_a = \sigma_m \times \sqrt{12} \tag{2.5}$$

We also compute the Sharpe ratio for each portfolio as proposed in Edmister & Greene (1980) and corrected according to the method of Israelsen (2009).

$$SR = \frac{R_{p,a} - \overline{R_f}}{\sigma_a^{\left(\frac{R_{p,a} - \overline{R_f}}{\left|R_{p,a} - \overline{R_f}\right|}\right)}} \tag{2.6}$$

Where $\overline{R_f}$ is the mean monthly risk-free rate. The correction in the denominator allows to rank the Sharpe ratios when these present negative values.

2.1.3. Test for the return equality

In order to get evidence that the portfolios with low-priced and high-priced stocks produce significantly different returns from each other, we run a Wilcoxon rank sum test similarly to Waelkens & Ward (1997). This test allows us to compare the return distribution for the low-priced and high-priced portfolios and get evidence on that the returns of both portfolios present a statistically significant difference. Hence, the null hypothesis for the Wilcoxon rank sum test are as follows.

H_0: Distribution of returns is equal for both portfolios

The test statistic is given by the sum of the rank values of the returns for the low-priced portfolio and is represented by W. The critical value is obtained as follows.

$$\frac{W - \mu_W}{\sigma_W} \tag{2.7}$$

Where μ_W and σ_W are obtained as follows.

$$\mu_W = \frac{n_1 \times (N + 1)}{2} \tag{2.8}$$

$$\sigma_W = \sqrt{\frac{n_1 \times n_2 \times (N + 1)}{12}} \tag{2.9}$$

Where n_1, n_2 and N are the sample sizes for the low-priced portfolio, high-priced portfolio and both portfolios, respectively.

The use of the Wilcoxon test is justified by: (1) the purpose being to compare two populations (portfolios of low- and high-priced stocks), (2) the normality of the data is not necessary, and (3) the pairs are matched (we compare the returns of the portfolios for the same months).

2.1.4. Analysis of the return drivers

Several studies in the literature of the low-price effect have been analyzing the profitability of a strategy based on low-priced stocks. Similarly, we will apply a CAPM, three-factor model and four-factor model to the portfolio returns. The following equation shows the regression that will be estimated for a four-factor model.

$$r_{p,i,t} = \alpha_t + \beta_1 \times r_m + \beta_2 \times SMB + \beta_3 \times HML + \beta_4 \times WML + \varepsilon_i \qquad (2.10)$$

Where $r_{p,t}$ is the excess return of portfolio i in month t, α_t is the regression intercept and interpreted as the monthly abnormal return, r_m is the excess return on a value-weighted market portfolio, SMB stands for small minus big and corresponds to a size factor, HML stands for high minus low and corresponds to a value factor, WML stands for winners minus losers and corresponds to a momentum factor and ε_i is a residual term that follows the classic assumptions.

2.1.4.1. Excess market return factors, size factors, and value factors

The estimation of the market factors, size factors and value factors follow the methodology proposed by Fama & French (1993). The value-weighted market portfolio is calculated as a market capitalization weighted portfolio of all the stocks in a certain market. The risk-free rate is then subtracted to find the excess market return represented by r_m.

The size and value factors are found as follows. We begin by sorting the stocks into six portfolios. The choice of six portfolios follows Fama & French (1993) and is due to the small size of the markets being analyzed. The size sorting is based on the median of the stocks market capitalization and the value sorting is based on the lowest 30%, mid 40%, and highest 30% book-to-price ratios. Based on the intersection of each of these breakpoints, we construct six portfolios and assign each stock to a portfolio. The return of each portfolio is obtained through a value-weighted scheme. The SMB factor is computed as the difference between the simple average of the portfolios with small capitalization stocks and high capitalization stocks. The HML portfolio is computed in the same way but for the high and low book-to-market stocks.

2.1.4.2. Momentum factors

The momentum factor (WML) is estimated as in Cahart (1997). We begin by computing the 11-month returns prior to the month in which the factor is to be constructed. Based on these returns, we construct three portfolios for the lowest 30% stock returns, the medium 40% stock returns, and the highest 30% stock returns. The return for each portfolio is the equal-weighted average of the stock returns for that month. The momentum factor is found by subtracting the portfolio based in the lowest 30% returns from the portfolio of the highest 30% returns.

2.1.5. Transaction costs

Transaction costs are an important factor when considering the returns from an investment strategy because they decrease the final return obtained. We consider the effect of transaction costs in this dissertation.

Two of the most recognized transaction costs are the bid-ask spread and the brokerage commissions. This dissertation will only focus on the bid-ask spread in alignment with the study of Roll (1984). According to this author, in efficient markets the following measure is a good proxy for the bid-ask spread.

$$spread = 2 \times \sqrt{-cov} \tag{2.11}$$

Where cov is the first-order serial covariance of price changes which is mathematically represented as $cov(\Delta p, \Delta p_{t-1})$.

We apply this measure to each portfolio, so we obtain a portfolio-specific bid-ask spread. Furthermore, we do not consider brokerage commissions in line with Roll (1984), since they are negotiable.

2.2. Results and discussion

2.2.1. Portfolios return and risk

This first section aims at presenting and discussing the return and risk characteristics of the portfolios constructed under the methodology described in section 2.1.2. Table 2.1 summarizes some facts regarding the portfolios that were constructed.

The first row in the table shows the average total number of shares per year. This measure represents the number of stocks that were used in average each year for performing this study. As some stocks are listed and some are delisted during the period, we found prudent to report the average number of stocks instead of a total number. The results in the table suggest that the United Kingdom is by far the market with the largest number of stocks per year, with over a thousand stocks, whereas Ireland and Portugal are the markets with the lowest number of stocks included in the study per year.

The second row reports the average number of shares included in each portfolio per year. Once again, as the number of stocks changes from year to year, we found prudent to report an average number. As the stocks were split evenly across the portfolios, the average number reported is the same for all the portfolios. The results suggest that the United Kingdom is the country with the most stocks in each portfolio per year and Ireland is the country with the lowest.

The third row reports the total number of months for which we gathered observations. As our sample was collected from 1996 to 2016, we observed 252 months of data for each market.

The last five rows report the price intervals for each portfolio. These price intervals result from the ranking into quintiles of the stocks according to their unadjusted prices. The results show that price intervals vary from market to market, which strengthens the idea that setting a pre-defined price interval (used for US studies) for every market would not be a valid method because the price characteristics of each market are different.

Table 2.1 – Portfolio Statistics

	Austria	Belgium	France	Ireland	Italy	Netherlands	Portugal	Spain	United Kingdom
Average total number of shares per year	101	175	840	44	305	148	84	163	1,652
Average number of shares per portfolio per year	21	35	168	9	61	29	17	33	330
Number of months included	252	252	252	252	252	252	252	252	252
Average portfolio price intervals									
$\boldsymbol{P_1}$	€ 8.72	€ 10.46	€ 6.36	€ 0.29	€ 0.89	€ 5.69	€ 1.55	€ 4.05	£ 16.67
$\boldsymbol{P_2}$	€ 19.35	€ 27.14	€ 14.61	€ 1.13	€ 2.04	€ 12.82	€ 3.12	€ 7.43	£ 53.52
$\boldsymbol{P_3}$	€ 35.35	€ 65.62	€ 29.72	€ 3.05	€ 4.10	€ 22.19	€ 5.37	€ 13.25	£ 130.10
$\boldsymbol{P_4}$	€ 81.02	€ 158.47	€ 66.08	€ 7.77	€ 9.02	€ 37.33	€ 9.64	€ 23.74	£ 316.40
$\boldsymbol{P_5}$	€ 2,211.03	€ 8,899.07	€ 7,086.49	€ 42.99	€ 117.10	€ 5,003	€ 56.32	€ 478.39	£ 87,134.19

Notes: This table reports several information concerning the portfolios that were constructed to perform the study of the low-price effect for the period 1996-2016. The first row shows the total average number of stocks that were included in each year of study. The second row reports the average number of shares in each portfolio and in each year. As stocks were split into portfolios based in price percentiles, the number of shares in each portfolio in each year is equal, hence this measure is computed as the mean. The third row provides the number of months for which we have observations. The last five rows show the average price intervals for each portfolio. For instance, for Austria the average price for portfolio 1 ranges from €0 to €8.72 (inclusive), for portfolio 2 from 8.72€ to 19.35€ (inclusive), etc. Price intervals were obtained by ranking the unadjusted prices of stocks into quintiles in the last trading day of the previous year.

Table 2.2 reports some statistics for the portfolios under study. For each row, the first value represents the annualized geometric gross return, the value in parenthesis the annualized standard deviation and the value in brackets the Sharpe ratio.

The results reported in the table provide evidence that low-priced portfolios (P_1) produce a negative annualized return for all markets under study. Whereas most of the returns of high-priced portfolios (P_5) are positive. Whenever the return of a high-priced portfolio is negative, it seems to be less negative than the return for a low-priced portfolio. This suggests that high-priced portfolios in general seem to produce higher returns than low-priced portfolios.

As far as risk is concerned, the annualized standard deviations (value in parenthesis) of low-priced portfolios seem to be higher in general relative to the one of high-priced portfolios. This suggests that investors perceive low-priced stocks as being riskier. In fact, this result is in alignment with some previous studies, such as Christie (1982) and Dubofsky & French (1988), who provided evidence that low-priced stocks are riskier than high-priced stocks.

One interesting pattern that seems to arise in our previous discussion is that low-priced portfolios produce lower returns than high-priced stocks, but they seem to be riskier. This observation contradicts the traditional return-risk relationship in finance. In fact, further ahead in this dissertation, we will provide evidence that, in general, the systematic risk of low-priced portfolios is lower than that of high-priced portfolios, suggesting that low-priced portfolios have a higher degree of idiosyncratic risk.

The Sharpe ratios given in brackets seem to confirm that high-priced portfolios produce higher returns, but this time in a risk-adjusted basis. The correction of Israelsen (2009) allows to directly sort the negative and positive Sharpe ratios at the same time. Hence, after applying this correction, a less negative Sharpe ratio will be better than a more negative Sharpe ratio. In situations where high-priced portfolios do not produce enough return to outperform the risk-free rate, the Sharpe ratio is less negative than that of low-priced portfolios, suggesting that in fact high-priced portfolios produce higher risk-adjusted returns.

Table 2.2 – Descriptive statistics on gross returns

	Austria	Belgium	France	Ireland	Italy	Netherlands	Portugal	Spain	United Kingdom
$\boldsymbol{P_1}$	-9.800% (10.40%) [-0.0157]	-0.984% (7.11%) [-0.0039]	-2.385% (8.81%) [-0.0067]	-12.922% (23.44%) [-0.0397]	-10.380% (19.04%) [-0.0286]	-7.656% (11.05%) [-0.01281]	-4.586% (17.98%) [-0.0130]	-5.580% (17.55%) [-0.0183]	-9.119% (8.06%) [-0.0104]
$\boldsymbol{P_2}$	1.020% (11.88%) [-0.0051]	-2.320% (9.98%) [-0.0068]	-0.832% (9.75%) [-0.0051]	-9.206% (21.05%) [-0.0278]	-2.715% (17.50%) [-0.0128]	2.041% (12.67%) [-0.0024]	-5.753% (18.28%) [-0.01535]	1.235% (14.58%) [-0.00526]	-6.298% (7.99%) [-0.008]
$\boldsymbol{P_3}$	3.377% (12.84%) [-0.0024]	5.128% (9.14%) [0.0744]	-1.733% (9.20%) [-0.0064]	1.161% (21.88%) [-0.0062]	-1.292% (17.46%) [-0.0103]	5.633% (11.79%) [0.14398]	-1.343% (15.44%) [-0.00615]	4.871% (14.32%) [0.00184]	-4.079% (8.44%) [-0.0066]
$\boldsymbol{P_4}$	4.454% (12.03%) [-0.0001]	4.797% (8.41%) [0.04149]	1.987% (9.59%) [-0.00315]	7.165% (20.17%) [0.1568]	2.407% (17.85%) [-0.00396]	6.682% (11.73%) [0.23415]	-0.707% (14.26%) [-0.00478]	6.930% (13.51%) [0.15435]	-0.989% (9.32%) [-0.00442]
$\boldsymbol{P_5}$	3.090% (7.48%) [-0.0016]	6.514% (7.18%) [0.28774]	2.088% (9.20%) [-0.0029]	7.153% (19.02%) [0.1657]	-0.376% (17.38%) [-0.00869]	5.530% (10.04%) [0.15882]	3.679% (10.94%) [0.09479]	8.798% (12.24%) [0.32298]	-0.208% (10.20%) [-0.00404]

Notes: This table reports the average geometric return for each portfolio and for each country from 1996 to 2016. Each portfolio was constructed by ranking the unadjusted price of the stocks into quintiles in the last trading day of the previous year. Logarithmic returns were computed for the stocks and portfolio returns were obtained through the attribution of an equal weight to each stock in the portfolio. The number in parenthesis represents the standard deviation of portfolio returns and were computed as if portfolios were single assets. The number in brackets represents the Sharpe ratio for the portfolios.

Transaction costs are among the most important factors to consider when investing because they lower the total return one investor could get were transaction costs inexistent. Table 2.3 reports the annualized net returns for the portfolios. Bid-ask spreads were annualized through a multiplication of the monthly bid-ask spread by a factor of twelve.

The number in brackets represents the monthly bid-ask spread obtained from the method of Roll (1984). The results show that for low-priced portfolios, the bid-ask spread tends to be wider. From the table, it is perceivable that the returns for the high-priced portfolios are still higher than the ones of low-priced portfolios. This observation might be explained by the higher gross returns of high-priced portfolios or by the lowest bid-ask spread at which these portfolios are subject.

The conclusions for the Sharpe ratio (number in parenthesis) remain valid since most of these ratios rank higher for high-priced portfolios than for low-priced portfolios. Hence, even after transaction costs, high-priced portfolios seem to produce a higher risk-adjusted return.

Table 2.3 – Descriptive statistics on net returns

	Austria	Belgium	France	Ireland	Italy	Netherlands	Portugal	Spain	United Kingdom
P_1	-10.426% [0.052%] (-0.0163)	-1.511% [0.044%] (-0.0042)	-2.886% [0.042%] (-0.0072)	-14.332% [0.118%] (-0.0421)	-11.471% [0.091%] (-0.0306)	-8.265% [0.051%] (-0.01348)	-5.699% [0.093%] (-0.015)	-6.567% [0.082%] (-0.02003)	-9.587% [0.039%] (-0.0108)
P_2	-0.380% [0.053%] (-0.0067)	-2.915% [0.050%] (-0.0074)	-1.392% [0.047%] (-0.0065)	-10.518% [0.109%] (-0.0306)	-3.691% [0.081%] (-0.01456)	-1.369% [0.056%] (-0.00672)	-6.675% [0.077%] (-0.01703)	0.355% [0.073%] (-0.00655)	-6.799% [0.042%] (-0.0084)
P_3	2.705% [0.056%] (-0.0033)	4.546% [0.049%] (0.0107)	-2.251% [0.043%] (-0.0069)	-0.110% [0.106%] (-0.009)	-2.274% [0.082%] (-0.1204)	5.010% [0.052%] (0.09114)	-2.183% [0.070%] (-0.00745)	4.012% [0.072%] (-0.00119)	-4.589% [0.043%] (-0.00704)
P_4	3.704% [0.063%] (-0.0019)	4.249% [0.046%] (-0.0002)	1.456% [0.044%] (-0.0037)	6.066% [0.092%] (0.10235)	1.304% [0.092%] (-0.00593)	6.089% [0.049%] (0.18359)	-1.604% [0.075%] (-0.00605)	6.122% [0.067%] (0.09455)	-1.530% [0.045%] (-0.0049)
P_5	2.645% [0.037%] (-0.0011)	6.136% [0.031%] (0.23509)	1.556% [0.044%] (-0.0034)	5.909% [0.104%] (0.1003)	-1.428% [0.088%] (-0.01052)	4.938% [0.049%] (0.09986)	2.958% [0.060%] (0.02889)	8.054% [0.065%] (0.26211)	-0.842% [0.053%] (-0.0047)

Notes: This table reports the net average geometric return for each portfolio and for each country from 1996 to 2016. The number in brackets represents the bid-ask spread. The number in parenthesis represents the Sharpe ratio.
Portfolios were formed based on the ranking of unadjusted stock prices into quintiles in the last trading day of the previous year for the period 1996-2016. Portfolio returns were obtained by equally weighting the logarithmic return of each stock in the portfolio.
Transaction costs were calculated through the methodology of Roll (1984), who propose the following formula to assess the bid-ask spread.

$$c = 2 \times \sqrt{-cov}$$

Where cov is the first-order serial covariance of price changes.

2.2.2. Results for the Wilcoxon rank sum test

Table 2.4 reports the results for the Wilcoxon rank sum test. This test is important in assessing whether the return distributions of both portfolios are equal or not. This will allows to assess the robustness of evidence of the high-price effect above.

The first row reports the rank sum statistics, which is the sum of the ranking positions of the returns for the first portfolio. The last row reports the P-value, which shows the lowest level of significance for which we can reject the null hypotheses of equal portfolio return distributions.

The results show that for Austria, Belgium, Ireland, Netherlands, Spain and the United Kingdom the returns of both portfolios are significantly different for a 1% significance level. These results provide evidence that the return distribution of both portfolios are different showing that for these countries there seems to be a relevant high-price effect.

As for France, Italy and Portugal, the results are still statistically significant, but for a 5% significance level. Even so, the high-price effect seems to be statistically significant for these countries as well.

In summary, the results of the Wilcoxon rank sum test further support the existence of a high-price effect in European stock markets, since the return distributions of both portfolios are statistically different.

Table 2.4 – Results for the Wilcoxon Rank Sum Test

	Austria	Belgium	France	Ireland	Italy	Netherlands	Portugal	Spain	United Kingdom
Rank Sum Statistics ($\boldsymbol{W}$)	55,613	57,694	60,147	57,599	60,331	56,579	60,501	58,632	56,570
Observations	504	504	504	504	504	504	504	504	504
$\boldsymbol{\mu_W}$	63,630	63,630	63,630	63,630	63,630	63,630	63,630	63,630	63,630
$\boldsymbol{\sigma_W}$	1,634.77	1,634.77	1,634.77	1,634.77	1,634.77	1,634.77	1,634.77	1,634.77	1,634.77
$\boldsymbol{z}$	-4.9041	-3.6311	-2.1306	-3.6892	-2.0180	-4.3132	-1.9140	-3.0573	-4.3187
$\boldsymbol{P}$ - Value	0.0000005	0.000141	0.0167	0.000112	0.0218	0.000008	0.027808	0.001117	0.000008

Notes: This table reports the results for the Wilcoxon rank sum test. The purpose of the test is to assess the null hypothesis that the distribution of returns of the portfolios with low-priced stocks and high-priced stocks are equal. The first row in the table provides the rank sum statistics, which is the sum of the rank values for the low-priced portfolios. μ_W and σ_W are two parameters for a normal distribution which will help in assessing the significance of the null hypothesis and are computed as $\mu_W = \frac{n_1 \times (N+1)}{2}$ and $\sigma_W = \sqrt{\frac{n_1 \times n_2 \times (N+1)}{12}}$, where n_1 and n_2 are the number of observations in the low-priced and high-priced portfolios and N the total number of observations. z is a standard normal value obtained as $\frac{W-\mu_W}{\sigma_W}$. The p-value is the lowest level of significance for which the null hypothesis can be rejected.

2.2.3. Profitability of the low-price anomaly

The profitability of the low-price effect is analyzed in terms of its ability to generate abnormal returns or alpha. In order to know whether a return is abnormal and robust enough, we use the CAPM, three-factor model and four-factor model to decompose the original portfolio returns and get what could be considered a normal return.

In order to estimate the models above, we began by checking the stationarity of the portfolio return time series. Stationarity allows us to ensure that the regression does not yield spurious results. (Gujarati, 2003) We used a Dickey-Fuller stationarity test and checked that all the series were stationary.

The estimation of the models mentioned above was made through the least squares method. After the estimation, we checked for any violation of the classical regression assumptions, namely heteroscedasticity, autocorrelation and multicollinearity.

. Heteroscedasticity was assessed through a White test, and we were not able to reject the null hypothesis of no heteroscedasticity. Hence, we found evidence of the error term to be homoscedastic. The same was true for the Breusch-Pagan test on autocorrelation. Even so, we found to be prudent to estimate the regression with the Newey-West correction mechanism so we could have parameters valid for inference.

As for multicollinearity, we assessed its presence through a VIF test and through the factor correlations as presented in table 2.5. The correlations matrix below show that there are not much values above 50%, which is a sign in favor of no multicollinearity. Furthermore, the Spearman correlation test shows that most of the correlations are statistically different from zero, providing further evidence in favor of the robustness of the correlations. We also conducted VIF tests alongside with the regressions. All VIF values obtained were below 10, which according to Gujarati (2003) provide evidence in favor of no severe multicollinearity.

Table 2.5 - Descriptive statistics for the factors

		Mean	Standard deviation	Observations	Correlations			
					r_m	SMB	HML	WML
Austria	r_m	-0.123%	5.486%	252	1			
	SMB	-0.200%	3.555%	252	-0.1901***	1		
	HML	0.913%	0.913%	252	0.2152***	-0.4262***	1	
	WML	1.640%	1.640%	252	-0.2683***	0.0003	-0.1330**	1
Belgium	r_m	0.112%	6.230%	252	1			
	SMB	-0.068%	1.419%	252	-0.0519	1		
	HML	0.363%	2.052%	252	0.3891***	0.3582***	1	
	WML	0.286%	0.286%	252	-0.0157	-0.2370***	-0.2063***	1
France	r_m	0.120%	5.943%	252	1			
	SMB	-0.104%	1.698%	252	-0.4957***	1		
	HML	0.296%	0.296%	252	0.0879*	-0.3753***	1	
	WML	0.997%	0.997%	252	-0.3555***	0.0882*	0.0380	1
Ireland	r_m	-0.674%	9.587%	252	1			
	SMB	-1.248%	19.010%	252	0.0286	1		
	HML	-2.480%	-2.480%	252	0.1686***	0.8517***	1	
	WML	1.988%	1.988%	252	-0.4332***	-0.0853*	-0.2213***	1
Italy	r_m	-0.032%	7.181%	252	1			
	SMB	0.136%	2.080%	252	-0.3764***	1		
	HML	0.073%	3.378%	252	0.2936***	-0.2004***	1	
	WML	1.465%	5.699%	252	-0.5580***	0.2216***	-0.1921***	1

		Mean	Standard deviation	Observations	Correlations			
					r_m	SMB	HML	WML
Netherlands	r_m	0.066%	5.368%	252	1			
	SMB	-0.065%	2.320%	252	-0.2642***	1		
	HML	-0.146%	-0.146%	252	0.4793***	-0.1772***	1	
	WML	2.398%	2.398%	252	-0.3926***	0.0275	-0.4913***	1
Portugal	r_m	0.190%	5.906%	252	1			
	SMB	0.026%	3.058%	252	-0.0824*	1		
	HML	-0.197%	-0.197%	252	0.1947***	0.0382	1	
	WML	-0.221%	-0.221	252	-0.1833***	-0.0577	-0.2594***	1
Spain	r_m	0.079%	6.496%	252	1			
	SMB	0.197%	4.677%	252	0.0087	1		
	HML	0.039%	5.923%	252	0.1381**	-0.7352***	1	
	WML	1.139%	5.426%	252	-0.4411***	0.0326	-0.1174**	1
United Kingdom	r_m	-0.057%	4.679%	252	1			
	SMB	-1.333%	4.572%	252	-0.4496***	1		
	HML	0.946%	0.946%	252	0.1776***	-0.5280***	1	
	WML	2.934%	2.934%	252	-0.3863***	-0.1320**	-0.1891***	1

Notes: This table shows statistics for the factors included in the factor models. After obtaining the factors calculated as in Fama & French (1993) and Carhart (1997), the arithmetic average and standard deviation were obtained. The values in the table are monthly. The correlation between factors were also obtained to assess multicollinearity. A Spearman correlation test was conducted for the correlations in order to observe their significance. The null hypothesis for this test is that the correlation coefficient is equal to zero. The test statistic for this test is as follows.

$$t = \frac{r \times \sqrt{n-2}}{\sqrt{1-r^2}} \sim t_{n-2}$$

Where n is the sample size. *, ** and *** show that we reject the null hypothesis for a 10%, 5% and 1% level, respectively.

Table 2.6 provides the values for the parameters obtained from the process of estimation described above. In the sequence of our testing for the stationary of the return series, the classic assumptions violation and the use of the Newey-West mechanism, we have some assurance that the parameters are valid for inference and that spurious results had not arisen.

The observation of the results lead us to conclude that for all the markets, except Portugal, and for both for the CAPM, three-factor model, and four-factor model low-priced portfolios generate negative alphas. The statistical significance of these values provide evidence that these negative returns are robust. These returns get further negative when considering transaction costs (value in square brackets).

For high-priced portfolios, the pattern is not well defined. For such markets as Austria and Ireland, all the models point to the non-existence of alpha since this value is not statistically significant. For other markets, such as France and Spain, the alpha is negative and statistically significant. The unique market that seems to be able to generate statistically significant returns robust to transaction costs is Belgium.

We mentioned above that the standard deviation of low-priced portfolios is higher than high-priced portfolios. By looking at table 2.6, we are able to see that the beta estimation of the CAPM is higher for high-priced stocks than low-priced stocks for the generality of the markets. These results suggest that high-priced portfolios have higher systematic risk, but as shown above, lower total risk, which leads us to conclude that it is probable that high-priced portfolios have a lower level of idiosyncratic risk. Low-priced portfolios seem to have a higher level of idiosyncratic risk because they have a lower level of systematic risk and a higher level of total risk.

In summary, a strategy based on seeking alpha from low-priced portfolios would probably end up in a negative statistically significant return for all the markets except Portugal (based on the four-factor model). A strategy based on seeking alpha from high-priced portfolios seems not to be profitable for any market, except for Belgium. Furthermore, our results support a higher degree of idiosyncratic risk among low-priced portfolios.

Table 2.6 – Parameters for the CAPM, three-factor model and four-factor model

		CAPM			Three-factor model					Four-factor model					
		α	β	R^2	α	β^{r_m}	β^{SMB}	β^{HML}	R^2	α	β^{r_m}	β^{SMB}	β^{HML}	β^{WML}	R^2
Austria	P_1	-0.011*** (0.00174) [-1.152%]	0.2443*** (0.03167)	0.1923***	-0.012*** (0.00178) [-1.252%]	0.23105*** (0.03247)	0.01955 (0.05408)	0.1015** (0.0492)	0.2067***	-0.01*** (0.00184) [-1.05%]	0.2137*** (0.03338)	0.00929 (0.0599)	0.09048* (0.09048)	-0.051** (0.0296)	0.2197***
	P_5	-0.0005 (0.00093) [-0.087%]	0.2944*** (0.01685)	0.5497***	-0.00044 (0.00094) [-0.081%]	0.3035*** (0.01706)	0.0911*** (0.02842)	0.01387 (0.0258)	0.5688***	-0.0012 (0.00096) [-016%]	0.3163*** (0.01731)	0.0987*** (0.02814)	0.02206 (0.0256)	0.04437*** (0.01541)	0.5828***
Belgium	P_1	-0.0032** (0.00132) [-0.364%]	0.0062*** (0.01738)	0.1203***	-0.0035** (0.0014) [-0.394%]	0.101*** (0.02105)	0.2198*** (0.07244)	0.142** (0.0704)	0.1749***	-0.004** (0.0014) [-0.44%]	0.091*** (0.02011)	0.2413*** (0.07129)	0.1549** (0.07223)	0.02758 (0.0198)	0.1811***
	P_5	0.0028*** (0.01899) [0.249%]	0.2583*** (0.01898)	0.5897***	0.0032*** (0.0010) [0.289%]	0.273*** (0.02193)	0.1672** (0.07748)	-0.091* (0.05335)	0.6022***	0.003*** (0.0009) [0.269%]	0.272*** (0.0209)	0.1921** (0.07708)	-0.08489 (0.05519)	0.032*** (0.0111)	0.6104***
France	P_1	-0.006*** (0.001) [-0.642%]	0.3410*** (0.01804)	0.6202***	-0.006*** (0.00094) [-0.642%]	0.33950*** (0.0198)	0.4104*** (0.0666)	0.1577*** (0.05465)	0.6677***	-0.01*** (0.0011) [-1.04%]	0.3697*** (0.0244)	0.3885*** (0.0653)	0.16525*** (0.05318)	-0.07459** (0.03264)	0.6854***
	P_5	-0.002** (0.00093) [-0.244%]	0.3951*** (0.0198)	0.7620***	-0.002** (0.00085) [-0.244%]	0.4377*** (0.02137)	0.3238*** (0.0639)	0.1245*** (0.04454)	0.7891***	-0.001** (0.00094) [-0.14%]	0.4305*** (0.02197)	0.3175*** (0.06441)	0.12668*** (0.04466)	-0.02147 (0.02355)	0.7904***
Ireland	P_1	-0.009*** (0.0021) [-1.018%]	0.0521* (0.02656)	0.0271***	-0.009*** (0.0021) [-1.018%]	0.062** (0.0279)	0.0438** (0.0189)	-0.025** (0.01258)	0.0468***	-0.01*** (0.0023) [-1.12%]	0.0612** (0.0304)	0.044** (0.0186)	-0.025** (0.01224)	-0.00251 (0.0313)	0.0468***
	P_5	0.0011 (0.00153) [0.006%]	0.04522* (0.02608)	0.0401***	0.001 (0.00156) [-0.004%]	0.05133* (0.02799)	0.01874 (0.01209)	-0.01442 (0.00939)	0.0491***	0.001 (0.0016) [-.004%]	0.05168* (0.0301)	0.01864 (0.01239)	-0.01431 (0.0101)	0.00106 (0.0197)	0.0491**
Italy	P_1	-0.010*** (0.0023) [-1.091%]	0.6162*** (0.05148)	0.6413***	-0.011*** (0.00195) [-1.191%]	0.60021*** (0.0453)	0.3554*** (0.13135)	0.3959*** (0.07583)	0.7044***	-0.01*** (0.00215) [-1.09%]	0.5447*** (0.05121)	0.3591*** (0.13008)	0.3895*** (0.076966)	-0.128** (0.05631)	0.7165***
	P_5	-0.0018 (0.00172) [-0.268%]	0.6248*** (0.04331)	0.7879***	-0.00221 (0.00155) [-0.309%]	0.6014*** (0.0371)	0.12993** (0.0599)	0.2721*** (0.04214)	0.8189***	-0.00164 (0.00155) [-0.25%]	0.5844*** (0.03808)	0.13104** (0.0601)	0.2701*** (0.04512)	-0.03916 (0.0407)	0.8201***

		CAPM			Three-factor model					Four-factor model					
		α	β	R^2	α	β^{r_m}	β^{SMB}	β^{HML}	R^2	α	β^{r_m}	β^{SMB}	β^{HML}	β^{WML}	R^2
Nether-lands	P_1	-0.05*** (0.00204) [-5.05%]	0.3451*** (0.03791)	0.2489***	-0.05*** (0.00193) [-5.05%]	0.33863*** (0.04186)	0.42336*** (0.08637)	0.19246*** (0.06905)	0.3306***	-0.04*** (0.0021) [-4.05%]	0.3143*** (0.0425)	0.39773*** (0.08602)	0.12048 (0.07393)	-0.1004** (0.03947)	0.3477***
	P_5	-0.04*** (0.0016) [-4.05%]	0.4633*** (0.0297)	0.4939***	-0.04*** (0.00159) [-4.05%]	0.47795*** (0.03435)	0.1548** (0.0709)	0.0105 (0.05667)	0.5035***	-0.04*** (0.00176) [-4.05%]	0.4848*** (0.03528)	0.1620** (0.0714)	0.0307 (0.06138)	0.02819 (0.0328)	0.5050***
Portugal	P_1	-0.0039 (0.003) [-0.48%]	0.4297*** (0.0815)	0.2382***	-0.0036 (0.0029) [-0.45%]	0.4251*** (0.07325)	0.5419*** (0.01267)	0.1992*** (0.0767)	0.3699***	-0.0038 (0.0029) [-0.47%]	0.4136*** (0.07364)	0.5325*** (0.12897)	0.1735** (0.0801)	-0.0633 (0.04207)	0.3774***
	P_5	0.0022 (0.0014) [0.16%]	0.4084*** (0.0466)	0.5795***	0.0021 (0.0015) [0.15%]	0.4199*** (0.0468)	0.0464 (0.0498)	-0.0684 (0.04414)	0.5890***	0.0021 (0.00145) [0.15%]	0.4211*** (0.04689)	0.04742 (0.05005)	-0.0657 (0.04403)	0.00675 (0.01875)	0.5893***
Spain	P_1	-0.03*** (0.00502) [-3.08%]	0.9955*** (0.0774)	0.3982***	-0.03*** (0.0049) [-3.08%]	0.9332*** (0.07728)	0.5175*** (0.15682)	0.4687*** (0.12502)	0.4318***	-0.02*** (0.0048) [-2.08%]	0.7509*** (0.08115)	0.5097*** (0.14898)	0.4373*** (0.11892)	-0.5255*** (0.09589)	0.4893***
	P_5	-0.04*** (0.0021) [-4.06%]	0.5633*** (0.03238)	0.5476***	-0.04*** (0.0021) [-4.06%]	0.5616*** (0.03311)	0.08041 (0.0672)	0.00939 (0.05356)	0.5522***	-0.04*** (0.0022) [-4.06%]	0.5909*** (0.0364)	0.08168 (0.0668)	0.01443 (0.05335)	0.08127* (0.04302)	0.5586***
United Kingdom	P_1	-0.01*** (0.0014) [-1.04%]	0.3047*** (0.0287)	0.3744***	-0.01*** (0.00077) [-1.04%]	0.4701*** (0.02622)	0.44392*** (0.03138)	0.1859*** (0.02628)	0.8266***	-0.01*** (0.00097) [-1.04%]	0.4751*** (0.0306)	0.4492*** (0.0335)	0.1898*** (0.02676)	0.00867 (0.02137)	0.8268***
	P_5	-0.002** (0.00097) [-0.25%]	0.5343*** (0.0303)	0.7134***	0.00096 (0.00075) [0.043%]	0.659*** (0.0224)	0.3379*** (0.0259)	0.1489*** (0.02618)	0.8450***	-0.00006 (0.00086) [-0.06%]	0.6957*** (0.0288)	0.377*** (0.03147)	0.1773*** (0.02627)	0.06364*** (0.02162)	0.8810***

Notes: This table shows the results from the least squares estimation with the Newey-West correction mechanism for the CAPM, three-factor model and four-factor model. The statistical significance of the parameters is represented by the asterisks, where *, ** and *** represent a statistical significance for 10%, 5% and 1% level, respectively. The number in parenthesis represents the standard errors for the parameters. The number in brackets is the alpha after transaction costs.
Portfolios were formed based on the ranking of unadjusted stock prices into quintiles in the last trading day of the previous year for the period 1996-2016. Portfolio returns were obtained by equally weighting the logarithmic return of each stock in the portfolio. The results reported are only for the first and fifth portfolios. The market, size and value factors were calculated according to the methodology of Fama & French (1993) and the momentum factor according to Carhart (1997).

Chapter 3

The seasonality of the low-price effect

3.1. Methodology

We use two approaches to study the seasonality of the low-price effect. The first approach consists in the separation of the portfolios per month and analyze the average risk-adjusted return of each portfolio in each month. This approach will bring some insight on the portfolios' behavior in each month of the year.

The second approach consists in using regression analysis and dummy variables to capture the average return in each month of the year. It is wide accepted nowadays in the literature of the month and day of the week effect that estimating an equation with dummies is the best way to capture the average sentiment in each month of the year or day of the week. (Beller & Nofsinger, 1998) We also adopt this method to study the average return sign in each month of the year for each of the portfolios.

Although there is wide acceptance regarding the use of a regression with dummies, there is no much consensus on which estimation method should be used. The GARCH(1,1) model seems to be the preferred in these kind of estimations since it captures better the conditional volatility of the data. (Beller & Nofsinger, 1998)

We begin by computing the parameters for the following equation based on the least squares method and performing an ARCH test.

$$r_{pi,t} = \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \beta_7 D_7 + \beta_8 D_8 + \beta_9 D_9 + \beta_{10} D_{10} + \beta_{11} D_{11} + \beta_{12} D_{12} + \varepsilon_i \quad (3.1)$$

Where D_i is a dummy that assumes the value 1 in the month i and zero otherwise and $i = 1, \dots, 12$ where 1 corresponds to January and so on until December.

If we fail to reject the presence of an ARCH effect in the residuals, we estimate the previous equation based on the GARCH(1,1) model.

$$r_{pi,t} = \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \delta_4 D_4 + \delta_5 D_5 + \delta_6 D_6 + \delta_7 D_7 + \delta_8 D_8 + \delta_9 D_9 + \delta_{10} D_{10} + \delta_{11} D_{11} + \delta_{12} D_{12} + h_{it} \quad (3.2)$$

$$h_{it} = \sigma_{it} \varepsilon_{it} \quad (3.3)$$

$$\sigma_{it}^2 = \alpha_0 + \alpha_1 \times h_{t-1}^2 + \beta_1 \times \sigma_{it-1}^2 \quad (3.4)$$

Then, similar to Lundbergh & Teräsvirta (2002), we apply the ARCH test to the residuals of the GARCH(1,1) model and specify higher orders until the ARCH effect is no longer present.

When running the regression above, we have E-views using the Bollerslev (1987) quasi-maximum likelihood estimator because of the potential non-normality of residuals.

3.2. Results and discussion

As mentioned in the literature, some studies have been suggesting a connection between the January effect and the low-price effect. According to these studies, the January effect arises mainly among low-priced stocks. The results we obtained are provided in tables 3.1 and 3.2.

Table 3.1 provides evidence that low-priced portfolios tend to produce lower returns than high-priced ones for the different months of the year. Furthermore, we observe that high-priced portfolios consistently produce higher returns in January than in the other months of the year. These results are not in alignment with the ones for the studies for the United States.

A closer inspection reveals that July, October and December seem to be the months that produce the lowest returns in the year, especially for low-priced portfolios.

The main conclusion from these first results is that there seems to be a January effect among high-priced portfolios. We will now report the results for the GARCH model which intends to further advance these first results.

Table 3.1 – Return and risk for the months of the year

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Austria	P_1	-0.437% (8.91%) [-1.06%]	-0.205% (11.09%) [-0.83%]	-0.545% (8.95%) [-1.17%]	-0.118% (8.45%) [-0.74%]	0.138% (10.15%) [-0.49%]	-0.376% (13.64%) [-1.00%]	-0.357% (10.99%) [-0.98%]	-0.821% (10.63%) [-1.45%]	-0.402% (9.74%) [-1.03%]	-0.544% (10.69%) [-1.17%]	-0.562% (10.87%) [-1.19%]	-0.376% (7.41%) [-1.00%]
	P_5	0.481% (8.15%) [0.04%]	0.206% (8.18%) [-0.24%]	0.059% (7.98%) [-0.39%]	0.466% (6.51%) [0.02%]	0.230% (4.27%) [-0.22%]	0.222% (8.27%) [-0.22%]	0.147% (6.67%) [-0.30%]	0.050% (6.80%) [-0.40%]	-0.135% (5.12%) [-0.58%]	-0.259% (7.68%) [-0.70%]	-0.064% (8.80%) [-0.51%]	-0.037% (7.74%) [-0.48%]
Belgium	P_1	-0.058% (7.96%) [-059%]	0.020% (9.32%) [-0.51%]	0.032% (4.73%) [-0.50%]	0.096% (5.93% [-0.43%]	0.296% (6.46%) [-0.23%]	-0.301% (6.45%) [-0.83%]	-0.016% (9.05%) [-0.54%]	-0.011% (6.89%) [-0.54%]	0.016% (5.08%) [-0.51%]	-0.033% (5.02%) [-0.56%]	-0.026% (7.30%) [-0.55%]	-0.022% (5.93%) [-0.55%]
	P_5	0.043% (4.79%) [-0.33%]	0.022% (8.67%) [-0.36%]	0.014% (7.03%) [-0.36%]	0.353% (5.35%) [-0.02%]	0.459% (4.17%) [0.08%]	0.451% (5.94%) [0.07%]	0.021% (8.20%) [-0.36%]	0.022% (5.20%) [-0.36%]	0.013% (5.19%) [-0.36%]	-0.014% (7.71%) [-0.39%]	0.006% (11.63%) [-0.37%]	0.003% (6.92%) [-0.37%]
France	P_1	0.510% (6.90%) [0.01%]	0.131% (10.95%) [-0.37%]	0.034% (7.95%) [-0.47%]	0.162% (7.11%) [-0.34%]	0.159% (8.40%) [-0.34%]	-0.238% (7.54%) [-0.74%]	-0.453% (5.40%) [-0.95%]	-0.412% (10.70%) [-0.91%]	0.131% (8.02%) [-0.37%]	-0.776% (11.85%) [-1.28%]	-0.138% (7.27%) [-0.64%]	-0.184% (6.56%) [-0.69%]
	P_5	0.415% (6.16%) [-0.12%]	0.274% (11.15%) [-0.26%]	0.358% (9.14%) [-0.17%]	0.338% (6.89%) [-0.19%]	0.384% (7.85%) [-0.15%]	0.170% (5.61%) [-0.36%]	-0.301% (6.76%) [-0.83%]	-0.149% (11.27%) [-0.68%]	0.152% (9.12%) [-0.38%]	-0.850% (13.16%) [-1.38%]	0.113% (7.95%) [-0.42%]	0.028% (7.21%) [-0.50%]
Ireland	P_1	1.919% (24.73%) [0.51%]	-0.462% (24.00%) [-1.87%]	-0.545% (19.71%) [-1.96%]	-0.053% (19.62%) [-1.49%]	-1.327% (17.47%) [-2.74%]	-0.843% (23.30%) [-2.25%]	-0.555% (22.77%) [-1.97%]	-0.278% (21.64%) [-1.69%]	-1.116% (27.21%) [-2.53%]	-1.323% (24.25%) [-2.73%]	-0.337% (21.70%) [-1.75%]	-0.630% (22.85%) [-2.04%]
	$\boldsymbol{P_5}$	1.629% (15.78%) [0.38%]	1.283% (15.42%) [0.04%]	0.092% (20.46%) [-1.15%]	0.375% (10.93%) [-0.87%]	0.014% (18.68%) [-1.23%]	-1.218% (16.78%) [-2.46%]	-0.375% (21.22%) [-1.62%]	0.548% (21.64%) [-0.70%]	-0.478% (23.03%) [-1.72%]	-0.085% (15.62%) [-1.33%]	0.567% (20.00%) [-0.68%]	0.779% (14.01%) [-0.47%]
Italy	P_1	0.178% (20.16%) [-0.91%]	-0.121% (23.60%) [-1.21%]	0.378% (19.77%) [-0.71%]	-0.196% (18.56%) [-1.29%]	-0.321% (17.65%) [-1.41%]	-1.320% (13.69%) [-2.41%]	-1.708% (15.23%) [-2.80%]	-0.674% (16.64%) [-1.77%]	0.300% (16.77%) [-0.79%]	-1.192% (19.75%) [-2.28%]	0.042% (19.22%) [-1.05%]	-0.237% (17.27%) [-1.33%]
	P_5	0.320% (16.16%) [-0.73%]	0.419% (23.46%) [-0.63%]	0.579% (17.82%) [-0.47%]	0.756% (16.25%) [-0.30%]	0.093% (13.97%) [-0.96%]	-0.673% (11.94%) [-1.73%]	-0.880% (14.41%) [1.93%]	-0.393% (19.18%) [-1.45%]	-0.155% (17.86%) [-1.21%]	0.914% (19.05%) [-0.14%]	0.640% (15.84%) [-0.41%]	0.058% (12.46%) [-0.99%]

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Nether-lands	P_1	0.706% (12.19%) [0.10%]	-0.002% (10.48%) [-0.61%]	-0.430% (9.99%) [-1.04%]	-0.172% (12.14%) [-0.78%]	0.015% (10.31%) [-0.59%]	-0.415% (7.73%) [-1.02%]	-0.678% (8.61%) [-1.29%]	-0.849% (13.03%) [-1.46%]	-1.002% (9.30%) [-1.61%]	-0.055% (9.00%) [-0.66%]	-0.717% (11.07%) [-1.33%]	0.050% (10.35%) [-0.56%]
	P_5	0.031% (10.45%) [-0.56%]	0.450% (9.47%) [-0.14%]	0.885% (7.42%) [0.29%]	0.694% (5.86%) [0.10%]	0.313% (9.84%) [-0.28%]	-0.226% (8.66%) [-0.82%]	0.060% (8.79%) [-0.53%]	-0.317% (11.86%) [-0.91%]	-0.488% (12.72%) [-1.08%]	0.180% (8.96%) [-0.41%]	0.087% (10.17%) [-0.50%]	0.676% (8.33%) [0.08%]
Portugal	P_1	0.350% (10.15%) [-0.76%]	0.890% (25.44%) [-0.22%]	0.985% (16.42%) [-0.13%]	-0.406% (14.32%) [-1.52%]	-0.292% (16.44%) [-1.41%]	0.044% (14.59%) [-1.07%]	-1.441% (17.45%) [-2.55%]	-0.517% (12.42%) [-1.63%]	-0.021% (21.44%) [-1.13%]	-0.491% (18.46%) [-1.60%]	-0.388% (16.18%) [-1.50%]	-0.785% (18.39%) [-1.90%]
	P_5	0.223% (6.74%) [-0.50%]	0.615% (15.25%) [-0.11%]	0.498% (8.89%) [-0.22%]	0.690% (10.33%) [-0.03%]	0.428% (7.11%) [-0.29%]	0.294% (7.62%) [-0.43%]	-0.376% (9.34%) [-1.10%]	-0.276% (9.05%) [-1.00%]	0.044% (8.69%) [-0.68%]	-0.778% (15.42%) [-1.50%]	0.308% (12.35%) [-0.41%]	-0.041% (10.23%) [-0.76%]
Spain	P_1	0.011% (15.48%) [-0.98%]	0.452% (22.60%) [-0.53%]	-0.065% (17.41%) [-1.05%]	0.503% (16.96%) [-0.48%]	-0.127% (18.63%) [-1.11%]	-1.033% (14.19%) [-2.02%]	-0.751% (14.50%) [-1.74%]	-0.695% (16.92%) [-1.68%]	0.306% (15.63%) [-0.68%]	-0.447% (16.47%) [-1.43%]	-0.456% (18.60%) [-1.44%]	-0.251% (16.99%) [-1.24%]
	P_5	0.818% (13.82%) [0.07%]	0.346% (14.24%) [-0.40%]	0.737% (11.17%) [-0.01%]	0.826% (10.69%) [0.08%]	0.211% (12.34%) [-0.53%]	0.035% (11.63%) [-0.71%]	0.189% (10.47%) [-0.55%]	-0.189% (12.72%) [-0.93%]	0.012% (11.37%) [-0.73%]	-0.073% (14.00%) [-0.82%]	0.397% (11.60%) [-0.35%]	0.476% (8.19%) [-0.27%]
United Kingdom	P_1	0.090% (4.28%) [-0.38%]	-0.155% (8.50%) [-0.62%]	-0.078% (4.89%) [-0.55%]	-0.717% (7.19%) [-1.19%]	0.148% (7.75%) [-0.32%]	-0.315% (6.73%) [-0.78%]	-1.031% (7.48%) [-1.50%]	-0.537% (9.28%) [-1.01%]	0.141% (8.28%) [-0.33%]	-0.949% (9.34%) [-1.42%]	-0.249% (7.10%) [-0.72%]	-0.611% (7.10%) [-1.08%]
	P_5	0.512% (6.62%) [-0.12%]	0.129% (10.08%) [-0.51%]	0.333% (8.15%) [-0.30%]	0.042% (8.58%) [-0.59%]	0.363% (9.72%) [-0.27%]	-0.157% (7.09%) [-0.79%]	-0.708% (10.36%) [-1.34%]	-0.180% (14.14%) [-0.81%]	0.419% (8.97%) [-0.22%]	-0.829% (14.12%) [-1.46%]	0.134% (8.24%) [-0.50%]	-0.142% (6.98%) [-0.78%]

Notes: This table shows the annualized geometric average return of the first and fifth portfolios for the different months of the year. For the calculation of monthly average returns, monthly returns were obtained for each portfolio and annualized assuming compounding. The number in parenthesis represents the annualized standard deviation calculated as if portfolios were single assets. The standard deviation was annualized by multiplying the monthly standard deviation by the square root of 12. The number in brackets is the return after transaction costs.

Portfolios were formed based on the ranking of unadjusted stock prices into quintiles in the last trading day of the previous year for the period 1996-2016. Portfolio returns were obtained by equally weighting the logarithmic return of each stock in the portfolio. The results reported are only for the first and fifth portfolios.

Table 3.2 shows the results from the GARCH regression. The first value in a certain row represents the parameter estimate, the value in parenthesis the standard error for that estimate and the value in square brackets the return obtained after transaction costs. It is worth noticing that the parameter estimate is the approximate average return one would get in a specific month of the year.

The results provide evidence that high-priced portfolios produce statistically significant returns during the month of January. Furthermore, these returns seem to be robust to transaction costs. The only exceptions to these findings are Netherlands and Portugal.

Low-priced portfolios seem also to perform good in January for the majority of the markets. However, the parameters estimated for these portfolios are not statistically significant.

As for the other month of the year, there seems not to be a pattern related with returns in particular months. We would highlight February because it seems to be a month where high-priced portfolios seem to perform well for the generality of markets.

In summary, the results from the GARCH regression provide evidence that high-priced portfolios perform better in January since they are able to provide statistically significant returns which are robust to transaction costs.

Table 3.2 – GARCH model results

		δ_1	δ_2	δ_3	δ_4	δ_5	δ_6	δ_7	δ_8	δ_9	δ_{10}	δ_{11}	δ_{12}	α_1	α_1	β_1
Austria	P_1	-0.0079 (0.006) [-0.84%]	0.00001 (0.005) [-0.05%]	-0.009 (0.006) [-0,95%]	-0.0012 (0.007) [-0.17%]	-0.002 (0.005) [-0.25%]	-0.009 (0.005) [-0.95%]	-0.004 (0.006) [-0.45%]	-0.02*** (0.006) [-2.05%]	-0.012* (0.007) [-1.25%]	-0.011 (0.007) [-1.2%]	-0.009 (0.008) [-1%]	-0.008 (0.008) [-0.9%]	0.00015 (0.0001)	0.1174* (0.065)	0.72*** (0.1707)
	P_5	0.01** (0.004) [0.96%]	0.007** (0.004) [0.66%]	0.0037 (0.004) [0.33%]	0.0056 (0.004) [0.52%]	0.0038 (0.006) [0.34%]	0.0054 (0.004) [0.50%]	0.0044 (0.004) [0.40%]	-0.0004 (0.004) [-0.08%]	-0.003 (0.005) [-0.34%]	-0.003 (0.005) [-0.3%]	-0.0015 (0.004) [-0.2%]	0.0008 (0.004) [.04%]	0.000009 (0.00001)	0.069** (0.038)	0.91*** (0.047)
Belgium	P_1	0.000039 (0.003) [-0.04%]	0.0039 (0.003) [0.35%]	0.01*** (0.004) [0.96%]	0.00208 (0.004) [0.16%]	0.0075** (0.004) [0.71%]	-0.00506 (0.004) [-0.55%]	0.0048* (0.003) [0.44%]	-0.0011 (0.004) [-0.15%]	0.00452 (0.005) [0.41%]	-0.007 (0.005) [-0.7%]	-0.01** (0.003) [-1%]	-0.0032 (0.003) [-0.4%]	0.000008 (0.00001)	0.138** (0.059)	0.85*** (0.065)
	P_5	0.013*** (0.003) [1.27%]	0.0053** (0.003) [0.50%]	0.0081** (0.003) [0.78%]	0.0084** (0.003) [0.81%]	0.0091** (0.004) [0.88%]	0.009*** (0.003) [0.87%]	0.0011 (0.003) [0.08%]	0.009** (0.004) [0.87%]	0.00405 (0.004) [0.37%]	0.0002 (0.003) [-.01%]	0.006* (0.003) [0.6%]	0.0035 (0.003) [0.3%]	0.000019 (0.00001)	0.095** (0.048)	0.85*** (0.073)
France	P_1	0.014*** (0.004) [1.36%]	0.022*** (0.004) [2.16%]	0.016*** (0.004) [1.56%]	0.0055 (0.004) [0.51%]	0.0063 (0.004) [0.59%]	0.0047 (0.005) [0.43%]	-0.0003 (0.004) [-0.07%]	0.0029 (0.003) [0.25%]	0.0084** (0.004) [0.80%]	-0.002 (0.005) [-0.2%]	0.0023 (0.004) [0.2%]	0.0055 (0.005) [0.5%]	0.00006* (0.00003)	0.253** (0.1129)	0.71*** (0.1011)
	P_5	0.02*** (0.003) [1.96%]	0.0056 (0.004) [0.52%]	0.009** (0.003) [0.86%]	0.009*** (0.003) [0.86%]	0.008*** (0.003) [0.76%]	0.007** (0.003) [0.66%]	0.0032 (0.004) [0.28%]	0.0049 (0.004) [0.45%]	0.01*** (0.003) [0.96%]	0.0011 (0.004) [0.07%]	0.0035 (0.003) [0.3%]	0.0043 (0.003) [0.4%]	0.0001** (0.00003)	0.2925* (0.174)	0.56*** (0.148)
Ireland	P_1	-0.0079 (0.006) [-0.91%]	0.00005 (0.005) [-0.11%]	-0.0088 (0.006) [-0.91%]	-0.0025 (0.007) [-0.37%]	-0.0012 (0.005) [-0.24%]	-0.0079 (0.005) [-0.91%]	-0.0036 (0.006) [-0.48%]	-0.02*** (0.006) [-2.12%]	-0.0118* (0.007) [-1.30%]	-0.01 (0.007) [-1.1%]	-0.0086 (0.008) [-1%]	-0.0085 (0.008) [-1%]	0.00015 (0.00012)	0.1174* (0.0647)	0.722*** (0.1707)
	P_5	0.0076** (0.004) [0.66%]	0.0073** (0.004) [0.63%]	0.003690 (0.004) [0.27%]	0.00559 (0.004) [0.46%]	0.003797 (0.006) [0.28%]	0.00543 (0.004) [0.44%]	0.0044 (0.004) [0.34%]	-0.00041 (0.004) [-0.15%]	-0.00343 (0.005) [-0.45%]	-0.003 (0.005) [-0.4%]	-0.0015 (0.004) [-0.2%]	0.0008 (0.004) [-.02%]	0.000009 (0.00001)	0.069** (0.038)	0.913*** (0.047)
Italy	P_1	0.0081 (0.009) [0.72%]	-0.00072 (0.009) [-0.16%]	0.00729 (0.010) [0.64%]	-0.00896 (0.013) [-0.99%]	-0.00632 (0.014) [-0.72%]	-0.028** (0.014) [-2.90%]	-0.04*** (0.011) [-4.09%]	-0.0121 (0.012) [-1.30%]	0.01211 (0.012) [1.12%]	-0.017 (0.010) [-1.8%]	-0.0009 (0.013) [-0.2%]	-0.003 (0.012) [-.04%]	0.00076 (0.0008)	0.1364 (0.104)	0.5937* (0.334)
	P_5	0.0193** (0.008) [1.84%]	0.031*** (0.007) [3.01%]	0.0115 (0.009) [1.06%]	0.00704 (0.01) [0.62%]	0.00728 (0.009) [0.64%]	-0.00799 (0.009) [-0.89%]	-0.0077 (0.008) [-0.86%]	-0.0037 (0.007) [-0.46%]	0.01371 (0.009) [1.28%]	0.0007 (0.01) [-.02%]	0.0087 (0.01) [0.8%]	0.0094 (0.012) [0.9%]	0.00027* (0.00015)	0.26** (0.1154)	0.654*** (0.1153)

		δ_1	δ_2	δ_3	δ_4	δ_5	δ_6	δ_7	δ_8	δ_9	δ_{10}	δ_{11}	δ_{12}	α_1	α_1	β_1
Nether-lands	P_1	0.013** (0.006) [1.25%]	-0.002 (0.006) [-0.25%]	-0.0083 (0.006) [-0.88%]	-0.0028 (0.008) [-0.33%]	-0.00116 (0.006) [-0.17%]	-0.01121 (0.01) [-1.17%]	-.0157* (0.008) [-1.62%]	-0.02*** (0.005) [-2.05%]	-0.02*** (0.007) [-2.05%]	0.0012 (0.008) [0.07%]	-0.02** (0.006) [-2.1%]	0.0051 (0.007) [0.46%]	0.00001 (0.00001)	-0.04*** (0.0084)	1.02*** (0.0002)
	P_5	0.004 (0.005) [0.35%]	0.013** (0.006) [1.25%]	0.019*** (0.0073) [1.85%]	0.0145* (0.008) [1.40%]	0.008 (0.005) [0.75%]	-0.0013 (0.006) [-0.18%]	0.0017 (0.0061) [0.12%]	-0.0043 (0.0053) [-0.48%]	-0.008* (0.0047) [-0.85%]	0.0046 (0.007) [0.41%]	0.007 (0.006) [0.7%]	0.02** (0.006) [1.95%]	0.00006 (0.00006)	0.064 (0.049)	0.8640 (0.1037)
Portugal	P_1	0.0042 (0.01) [0.33%]	0.0122* (0.007) [1.13%]	0.022*** (0.008) [2.11%]	-0.0099 (0.008) [-1.08%]	0.0034 (0.01) [0.25%]	0.009 (0.01) [0.81%]	-0.02*** (0.008) [-2.09%]	-0.0078 (0.011) [-0.87%]	-0.0004 (0.007) [-0.13%]	0.0007 (0.008) [-0.02%]	-0.0008 (0.007) [-0.2%]	-0.0012 (0.008) [-0.2%]	0.000009 (0.00001)	-0.03*** (0.006)	1.032*** (0.0002)
	P_5	0.0005 (0.004) [-0.01%]	0.0059 (0.004) [0.53%]	0.009* (0.006) [0.84%]	0.012** (0.005) [1.14%]	0.0083* (0.005) [0.77%]	0.011** (0.005) [1.04%]	-0.0044 (0.005) [-0.50%]	-0.0029 (0.004) [-0.35%]	0.0041 (0.005) [0.35%]	-0.01** (0.004) [-1.06%]	0.01** (0.005) [1%]	0.001 (0.004) [0.04%]	0.00004 (0.00003)	0.202** (0.087)	0.779*** (0.084)
Spain	P_1	0.046*** (0.013) [4.52%]	-0.0078 (0.015) [-0.86%]	0.0125 (0.015) [1.17%]	0.0253* (0.014) [2.45%]	0.0074 (0.015) [0.66%]	-0.0203 (0.014) [-2.11%]	-0.014 (0.017) [-1.48%]	-0.0081 (0.015) [-0.89%]	0.0178 (0.014) [1.70%]	0.0011 (0.015) [0.03%]	-0.0031 (0.014) [-0.4%]	-0.0061 (0.014) [-0.7%]	0.00485 (0.0062)	-0.0261* (0.0135)	0.5774 (0.5666)
	P_5	0.023*** (0.009) [2.24%]	0.0111 (0.008) [1.05%]	0.0117 (0.0091) [1.11%]	0.0188 (0.011) [1.82%]	0.0007 (0.01) [0.01%]	-0.007 (0.0091) [-0.76%]	-0.0096 (0.01) [-1.02%]	-0.0114 (0.011) [-1.20%]	0.00225 (0.010) [0.16%]	0.0010 (0.0077) [0.04%]	0.0048 (0.012) [0.4%]	0.0072 (0.01) [0.66%]	0.00016 (0.00011)	0.148** (0.073)	0.805*** (0.0754)
United Kingdom	P_1	0.0032 (0.006) [0.28%]	0.00097 (0.004) [0.06%]	0.00016 (0.005) [-0.02%]	-0.01*** (0.004) [-1.04%]	0.0046 (0.004) [0.42%]	-0.0064 (0.005) [-0.68%]	-0.02*** (0.004) [-2.04%]	-0.011** (0.004) [-1.14%]	0.0053 (0.005) [0.49%]	-0.02*** (0.004) [-2.04%]	-0.004 (0.005) [-0.4%]	-0.009* (0.005) [-0.9%]	0.00003 (0.00003)	0.0706 (0.048)	0.872*** (0.0837)
	P_5	0.014*** (0.005) [1.35%]	0.013*** (0.004) [1.25%]	0.0101** (0.005) [0.96%]	0.00003 (0.004) [-0.05%]	0.0076* (0.004) [0.71%]	-0.0008 (0.005) [-0.13%]	-0.0044 (0.004) [-0.49%]	-0.0004 (0.004) [-0.09%]	0.015*** (0.005) [1.45%]	-0.0051 (0.004) [-0.56%]	0.0045 (0.005) [0.4%]	0.0014 (0.005) [0.09%]	0.00007 (0.00005)	0.2313* (0.125)	0.725*** (0.1167)

Notes: This table shows the results from the application of a GARCH(1,1) model, which assumes the following functional form.

$$r_{pi,t} = \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \delta_4 D_4 + \delta_5 D_5 + \delta_6 D_6 + \delta_7 D_7 + \delta_8 D_8 + \delta_9 D_9 + \delta_{10} D_{10} + \delta_{11} D_{11} + \delta_{12} D_{12} + h_{it}$$

$$h_{it} = \sigma_{it} \varepsilon_{it}$$

$$\sigma_{it}^2 = \alpha_0 + \alpha_1 \times h_{t-1}^2 + \beta_1 \times \sigma_{it-1}^2$$

For each country, the results are presented for the two extreme portfolios. The statistical significance of the parameters is represented by the asterisks, where *, ** and *** represent a statistical significance for 10%, 5% and 1% level, respectively. The number in parenthesis represents the standard errors for the parameters. The number in brackets is the return after transaction costs.

Portfolios were formed based on the ranking of unadjusted stock prices into quintiles in the last trading day of the previous year for the period 1996-2016. Portfolio returns were obtained by equally weighting the logarithmic return of each stock in the portfolio. The results reported are only for the first and fifth portfolios.

Chapter 4

Low-price effect during Bull and Bear markets

4.1. Methodology for identifying Bull and Bear markets

The study of the low-price anomaly during bull and bear market phases implies first to distinguish between bull and bear periods and then study the performance of the portfolios in the two periods.

The distinction between bull and bear markets will be made through the approach of Pagan & Sossounov (2003). According to this approach, one can distinguish between bull and bear markets by analyzing the turning points in a time series representing a certain financial market. According to these authors, a peak exists in the location where the following is true.

$$PK = [\ln P_{t-8}, \dots, \ln P_{t-1} < \ln P_t > \ln P_{t+1}, \dots, \ln P_{t+8}]$$

According to Pagan & Sossounov (2003), the selection of the peaks and troughs must obey to the following rules.

- Peaks and troughs within 6 months of the beginning and end of the series should be ignored.
- Peaks and troughs lower or higher than the ends of the series must not be considered.
- Complete cycles inferior to 6 months should be eliminated.
- Phases with durations less than 4 months should be eliminated, except for those phases with less than 4 months experiencing a rise or fall exceeding 20%.

We estimate the turning points recurring to the main market index of each country, since this seems the best proxy for the general market sentiment.

After estimating the turning points, we obtain average duration of a bull phase given by the following measure.

$$\widehat{D} = NTP^{-1} \times \sum_{t=1}^{T} S_t \tag{4.1}$$

Where S_t is a dummy assuming the value 1 for a month considered bull and zero otherwise and NTP is computed as follows.

$$NTP = \sum_{t=1}^{T-1} (1 - S_{t+1}) \times S_t \qquad (4.2)$$

The study of the low-price effect during these two periods will be done by analyzing the portfolios constructed above and analyzing the average return during these periods.

4.2. Results and discussion

Financial crisis can have a deep impact in the returns of most stocks and portfolios. The inclusion of periods of crisis into the analysis of anomalies may affect the final results. For instance, the inclusion of 2008 in our analysis may significantly impair the returns of the portfolios, since this was an abnormal period in financial markets. Thus, it seems prudent to make an analysis of the low-price effect during the different phases of market sentiment. The following table presents the decomposition of the sample period into market phases according to the Pagan & Soussonov (2003) model.

Table 4.1 presents the results of the application of Pagan & Soussonov (2003) method. The first two columns represent the peaks and the troughs identified in the main market index series. The third column presents the total number of bull months. The last column shows the average duration of a bull phase in months.

From the table, it is perceivable that the peaks and troughs are more or less synchronized, especially in the years 2000 and 2009. Austria and the Netherlands are the markets which seem to present more bull market phases, whereas Portugal seems to be the country with the least bullish sentiment. Ireland is the market where in average bull markets last longer, with an average of 91 months.

Table 4.1 – Statistics on Bull and Bear phases of the market

	Peaks	Troughs	Total bull months	Average bull phase duration (months)
Austria	07/2007 04/2011 01/2014 06/2015	03/2009 10/2011 10/2014 07/2016	204	41
Belgium	01/1999 05/2007 11/2010	03/2003 03/2009 06/2012	161	40
France	09/2000 07/2007 02/2011 04/2015	03/2003 03/2009 09/2011 02/2016	185	37
Ireland	06/2001 05/2007	02/2003 08/2011	181	91
Italy	03/2000 05/2007 01/2010 01/2015	10/2002 03/2009 06/2012 02/2016	157	31
Netherlands	09/2000 07/2007	03/2003 03/2009	202	67

	Peaks	Troughs	Total bull months	Average bull phase duration (months)
Portugal	03/2000 07/2007 01/2010 05/2014	03/2003 03/2009 06/2012	136	34
Spain	03/2000 12/2007 12/2009 03/2015	10/2002 03/2009 06/2012 02/2016	165	33
United Kingdom	03/2000 12/2007 12/2009 03/2015	10/2002 03/2009 06/2012 02/2016	165	33

Notes: This table shows statistics for the bull and bear markets in the different countries. The first and second columns present the peaks and troughs obtained from the application of Pagan & Soussonov (2003) methodology. The third column reports the total number of months in which a bull sentiment was detected. The last column presents the average duration in months of a bull phase, calculated through the following equation.

$$\widehat{D} = NTP^{-1} \times \sum_{t=1}^{T} S_t$$

Where S_t is a dummy which assumes the value 1 if month t presents a bull sentiment and 0 otherwise and $NTP = \sum_{t=1}^{T-1}(1 - S_{t+1}) \times S_t$.

Table 4.2 shows the average annualized portfolio returns and standard deviations (value in parenthesis) for the two phases of the market. The results clearly suggest that during the bull phases of the market, high-priced portfolios produce higher returns than low-priced portfolios. Portugal is an exception to this general trend.

As for the riskiness of the portfolios during bull markets, we can see that low-priced portfolios present a higher standard deviation than high-priced portfolios. This suggests that high-priced portfolios are able to generate higher returns for a lower standard deviation.

During bear markets, high-priced portfolios seem to lose less than low-priced portfolios. As for riskiness, high-priced portfolios for some markets, namely Belgium, France, Ireland, Netherlands and the United Kingdom, seem to be riskier during the bull phase of the market. The other markets have the reverse pattern.

The Sharpe ratios (value in square brackets) confirm the results above. During bull markets, the Sharpe ration ranks better in general for high-priced portfolios than low-priced ones. During bear markets, the Sharpe ratios of high-priced portfolios perform better than the Sharpe ratio of low-priced ones.

We also provide the returns net of transaction costs (value in commas) and the Sharpe ratio after transaction costs (value in brackets). The conclusions before transaction costs remain the same after transaction costs. High-priced portfolios continue to produce higher returns during bull markets and perform better during bear markets.

In summary, our results suggest that high-priced portfolios seem to perform better both during bull and bear markets. Furthermore, they seem to be less risky than high-priced portfolios during bull markets and riskier during bear markets.

Table 4.2 – Portfolio average return for bull and bear phases of the market

		Austria	Belgium	France	Ireland	Italy	Netherlands	Portugal	Spain	United Kingdom
Bull Phase	P_1	-7.133% (10.11%) [-0.0125] "-7.760%" {-0.0132}	1.528% (7.62%) [-0.00223] "1.001%" {-0.0026}	4.426% (7.62%) [-0.0006] "3.925%" {-0.001}	-4.255% (23.17%) [-0.0191] "-5.665%" {-0.0224}	4.035% (17.93%) [-0.0011] "2.944%" {-0.003}	-2.842% (10.85%) [-0.0074] "-3.451%" {-0.0080}	18.387% (15.78%) [0.9978] "17.274%" {0.9272}	9.292% (16.73%) [0.2658] "8.305%" {0.2068}	-3.902% (7.19%) [-0.0055] "-4.370%" {-0.0058}
	P_5	7.255% (6.50%) [0.3054] "6.810%" {0.2369}	13.659% (6.27%) [1.4691] "13.281%" {1.4088}	10.521% (7.32%) [0.7172] "9.989%" {0.6446}	20.344% (14.89%) [1.0975] "19.100%" {1.014}	17.962% (14.94%) [0.8928] "16.910%" {0.8224}	11.554% (9.25%) [0.8236] "10.962%" {0.7596}	13.013% (12.11%) [0.8564] "12.292%" {0.7968}	19.728% (11.65%) [1.2775] "18.984%" {1.2137}	7.232% (8.22%) [0.42326] "6.598%" {0.34608}
Bear Phase	P_1	-20.306% (10.88%) [-0.02783] "-20.933%" {-0.0285}	-5.331% (5.93%) [-0.0058] "-5.858%" {-0.0061}	-18.971% (9.66%) [-0.0234] "-19.472%" {-0.0239}	-31.630% (22.70%) [-0.081] "-33.040%" {-0.084}	-29.957% (18.75%) [-0.0648] "-31.048%" {-0.0669}	-24.798% (9.48%) [-0.0272] "-25.407%" {-0.0278}	-25.908% (17.73%) [-0.0506] "-27.021%" {-0.0526}	-28.453% (16.29%) [-0.054] "-29.440%" {-0.056}	-18.249% (8.74%) [-0.01923] "-18.717%" {-0.01964}
	P_5	-12.883% (9.29%) [-0.0169] "-13.328%" {-0.0173}	-5.045% (7.48%) [-0.0071] "-5.423%" {-0.0074}	-18.022% (10.84%) [-0.0253] "-18.554%" {-0.0258}	-20.299% (25.04%) [-0.0609] "-21.543%" {-0.064}	-24.648% (18.22%) [-0.0533] "-25.700%" {-0.0553}	-16.394% (10.41%) [-0.0212] "-16.986%" {-0.0218}	-6.286% (8.46%) [-0.0076] "-7.007%" {-0.0082}	-9.267% (11.60%) [-0.0164] "-10.011%" {-0.0172}	-12.929% (12.27%) [-0.0205] "-13.563%" {-0.02125}

Notes: This table reports the annualized geometric returns for bull and bear markets and for the different portfolios. The value in parenthesis represents the annualized standard deviation. The Sharpe ratio is given in square brackets. Net returns are given in commas and the Sharpe ratio based on net returns is in brackets. Portfolios were formed based on the ranking of unadjusted stock prices into quintiles in the last trading day of the previous year for the period 1996-2016. Portfolio returns were obtained by equally weighting the logarithmic return of each stock in the portfolio. The results reported are only for the first and fifth portfolios.

Conclusion

This dissertation was a humble attempt of studying the presence of the low-price effect in the main European stock markets. By sorting stocks into portfolios according to their nominal prices and by using a four-factor model, we were able to analyze the presence of this effect and the drivers that might explain it. Our results suggest that the low-price effect is not present in European stock markets and that high-priced portfolios were able to outperform the low-priced ones. Furthermore, the Wilcoxon sum rank test confirms us that the returns of both portfolios are statistically different.

As for the return drivers of the low-price effect, we found that the factors contained in the four-factor model explain a great part of the return of high-priced portfolios. The same in not true for low-priced portfolios which present negative and statistical significant alphas. We failed to provide evidence on the extraction of abnormal returns from a strategy based on nominal price. We also provided evidence that high-priced portfolios have a lower degree of total risk, but a high degree of systematic risk.

We also aimed at researching whether the low-price anomaly is particularly strong in certain months of the year and the behavior of this effect during bull and bear markets. Our results showed that for most of the markets January would produce statistically significant returns and robust to transaction costs. Furthermore, we provided evidence that high-priced portfolios perform better both during bull and bear markets relative to low-priced portfolios.

As it was impossible to study all the relevant topics concerning the low-price anomaly in this dissertation, we give three suggestions of future research. First, this study was no yet extended to East Europe countries, South America countries, Asian countries, and African countries. Furthermore, some other European stock markets are still to be studied such as Denmark, Sweden, Norway, Greece, etc. A natural step would be the expansion of this study for more markets. Second, due to time and data constraints, it was not possible to include illiquidity as an explanatory factor in this dissertation. Hence, illiquidity could be a future research topic, especially when large amounts of data on volume are available. Third, the low-price anomaly could be studied for the different days of the week, much in the same way it is studied for the different months in the year.

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