ERASMUS UNIVERSITY ROTTERDAM
ERASMUS SCHOOL OF ECONOMICS
Bachelor Thesis Economics & Business
Specialization: Financial Economics

Price deviations in cross-listed companies

Arbitrage opportunities in European and U.S. multi-market trading

Author: Raluca Stan
Student number: 602260
Thesis supervisor: Fabrizio Core
Second reader: Ruben de Bliek
Finish date: 27.06.2024

The views stated in this thesis are those of the author and not necessarily those of the supervisor, second reader, Erasmus School of Economics or Erasmus University Rotterdam.

ABSTRACT

The aim of this research is to provide insights into the complexity of cross listed companies with their primary listing in Europe and secondary listing in U.S. By analysing the magnitude and behaviour of prevalent stock price deviations between the two components, this paper shows that the degree of divergence between the two international capital markets fluctuates over time but exhibits an increasing trend over the sampled interval 2009-2024. The second part of the analysis entails the use of these observed deviations in returns to construct an investment portfolio exploiting the sign of the differentials. Following a momentum strategy and undertaking long and short positions in the two respective parts of the cross-listings, the portfolio shows a roughly 8.3% annualized return after the inclusion of a currency risk factor. The implications of this result point toward foreign exchange exposure not being priced in the listing quotas, which can account for the reduction in the number of companies adopting the corporate decision of internationally expanding on foreign capital markets.

Keywords: cross listings, market integration, price deviation, currency risk

TABLE OF CONTENTS

CHAPTER 1. Introduction

In recent decades, globalization has dramatically reshaped the landscape of capital markets. The emergence of interconnected financial environments has enabled capital to flow more freely across borders than ever before. While firms have the option to either embrace or resist this trend, the decision to expand beyond domestic markets in order to diversify their investment base and access greater capital, remains one of the most debated themes in contemporary corporate strategy (Peng & Su, 2014). Serving as a bridge between different countries and exchanges, cross listings offer companies the possibility to trade their shares simultaneously in different markets across the world (Gagnon & Karolyi, 2010).

Although this operational approach is previously argued as benefiting the firm by lowering its cost of capital, extending its shareholder base and increasing liquidity (De Landsheere, 2012), a more recent statistic shows a major decline in the number of entities opting for an international expansion, from a high of 4,700 in 1990 to nearly 50% less in 2002 (Karolyi, 2006). Where global market integration has always been hindered by exchange rate risks and fluctuations, White and Woodbury (1980) argue that this uncertainty is not the only impediment causing worldwide capital segmentation, but barriers such as information costs and government capital controls play a much bigger role than it is often believed.

The underlying premise of a stock being listed simultaneously in different capital markets gives raise to additional queries oftentimes discussed in asset pricing topics. When it is consistently observed that similar securities trade at different quotas in different locations (Froot & Dabora, 1999), deviations in cross listings' stock prices across markets could bring crucial insights into these unique characteristics of such establishments and their influence on determining potential profit opportunities for investors and corporate decisional strategies for companies. As existing literature shows that price deviations in dual listed companies have existed over a long period of time, with both Rosenthal and Young (1990) and Froot and Dabora (1999) concluding that the magnitude of these significant mispricings are not sufficiently explained by fundamental factors such as currency risk, governance structures, legal contracts, liquidity and taxation, it becomes crucial to narrow these findings in magnitude and location. Furthermore, since any sort of mispricing gives raise to one of finance's most discussed phenomena: arbitrage; Karolyi (2006) shows that in the context of multi-market trading, investors actively exploit these price differentials such that foreign and domestic shares maintain a consistent price parity when adjusted for currency differences.

Whereas prior studies have concentrated on either the corporate aspects of cross-listing as a strategic decision or its effects on potential profit opportunities from investment strategies, this paper aims to integrate these two areas. By analysing the origins of price differentials using established models, this paper seeks to give a narrowed but more in-depth approach on what causes these price deviations and how market participants gain or suffer from this strategic approach. Hence, focusing on European and North American capital markets will allow for a more detailed analysis on what are known as the most developed capital markets in the world (Greene, 2007), while also keeping the relevance of the results as NYSE and Euronext are the largest stock exchanges by size and number of cross listings (Statista, 2024).

Examining price deviations in European companies cross listed in the U.S. will account in its essence and depth for the increased economic relevance of transatlantic integration and the impact of regulatory and compliance differentials, thus offering a unique look into the world of cross-listings. Building on the approach developed by De Jong et al. (2009) on dual listings, this paper aims at investigating price deviations in cross listed companies through established asset pricing models, where the underlying research question can be formulated as:

What factors contribute to price differentials between the U.S. and European cross-listed companies, and how do they influence corporate decisions and investors' behaviours?

To address this question and develop the onset analysis, companies cross listed in the two geopolitical areas were selected based on their inclusion in a comprehensive yet focused index. For these reasons, the analysis was narrowed to include companies having their primary listing in the EuroStoxx 50 index, which tracks the largest and most frequently traded companies in the Eurozone area across a variety of industries (Euro Stoxx 50, 2024). The use of this index allows the analysis to delve deeper into well-established companies, oftentimes market leaders in their industry, whose securities have been cross listed on U.S. exchanges or over the counter for a lengthy enough period of time such that the scientific significance of the research is maintained. Europe is considered throughout the analysis the domestic market; hence the U.S. prices and returns will be adjusted according to the time spot exchange rate of EUR relative to USD. Following De Jong et al. (2009), price differentials will be firstly accounted for in the form of logarithmic deviations and further regressed on standard and augmented asset pricing models. The benchmark model is Fama-French (1993) three factor model, where the portfolios are created and adjusted on a monthly basis using European and U.S. companies. To further adapt the analysis to the specific context of cross-listings, foreign exchange risk – here EUR returns relative to a basket of foreign currencies; will be added to the approach, following Kolari et al. (2008).

Considering the prevalence of studies on this topic and the increased attention given to North American – European market integration, the results of the analysis are expected to point towards an upward trend in observed price deviations over time. Conversely, consistent with previous findings it is expected that the difference in returns on the two foreign exchanges are highly dependent on their domestic markets, and that it is mostly due to this dependence that deviations arise in their prevalent prices. Whereas previous research found abnormal returns up to 10% annualized for arbitrage strategies using multi-listings (De Jong et al., 2009), the selected sample is expected to perform in a similar manner, where the foreign exchange sensitivity serves as an additional explanatory tool. The rest of the analysis is developed as following: theoretical framework will underline different constituents of the topic and the research question, tackling all the implications cross listings have in the context of the analysis; the data section will explicitly describe the sample selection process and adjustments; the research methods will be then discussed following previous approaches on the matter; the chapter of results and discussion will further provide an answer to the underlying question which will be consolidated within the last section of the paper.

CHAPTER 2. Theoretical Framework

2.1. Corporate landscape and international expansion

Current literature on multi-market trading is extensive and compels a wide series of approaches on the topic and its numerous implications. Beginning with firms' choice to list their shares on foreign exchanges, Chemmanur and Fulghieri (2006) argue that this is dependent on the low cost of domestic information producers and high information availability to foreign investors. Peng and Su (2014) go further to show that the short-term negative impact of market expansion, often associated with increased bureaucratic and compliance costs, is outweighed by the long-term expansion of company scope and positioning. This can serve as a strong reasoning factor for growth companies to adopt this corporate structure and broaden their investor base across the borders.

As the decision of whether to follow the trend of international expansion is subject to both operational and strategic considerations, the corporate landscape facilitating this approach remains a subjective matter. Baker et al. (2002) argues that cross listing on foreign exchanges increases firm's visibility both in terms of media attention and analysts' coverage, which later reduces the equity cost of capital. In addition, Bailey et al. (1999) find that unrestricted shares in markets with foreign ownership barriers are often associated with large equity premiums, indicating the existence of a high demand for cross-border investments which can further reason a company's international expansion.

2.2. Arbitrage trading in multi-market settings

Arbitrage remains to this day one of the central topics in financial economics, as throughout time several attempts were made to dissect the roots of the phenomenon and its limitations in the broader structure of today's capital markets, where the occurrence of price discrepancies is thought to be temporary and quickly acted upon by investors. Defined as the simultaneous buying and selling of identical or similar assets in two different markets to take advantage of the price difference, at no risk or significant investment (Sharpe & Alexander, 1990), arbitrage is caused by many pricing anomalies differentiated for each asset class.

Price differentials in cross-listed companies widely studied by Gagnon and Karolyi (2010) show a 4.9 basis points deviation, controlled both for holding and transaction costs, whose implications point towards potential arbitrage opportunities investors can exploit with strategies involving multi-listings. Similarly, a study carried by De Jong et al. (2009) on dual listed companies – quasi-mergers of two different entities – finds abnormal returns up to 10% per annum adjusted for systematic risk, transaction

costs and margin requirements, further implying the relevance of dissecting these prevalent price deviations in portfolio analysis. As Chan et al. (2003) find that the location of trade has a significant effect on stock price behavior, mainly affected by the changes in investor base and market sentiment, following the previous findings of Froot & Dabora (1999) who show that relative price differentials in dual listed companies are strongly correlated with the markets where they are most actively traded. These widely observed differentials in returns of companies listed on different exchanges therefore prove to be arbitrage machines in themselves, whose implications on investor patterns, cross-border capital flows and price parity matching are crucial for understanding the phenomenon.

2.3. Cross-market integration

Stock market integration can be defined as a situation where capital markets in different locations follow the same trend and exhibit identical expected risk adjusted returns (Sharma & Seth, 2012). Markets are considered perfectly integrated if market participants can transition between them at no additional cost or profit opportunities (Jawadi & Arouri, 2008).

In a financial landscape where markets strive towards complete integration across continents, time-zones and regulatory environments, there are still persistent signs of segmentation in the cross-border flow of capital, particularly due to exchange rate risks, political factors, and investor behaviors (Aliber, 1978). While Bekaert & Harvey (1995) find that integration in emerging markets is highly volatile over time, they also argue that domestic markets are strongly affected by local policies and regulatory decisions, as they are by global economic conditions, and therefore complete integration or segmentation is not reasonable. Moreover, Chan et al. (1997) observe that in the long run cross-market integration is less likely to persist, despite depicting short cointegration periods, and that international diversification in equity markets remains an effective measure in reducing systematic or country-specific risk for investors. Hence, the first research hypothesis explores the extent to which European and U.S capital markets exhibit a trend to integrate over time:

H1: Price differentials in cross listed companies increase over time

By analyzing time developments of price deviations in cross-listings, this research improves the scientifical relevance of the subject discussed by proving the persistence of a price anomaly as a market imperfection. The null hypothesis explores the existence of an upward trend in logarithmic price deviations between the two components of the listings: European and U.S., while the alternative suggests a more sporadic series of differentials.

2.4. Currency exposure

By definition, cross-listed companies imply a trade of securities of one singular entity on multiple exchanges, hence certain considerations on exchange rate risk and interest rate differentials arise when the transaction occurs in different currencies. With the decision to expand on foreign capital markets comes the need to account of currency risk and adequately mark its premia in the prevalent listing price. Karolyi et al. (2021) investigate whether this exposure is priced in their underlying securities and find that while the carry trade risk factor – investment strategy that goes long in high interest rate currency portfolios and vice-versa (Karolyi et al., 2021) – proves to be globally priced and have a significant effect on its implied premium, the dollar risk is less prevalent. Similarly, De Santis and Gerard (1998) conclude that currency risk premium often constitutes a large fraction of the international premium, supporting the importance of exchange risk inclusion to better specify established asset pricing models such as the Capital Asset Pricing Model (CAPM). Hence, following Kolari et al. (2008), a second hypothesis explores the sensitivity of cross listing to a foreign exchange risk factor:

H2: Foreign exchange risk is priced in cross-listed European stocks

By augmenting the three-factor Fama-French (1998) model using a currency risk factor, a better specification of the research is expected. Where foreign exchange sensitivity leads oftentimes to conflicting results depending on the underlying methodology, Fama-French (1998) three factor model is widely known for its robustness in capturing cross-section variation in returns. Hence, the null hypothesis explores the inclusion of the currency risk exposure of international cross-listings in their prevalent quotas, while the alternative hypothesis implies that the additional factor does not significantly change the specification of the original model and thus no conclusions on its importance can be drawn.

2.5. American Depositary Receipts

This paper develops an analysis on public companies whose primary listing resides in Eurozone[1] area and their secondary listing by volume of traded shares in the United States. When companies decide to cross-list their shares in the United States markets, non-U.S. companies have the choice between following several different procedures. One of the most common forms of U.S. listed foreign shares

[1] Eurozone Area defined as the EU member states who replaced their national currencies with the single currency – euro, according to the European Commission.

comes in the form of American Depositary Receipts (ADRs), which represent official certificates created by depositary banks and underwriters (U.S. Securities and Exchange Commission, 2024).

ADRs essentially represent foreign shares of non-U.S. companies that are held in custody outside of U.S., nominated in dollar currency (Gagnon & Karolyi, 2004). As these derivatives offer companies the flexibility to list securities internationally benefiting from U.S. regulatory clearance, their benefits for investors range widely between: providing the possibility to effortlessly trade between U.S. and home markets, exempt investors from a "conversion fee", enable investors to keep stocks denoted in currencies according to the market where they were bought from, keep the dividends partition unaffected by the currency or market of cross-listing (Fountain, 1969; Gagnon & Karolyi, 2004).

2.6. Transaction costs

With every exchange of information or property rights comes the associated fee. Transaction costs in the context of trading of securities on a stock market exchange range from difference in bid-ask spread incurred by traders, commissions demanded by brokers, exchange fees, opportunity costs such as cost of capital or even taxes (Lesmond et al., 1999). As cross listed companies are required to follow regulatory and compliance guidelines according to all underlying exchanges, market fees play a significant role in potentially deterring arising arbitrage profits. Barclay et al. (1998) find that transaction costs, taken as the difference between the bid-ask spreads, exhibit no significant relationship with stock prices or returns, but do in fact lead to a significant decrease in trading volumes. On the other hand, in the context of dual listed companies and investment strategies, De Jong et al. (2009) show that when accounting for 25 basis points of transaction fees and margin requirements for short sells, the impact on arbitrage profits is low and unlikely to lead to significant impediments.

As the impact of fees is oftentimes difficult to depict in quantitative studies, Collins and Fabozzi (1991) propose a way to measure the magnitude of transaction costs by firstly differentiating between fixed costs (transfer fees, taxes) and variable costs (execution costs, market timing and opportunity costs). When constructing investment strategies involving the trade of securities on different exchanges, execution fees could play a major role in reducing returns to zero, as Lesmond et al. (1999) conclude that high transaction costs lead to more null returns on average, and that this effect is inversely proportional to the size of the firm. As specifically in the context of multi-market trading, previous studies show no significant decrease in returns of trading strategies due to fees impediments (De Jong et al., 2009), this paper will not quantify them directly during the analysis but will account for their potential implications when drawing conclusions on the effectiveness of portfolio construction using cross listings.

CHAPTER 3. Data

3.1. Sample description

The sampled data consists of the largest and most traded public companies in Europe, listed in the Euro Stoxx 50 index (see Appendix). As these companies have also listed their shares on U.S. exchanges in the form of normal securities serving as secondary listings, American Depositary Receipts or over-the-counter equities, developing the models on this index structures the analysis to be relevant both in the context of global geopolitical relations and financial integration. For each stock, its primary listing is on a European index, usually the home country where the company was established, while its secondary listing is in the U.S.

A summary list of the countries of establishment and operating industries are displayed in Table 1. Euro Stoxx 50 index comprises stocks of companies listed under the euro currency, where France, Germany, Netherlands and Italy account for the majority of domestic indexes. As these price differentials have been observed for a long time, expanding the analysis over 13 years (January 2009-March 2024) will assure the validity of the results in the broad scheme of market developments, augment previous findings and literature and provide results for the most recent years. The operating industries are diversified and mostly include market leaders for each sector described in Panel B. This time frame was carefully selected to ensure a comprehensive inclusion of stocks and their U.S. cross listing, as in the majority of cases this later issuing takes places with a few years delay from the domestic IPO.

Table 1. Descriptive summary of the sample of cross- listed companies

Panel A: By country

Country	**Frequency**	**Percent**
Belgium	1	1.72
Denmark	1	1.72
Finland	2	3.45
France	16	2.59
Germany	15	25.86
Ireland	1	1.72
Italy	6	10.34
Netherlands	5	8.62
Spain	5	8.62
United Kingdom	6	10.34

Panel B: By industry		
Industry	**Frequency**	**Percent**
Chemicals	2	3.51
Banks	8	14.04
Consumer Goods	12	21.05
Energy Sector	3	5.26
Financial Services	2	3.51
Healthcare Sector	5	8.77
Manufacturing Sector	12	21.05
Real Estate	2	3.51
Technology & Telecommunications	7	12.28
Transportation & Logistics	2	3.51
Utilities	2	3.51

3.2. Data sources

Data on monthly share prices of both European and US listings are extracted from Datastream, corporate decisional information on each cross listing is extracted from official issuance documents and underwriter's releases. To accurately depict price deviations in the indices, the bid-ask spread of monthly exchange rates for EUR (domestic) relative to USD (foreign) are obtained from Datastream. In special cases where company's secondary (US) listing is non-fungible – one foreign listed share is not equivalent to the domestic share, also known as the ADR[2] ratio not being 1:1 – conversion information is taken from issuer's website. Lastly, domestic market returns used as benchmark for some of the models: Euro Stoxx 50 for European comparison and S&P500 for the U.S. counterparts; are also compiled using Datastream database. In order to construct the fourth currency risk factor augmenting the three-factor Fama-French model, monthly nominative exchange rates of the euro are gathered from the European Central Bank database, which tracks the weighted average return of the euro compared to a basket of foreign currencies.

Lastly, price deviations will be quantified using established asset pricing models, where the Fama-French (1993) three factor model will serve as the initial benchmark for potentially explaining the

[2] American Depositary Receipt Ratio (ADR) is the fraction of shares out of the underlying stock the ADR represents and can be converted into, according to the U.S Securities and Exchange Commission

mispricings in cross listed stocks. As such, monthly data on the risk-free rate, market return, SMB and HML factors for Europe and the U.S. are obtained from Kenneth French Library.

3.3. Data adjustments

Before the extracted monthly prices could be used in the developed analysis, several adjustments needed to be made to ensure the robustness of the results. As such, isolate cases where companies have been listed in the index after 2009 were dropped to keep the observations complete (see Appendix for full list of companies included). Moreover, Europe is considered the home market throughout the analysis, hence the U.S. listing prices are adequately converted in domestic currency (EUR) using the averaged bid-ask spread of the spot exchange rate for each month. Lastly, to assure the accuracy of the deviations in the prevalent cross-listed prices, ADRs are converted to be equivalent to one European share according to their listing ratios extracted from IPO releases (see Appendix for ADR ratio converstion).

Table 1 shows the descriptive statistics of the variables used to estimate the price deviations. Monthly stock returns in the respective markets (Europe and U.S.) are computed using end-of-month closing prices in the respective currencies.

Table 2. Descriptive statistics of the sample of cross listed companies

	Obs.	Mean	Std. dev.	5th percentile	95th percentile
Return Europe stock	10348	0.0101	0.08621	-0.11786	0.14147
Return U.S. stock	9453	0.00147	0.12798	-0.12852	0.14174
Return S&P500	10488	0.01044	0.04397	-0.07176	0.07986
Return EuroStoxx50	10488	0.00515	0.05088	-0.07371	0.07829
Exchange rate EUR/USD	10488	1.20771	0.12282	1.0572	1.43175

Notes: The table presents summary statistics for the sample of cross listed companies in the Euro Stoxx 50 index. Returns are reported as proportions, rounded to five decimal points, computed using the ratio of stock prices in the previous period and the current one - 1. Percentages can be derived by multiplication with 100. The number of observations differs for U.S. returns as some companies cross-listed their shares with a few periods delay from their domestic IPO.

CHAPTER 4. Methodology

4.1. General approach

The method of analysis will combine approaches on dual listed companies developed by De Jong et al. (2009) and Froot and Dabora (1999), cross listed studies by Gagnon and Karolyi (2004) and foreign exchange risk analysis similar to Kolari et al. (2008). By merging the most essential parts of previous analyses and constructing a more applied and specific model, this paper will firstly depict price differentials between cross listed companies in Europe and the United States and further exploit these deviations by constructing investment portfolios. Lastly, established asset pricing models such as Fama and French (1993) three factor model is deployed as a potential explanatory tool for the abnormal returns in the case of arbitrage portfolios using the domestic and foreign part of the cross-listing. A foreign exchange risk will be added to account for the currency exposure of cross listing in an international environment, according to the portfolio construction method of Kolari et al. (2008).

4.2. Price deviations in cross-listings

Following De Jong et al (2009) and Froot and Dabora (1999), deviation in returns is quantified subject to changes in local market indices as well as changes in the exchange rate. Equation (1) relates to the approach of Gagnon & Karolyi (2010) in depicting the difference in returns, while equation (2) follows Froot and Dabora (1999) by including the one period (month) lagged differential.

$$r_{A,t} - r_{B,t} = \alpha + \sum_{i=0}^{1} \gamma_i^1 Index1_{t+i} + \sum_{j=-1}^{0} \gamma_j^2 Index2 + \sum_{k=-1}^{1} \delta_k e.r_{t+k} + \boldsymbol{\varepsilon_t} \qquad (\mathbf{1})$$

$$r_{A,t} - r_{B,t} = \alpha + \beta\left(r_{A,t-1} - r_{B,t-1}\right) + \sum_{i=0}^{1} \gamma_i^1 Index1_{t+i} + \sum_{j=-1}^{0} \gamma_j^2 Index2 + \sum_{k=-1}^{1} \delta_k e.r_{t+k} + \boldsymbol{\varepsilon_t} \qquad (\mathbf{2})$$

where:

- $r_{A,t}, r_{B,t}$ represent the one month log returns at time t for the European (A) and U.S. (B) stocks in local currency
- $r_{A,t-1}, r_{B,t-1}$ are the one-month lag returns of the two parts of cross-listing, also on a logarithmic scale

- $Index1, Index2$ correspond to the local market returns for the same period: Index1 being the Eurostoxx 50 return and Index2 is the return on S&P500
- $e.r.$ represents the spot exchange rate between euro/dollar at each point in time

The models resulting from equation (1) and (2) will be estimated using Ordinary Least Squares Regressions (OLS), with Newey-West corrections for autocorrelation in standard errors where needed.

4.3. Portfolio construction

Following previous papers and motivations to exploit the observed differentials in cross-listings, an investment portfolio is created based on a one-month momentum[3] strategy. Hence, returns on the pair of European and U.S. components in the previous month are computed using end-of-month closing prices. These returns determine which part of the listing is going to be part of a long position in the current month and which part is going to be shorted. The portfolio is then formed and adjusted on a monthly basis: going into long positions on all losing stocks in the previous period and going in short positions on their winner counterparts. The returns of this portfolio are equal to the total return of this investment strategy – sum of the two returns in the two positions - and will be used as a potential arbitrage portfolio in established asset pricing models.

4.4. Asset pricing models

To construct arbitrage portfolios using the information on the price differential between the two parts of the cross listing, Fama - French (1993) three factor model will be used to account for abnormal returns in the investment positions. As such, the methodology entails the use of the following regression (Brooks, 2019):

$$R_t = \alpha_t + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \varepsilon_t \qquad (\mathbf{3})$$

where:

- R_t is the total return of the portoflio longing previous losing stocks and shorting previous winners in each month
- $RMRF$ represents the excess market return measured as the difference between the index and the yield on Treasury bills

[3]Momentum defined as the trading of stocks who tend to follow their past performance over an intermediary period of time (Nasdaq, 2024)

- SMB or the Small Minus Big factor is the difference in returns between a portfolio of small stocks and a portfolio with large stoks
- HML or the High Minus Low factor is the difference in returns between a portfolio with value stocks (high book-to-market value ratio) and a portfolio with growth stocks (low book-to-market value ratio)

Fama French (1993) three factor model is a widely used asset pricing model in financial economics, developed by augmenting the Capital Asset Pricing Model (CAPM) with two additional factors (HML and SMB) meant to increase the explanatory power of cross-section series of returns.

4.5. Foreign exchange risk factor

To account for the currency risk of cross-listings in the case of dual-currency expansion – here Euro and U.S. dollar; an approach similar to Kolari et al. (2008) is deployed. Hence, a fourth factor is added to the previous Fama-French three factor model which measures foreign exchange exposure by regressing stock returns on a foreign exchange series (X) capturing the return of the Euro currency and a basket of foreign currencies (European Central Bank, 2024).

$$R_{i,t} = \alpha_i + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 X_t + \varepsilon_{i,t} \qquad (\mathbf{4})$$

In order to construct the fourth factor augmenting the Fama-French approach, the regression in Equation (4) is run separately on European stock returns for each company in the sample. The estimated parameter for the X series (β_4), which depicts stocks' sensitivity to currency risk is the one used to categorize portfolio companies into high sensitivity stocks – highest positive and lowest negative coefficients, and low sensitivity stocks – middle ranks.

Following the distribution of the estimated betas, the ranking criteria is as follows: top 25% and bottom 20% of companies are considered having a high exposure to foreign currencies, while the in-between percentiles are considered having low sensitivity. The portfolio is then formed by taking long positions in the high sensitivity stocks and shorting the rest. The returns of this portfolio for each month constitute the fourth factor augmenting the Fama - French (1993) model, further referred to as the HMI factor (sensitive – minus - insensitive).

Hence, the augmented model used for the portfolio constructed on the cross-listings deviations, robust to foreign exchange risks is denoted as:

$$R_t = \alpha_t + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 HMI_t + \varepsilon_t \qquad (\mathbf{5})$$

CHAPTER 5. Results & Discussion

5.1. Price deviations

Figure 1 displays the aggregate log deviations in the prevalent prices of the cross listed companies on the European and U.S. markets. Price deviations expressed on a percentage basis in the sampled data show a positive and increasing trend over time.

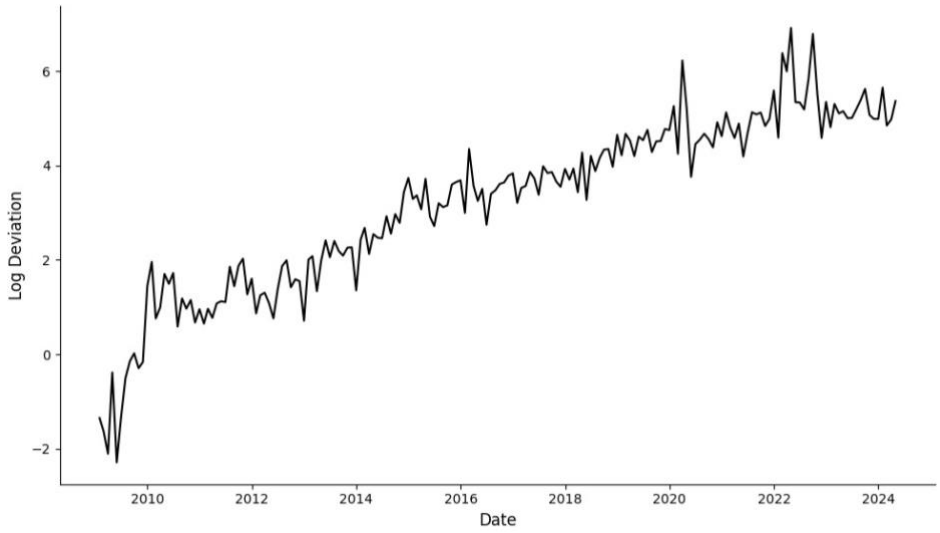

Figure 1. Time series of log deviations in stock prices from parity for the sample of cross-listed European companies, between January 2009 - March 2024

Notes: Figure 1 shows log deviations in adjusted prices between the European stock and U.S. one. U.S. stock prices were adjusted firstly based on ADR conversion rate and secondly according to the spot exchange rate. The log deviation at each point in time is then computed as follows:

$$Log\ deviation_t = \left(Ln(Price_{EU}) - Ln(Price_{US})\right) * 100$$

Cross-listed companies in the EuroStoxx50 index exhibit increasing deviations in listing prices over the time period selected. Table 3 shows the results of the regression having the price deviation in logarithmic form as a dependent variable and the time variable expressed in months as the independent variable. The time effect on price differentials in European compared to U.S. listings is positive and statistically significant at 1% level, concluding that the first hypothesis cannot be rejected and deviations in cross-listings demonstrate substantial increase over the sample time. Hence, with one additional month, the log deviation of the difference between the European and the U.S. component of the listings increases on average by 0.032%, which leads to an annual average increase of approximately 0.40%. The fluctuations are often large and point towards growing deviation in the direction of the two parts of the listing, indicating the complexity of market developments in recent years.

Table 3. Monthly time series regression of log-price deviations in cross listed companies between January 2009 – March 2024

	Log Price Deviation
Time	0.00032***
	(0.00008)
Constant	-0.18617***
	(0.00606)
Number of observations	184
R^2	0.87731
R^2 adjusted	0.87663

Notes: Table 1 shows the results of the regression having price log deviations as the dependent variable and a time variable as independent. Prices are converted in Euro currency and adjusted for ADR conversion ratio. Column (2) reports the coefficients in logarithmic forms, rounded to five decimal points. Standard errors reported in paratheses. The estimated regression can be described as:

$$Log\ Price\ Deviation_t = \alpha_t + \beta_t Time + \epsilon_t$$

Significant at 10%: *

Significant at 5%: **

Significant at 1%: ***

Table 4 shows the results for the two regression models associated with Equation (1) and (2). The two components of the stock are averaged between the companies on a monthly basis to depict a portfolio perspective of the index. Similar to De Jong et al. (2009), stocks exhibit positive and highly significant co-movements with their domestic market and negative with the foreign (U.S.) part, while the exchange rate has significant but opposite signs after the inclusion of the lagged variable, also in line with previous findings. Co-movements of stocks with their home market and countermovement with the foreign one have been predicted in studies by Bodurtha et al. (1995) who finds that price changes are affected by local risk and Froot and Dabora (1999) who more generally argue that location of trade affects prices of twin stocks. Moreover, the results of the highly positive and significant domestic index coefficient in Table 4 are in line with Chan et al. (2003), who goes further to discuss the importance of country-specific investor sentiment on stock price fluctuations. The inclusion of the lagged differential in Model 2 shows a negative and significative effect of the one-month past deviation, which strengthens highly volatile relationship between the two parts of the cross-listing.

The R^2 of the regressions are low in magnitude pointing towards the complexity of cross-market integration with its sensitivity to country or market-specific factors and the potential effect of aggregation across the companies listed in the EuroStoxx50.

Table 4. Regression results of the differential in the stocks returns of the paired listings on their movement with local and foreign market and exchange rate,

	Model 1	**Model 2**
Return Eurostoxx50	0.51691***	0.49028***
	(0.07096)	(0.06732)
Return S&P 500	-1.59588***	-1.5728***
	(0.08751)	(0.09916)
Exchange rate EUR/USD	0.29665***	-0.30713***
	(0.29665)	(0.0174)
Lagged returns	-	-0.06772***
		(0.00911)
Constant	-0.32927***	-0.34201***
	(0.02241)	(0.0214)
Number of observations	10488	10431
R^2	0.06044	0.05932
R^2 adjusted	0.06017	0.05896

Notes: Columns (2) and (3) show the results of the OLS regression according to respective equation (1) and (2), rounded to five decimal points. All returns are reported in local currencies: EUR for the European index and the European stock, and USD for the S&P500 index and the U.S. stock return. Standard errors are in parentheses. Model 2 is estimated using Newey West standard error to correct of autocorrelation in returns.

Significant at 10%: *

Significant at 5%: **

Significant at 1%: ***

5.2. Robustness check in price deviations

To potentially account for the effect of aggregation in the index, a robustness check is done by segregating the country of origin of the included companies. As the Euro Stoxx 50 is constructed over the Eurozone area, the most prominent countries in the index using the euro currency are Germany, France and the Netherlands. Hence, three additional models are depicted in Table 3 following the regression estimated by Equation (2). As displayed in Table 3, the direction of the effect of each index and the exchange rate respectively remain constant to those of the original model and the coefficients across the model are close in magnitude, pointing towards robustness in aggregation. The persistent low R^2 points once again into the direction of macroeconomic factors potentially affecting the diverging

performances of the two markets, where components such as local regulations, speed of information integration and investor patterns come at increased relevance.

Table 5. Robustness analysis for price deviations in cross-listed companies

	Model 3	**Model 4**	**Model 5**
	Germany	**France**	**Netherlands**
Return Eurostoxx50	0.49276***	0.48773***	0.49276***
	(0.16380)	(0.15158)	(0.28437)
Return S&P500	-1.57654***	-1.56895***	-1.67655***
	(0.19189)	(0.17751)	(0.3331)
Exchange rate EUR/USD	0.30779***	0.30628***	0.30796***
	(0.04087)	(0.0378)	(0.07096)
Lagged returns	-0.06789***	-0.06755***	-0.06789***
	(0.02106)	(0.01949)	(0.0365)
Constant	-0.03429***	-0.03410***	-0.34298***
	(0.00334)	(0.04560)	(0.08559)
Number of observations	2196	2562	732
R^2	0.05942	0.05921	0.05942
R^2 adjusted	0.05771	0.05774	0.05425

Notes: Columns (2), (3) and (4) show the results of the OLS regression according to equation (2), rounded to five decimal points. All returns are reported in local currencies: EUR for the European index and the European stock, and USD for the S&P500 index and the U.S. stock return. Standard errors are in parentheses.

Significant at 10%: *

Significant at 5%: **

Significant at 1%: ***

5.3. Portfolio returns in cross-listings

The second part of the analysis entails the use of the above detailed price differentials in developing an investment portfolio to potential generate arbitrage profits. Table 5 displays regression results where the returns of the portfolio constructed using both sides of cross listings are the dependent variables and the model factors are the independent variables. Previous studies on multi-market trading involve the use of proven models to account for the abnormal returns and variation seen in the underlying stocks (Froot & Dabora,1999; De Jong et al.,2009; Rosenthal & Young, 1990). Estimates

of abnormal returns in the Fama-French (1993) three-factor model are denoted by the constant (alpha) of the regressions associated with Equation (3) and Equation (5). The four-factor model in the second column represents the augmented Fama-French currency risk factor (HMI), following the methodology of Kolari et al. (2008). Alphas are computed as time-series on monthly portfolio returns using the cross-listing loser-winner momentum strategy. Both models exhibit positive alphas that are significant at 1% level, with the highest return in the augmented regression, result which is line with previous findings of De Jong et al. (2009) and Kolari et al. (2008).

Table 6. Regression results of Fama-French 3 factor model and augmented Fama-French 4 factor model on the momentum portfolio constructed using cross-listed companies

	Fama French 3 - Factor model	**Fama French+ HMI 4 - Factor model**
RF	-0.00735***	-0.00802***
	(0.00129)	(0.00129)
RMRF	0.00015***	0.00012***
	(0.00003)	(0.0003)
SMB	0.00012	-0.00013
	(0.00005)	(0.00009)
HML	0.00015***	0.11508***
	(0.00005)	(0.00005)
HMI	-	0.00666***
		(0.01443)
Alpha	0.00665***	0.00667***
	(0.00018)	(0.00018)
Number of observations	10488	10488
R^2	0.0068	0.0128
R^2 adjusted	0.0064	0.0123
F statistic	17.87	27.09

Notes: Columns (2) and (3) show the results of the OLS regression according to equation (3) and (5), rounded to five decimal points. All returns are reported in Euro currency, taken as the home market. Standard errors for each coefficient are reported in parentheses.

Significant at 10%: *

Significant at 5%: **

Significant at 1%: ***

The portfolio constructed using price deviations in cross-listed companies shows a monthly return of roughly 0.665%, annualized[4] to 8.24% using the three-factor model and 0.667% monthly abnormal return annualized to 8.31% for the augmented model. The inclusion of a currency risk factor (HMI) does not change the significance nor the signs of the initial Fama-French factors, proving the robustness of this model in capturing variation in returns. The high statistical significance of the factors: risk free rate, HML, as well as the intercepts coming close to 0 prove their high explanatory power in absorbing time-series returns fluctuations (Fama & French, 1993). With p – values falling under the 1% significance bracket, excess market return and value of a firm can articulate the difference in average returns across the time horizon, whereas the size factor proves to have an insignificant effect for the sample of cross-listings chosen. This later finding on the significance of a firm's size further supports existing controversies on the disappearance of the size premium in explaining equity returns. Van Dijk (2011) argues that although previous research points towards a disappearance of the size effect after early 1980s (Dichev, 1998; Chan et al., 2000), it would be premature to generalize the findings and assume a total extinction of this factor.

According to the theory of asset pricing models described by Fama and French (1993), if HMI is a priced factor, then it should lead to a decrease in the mean pricing error, also referred to as the absolute value of the constant. The increase in regression's alpha leads to a rejection of the second hypothesis stating that the currency risk is priced in the sampled cross-listings, which is line with Griffin (2002) who concludes that the addition of international factors to domestic models generates less accurate predictions. As previous findings on this matter are rather contradictory: the decrease in alphas following the inclusion of the currency risk factor leads to inconsistencies between the significance of results for the three factors Fama-French model or, adversely, shows an increase in the context of International Capital Asset Pricing Model (ICAPM) (Kolari et. al. 2008); it becomes difficult to generalize the implications of this additional factor. Nevertheless, while the augmented model shows a small increase in the unexplained returns, statistical fit of the augmented model is larger: the R squared doubles from 0.68% to 1.28% and the F – statistic of joint significance of factors increases from 17.87 to 27.09, inferring a similar conclusion to Kolari et al. (2008) that the HMI factor enriches model specification.

While a model with a stronger fit is generally desired in understanding abnormal returns of different investment strategies and portfolios, accounting for exposure to currency risk is especially relevant in the case of companies listing their shares in internationally diversified markets, which makes the augmented model an economically and statistically significant tool for investors and decision makers.

[4] Annualized values are used to facilitate comparison in returns with other asset classes and risk-free assets, following the transformation:

$$Annualized\ return = (1 + Monthly\ return)^{number\ of\ months} - 1$$

CHAPTER 6. Conclusion

6.1. Outline and implications

This paper analyses price differentials in cross-listed companies of Euro Stoxx 50 index and the U.S. equity markets and constructs investment portfolios according to the sign of one-month momentum deviations from parity. While previous research is well-diversified on the topic, including analysis on dual-listed stocks carried by De Jong et al. (2009), Froot and Dabora (1999) and Rosenthal and Young (1990), multi-market trading (Gagnon & Karolyi, 2004; Halling et al., 2008) and currency exposure frameworks constructed by White and Woodburry (1980), De Santis and Gerard (1998) and Kolari et al. (2008), through this research several approaches were combined and adapted to the European market or cross listings. Beginning with companies' corporate motivation and operational implications to cross-list their shares on a foreign exchange market, this paper outlines the benefits and disadvantages of such international expansion in the global context of transatlantic integration by quantifying price deviations and leveraging the gaps observed into potential profit strategies. Whereas the generic research question for the underlying analysis explored factors causing price deviations in cross listed companies and their impact in portfolio creation and arbitrage trading, two hypotheses were developed following the line of the analysis.

To investigate the core research question, a two-step framework was developed in order to account for the numerous variations and implications cross-listings have in the recent landscape of global markets. While the first part of the analysis corresponding to the first hypothesis takes on De Jong's et al. (2009) regression study of return differentials between the two components of the sampled cross listings, the results point towards an upward trend of roughly 0.40% annual increase in the observed aggregate deviations, with an average deviation around 3-4%. Although Meric and Meric (2015) found that there is correlation between European and U.S. equity markets, concluding that in this sense diversification benefits have decreased over the years, most literature points towards a time volatile relationship (Bekaert & Harvey, 1995). While efforts are made in the direction of complete integration between the markets, transfer of information, time zone differences as well as local regulations are time-resistant impediments in this long-lasting process. Hence, the second part of the developed framework attempts to exploit these widely observed price differentials by creating an investment portfolio using the two components of the cross-listing. Applying established asset pricing models with the addition of a foreign exchange risk factor, the constructed portfolio shows an annualized 8.3% abnormal return for the one-month momentum strategy, similar to the findings of De Jong et al. (2009). The implications of this result strengthen previous literature on multi-market

arbitrage, with dual listed companies offering profit opportunities for investors willing to diversify or hedge their positions in international capital markets.

6.2. Limitations and further research

Whereas this paper aims at developing a focused analysis on European stock markets and investment strategies, generalizing the results in a broader landscape of capital markets might impose certain limitations. Firstly, this research follows a line of analysis previously used on dual listed companies, which are fundamentally different than cross listings in the underlying premise of the mergers. Where in the case of dual listings, two independent companies agree to combine their operations and cash flows while maintaining separate shareholders registries and identities (Gagnon & Karolyi, 2004), cross listings represent a singular company having multiple listings on foreign exchanges and therefore might imply conceptually different approaches and results. A possible intermediary approach between the two could start by firstly building a comparison on the two types of institutional establishments and thereafter adapt the dual-listing methodology to the markets of cross-listings. Moreover, a main limitation in developing the models is determined by the aggregation problem, as returns of sampled companies listed in Euro Stoxx 50 are averaged at each point in time in order to depict a portfolio perspective, which could lead to affects in the regression analysis (Clark & Avery, 1976). As the panel used throughout the paper consisted of nearly 50 companies and hence running separate analysis would have not added significant value, a possible suggestion to further improve the analysis would be to split the listings into multiple portfolios. This can be done in a similar manner to Kolari et al. (2008), ranking companies' stock prices based on their foreign exchange sensitivity which in turn can diminish the aggregation effect.

Although the momentum strategy deployed in this research is widely covered in economic literature, with strong arguments in favour of stocks past performance used as a predictability tool, its effectiveness in all types of financial assets still raises questions. While this paper only tackles a one-month momentum strategy, several other time intervals could potentially shed a better light on the behaviour of foreign listed stocks. De Jong et al. (2009) conducts an analysis on dual listed companies deploying multiple investment strategies and portfolios, also adjusting for systematic risk, transaction costs and margin requirements. The portfolio depicted in this paper shows potential drawbacks in regard to the extent to which it accounts for such regulatory aspects of public stock exchanges, which could constitute a topic worth further investigation.

Since throughout this research month-end closing prices are used for the period of time and sample of companies, a potential limitation to consider is the turn-of-the-month effect, described as the

tendency of stock returns to achieve their peak during the last four days of each month and first three days of the following one (Kunkel et al., 2003). This could potentially induce an upward bias in the results, which can be addressed in further analyses by expanding the data selection for daily or weekly averages of stock prices and returns.

Although the financial complexity of cross-listed companies remains a heated topic in the current context of capital markets, this paper validates once again the pricing anomalies widely observed in cross-listed companies, with a focus on European and U.S. stock exchanges. The results prove how the importance of studying these unique corporate establishments increases constantly in a contemporary setting where cross-border market integration is strongly facilitated by technology advancements, growing information transfer and regulatory alignments.

REFERENCES

Aliber, R. Z. (1978). The integration of national financial markets: A review of theory and findings. *Review of World Economics, 114*(3), 448-480.

Andrew Karolyi, G., & Wu, Y. (2021). Is currency risk priced in global equity markets?. *Review of Finance*, *25*(3), 863-902.

Awwaliyah, I. N., & Husodo, Z. A. (2011). On the robustness of the extended Fama-French three factor model. *Available at SSRN 1983604*.

Bailey, W., Chung, Y. P., & Kang, J. K. (1999). Foreign ownership restrictions and equity price premiums: what drives the demand for cross-border investments?. *Journal of financial and quantitative analysis*, *34*(4), 489-511.

Baker, H. K., Nofsinger, J. R., & Weaver, D. G. (2002). International cross-listing and visibility. *Journal of Financial and Quantitative Analysis*, *37*(3), 495-521.

Barclay, M. J., Kandel, E., & Marx, L. M. (1998). The effects of transaction costs on stock prices and trading volume. *Journal of Financial Intermediation*, *7*(2), 130-150.

Bekaert, G., & Harvey, C. R. (1995). Time-varying world market integration. *the Journal of Finance*, *50*(2), 403-444.

Bodurtha Jr, J. N., Kim, D. S., & Lee, C. M. (1995). Closed-end country funds and US market sentiment. *The Review of Financial Studies*, *8*(3), 879-918.

Brooks, C. (2019). *Introductory econometrics for finance* (4th ed.). Cambridge University Press.

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal of finance*, *52*(1), 57-82.

Chan, K. C., Gup, B. E., & Pan, M. S. (1997). International stock market efficiency and integration: A study of eighteen nations. *Journal of business finance & accounting*, *24*(6), 803-813.

Chan, K., Hameed, A., & Lau, S. T. (2003). What if trading location is different from business location? Evidence from the Jardine Group. *The Journal of finance*, *58*(3), 1221-1246

Chan, L. K. C., Karceski, J., & Lakonishok, J. (2000). New Paradigm or Same Old Hype in Equity Investing? *Financial Analysts Journal*, *56*(4), 23–36. https://doi.org/10.2469/faj.v56.n4.2371

Chemmanur, T. J., & Fulghieri, P. (2006). Competition and cooperation among exchanges: A theory of cross-listing and endogenous listing standards. *Journal of Financial Economics*, *82*(2), 455-489

Clark, W. A., & Avery, K. L. (1976). The effects of data aggregation in statistical analysis. *Geographical Analysis*, *8*(4), 428-438.

Collins, B. M., & Fabozzi, F. J. (1991). A methodology for measuring transaction costs. *Financial Analysts Journal*, *47*(2), 27-36.

De Jong, A., Rosenthal, L., & Van Dijk, M. A. (2009). The risk and return of arbitrage in dual-listed companies. *Review of Finance*, *13*(3), 495-520.

De Landsheere, J. Cross-listing in the 21st century

De Santis, G., & Gerard, B. (1998). How big is the premium for currency risk?. *Journal of financial economics*, *49*(3), 375-412.

Dichev, I. D. (1998). Is the risk of bankruptcy a systematic risk?. *the Journal of Finance*, *53*(3), 1131-1147.

Euro Stoxx 50. STOXX. (2024, May 28). https://stoxx.com/index/sx5e/#:~:text=This%20index%20tracks%20the%20Eurozone's,to%20the%20region's%20supersector%20leaders.

European Central Bank. (2023, September 1). *Daily nominal effective exchange rate of the Euro*.https://www.ecb.europa.eu/stats/balance_of_payments_and_external/eer/html/index.en.html

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of financial economics*, *33*(1), 3-56.

Fountain, J. (1969). American depositary receipts and their uses. *Financial Analysts Journal*, *25*(1), 15-20.

Froot, K. A., & Dabora, E. M. (1999). How are stock prices affected by the location of trade?. *Journal of financial economics*, *53*(2), 189-216.

Gagnon, L., & Karolyi, G. A. (2004). *Multi-market trading and arbitrage* (No. 2004)

Greene, E. F. (2007). Resolving regulatory conflicts between the capital markets of the United States and Europe. *Capital Markets Law Journal*, *2*(1), 5-40.

Griffin, J. M. (2002). Are the Fama and French factors global or country specific?. *The Review of Financial Studies*, *15*(3), 783-803.

Halling, M., Pagano, M., Randl, O., & Zechner, J. (2008). Where is the market? Evidence from cross-listings in the United States. *The Review of Financial Studies*, *21*(2), 725-761.

Investing, S. (2024). Stock investing using Momentum. *Nasdaq*. https://www.nasdaq.com/articles/stock-investing-using-momentum

Investor bulletin: American Depositary Receipts. Investor.gov. (2012, August 17). https://www.investor.gov/introduction-investing/general-resources/news-alerts/alerts-bulletins/investor-bulletins-88

Jawadi, F., & Arouri, M. (2008). Are American and French stock markets integrated?. *The International Journal of Business and Finance Research*, *2*(2), 107-116.

Karolyi, G. A. (2006). The world of cross-listings and cross-listings of the world: Challenging conventional wisdom. *Review of Finance*, *10*(1), 99-152.

Kenneth R. French - Data Library (2024). https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Kolari, J. W., Moorman, T. C., & Sorescu, S. M. (2008). Foreign exchange risk and the cross-section of stock returns. *Journal of International Money and Finance*, *27*(7), 1074-1097.

Kunkel, R. A., Compton, W. S., & Beyer, S. (2003). The turn-of-the-month effect still lives: the international evidence. *International Review of Financial Analysis*, *12*(2), 207-221

Lesmond, D. A., Ogden, J. P., & Trzcinka, C. A. (1999). A new estimate of transaction costs. *The review of financial studies*, *12*(5), 1113-1141.

Meric, I., & Meric, G. (1997). Co-movements of European equity markets before and after the 1987 crash. *Multinational Finance Journal*, *1*(2), 137-152.

Peng, M. W., & Su, W. (2014). Cross-listing and the scope of the firm. *Journal of World Business*, *49*(1), 42-50.

Refinitiv. (2024). Eikon [Database]. Refinitiv. https://www.refinitiv.com

Rosenthal, L., & Young, C. (1990). The seemingly anomalous price behavior of Royal Dutch/Shell and Unilever NV/PLC. *Journal of Financial Economics*, *26*(1), 123-141.

Sharma, A., & Seth, N. (2012). Literature review of stock market integration: A global perspective. *Qualitative Research in Financial Markets*, *4*(1), 84-122.

Sharpe, William, and Gordon Alexander, 1990, Investments, 4th edition, (Prentice Hall, Engle- wood Cliffs, N.J.).

Statista Research Department, & 15, M. (2024, May 15). *Leading stock exchange operators by market cap 2024*. Statista.

Van Dijk, M. A. (2011). Is size dead? A review of the size effect in equity returns. *Journal of Banking & Finance*, *35*(12), 3263-3274.

What is the Euro Area? Economy and Finance. (2024). https://economy-finance.ec.europa.eu/euro/what-euro-area_en

White, B. B., & Woodbury, J. R. (1980). Exchange rate systems and international capital market integration. *Journal of Money, Credit and Banking*, *12*(2), 175-183.

APPENDIX

Table 7. Descriptive statistics of the Euro Stoxx 50 companies included in the sample

Name	Industry	Exchange EU	Exchange US	ADR ratio
Adidas AG	Personal Goods	Frankfurt Stock	OTC	1:1
Air Liquide	Commodity chemicals	Euronext Paris	OTC	1:5
Airbus SE	Aerospace & Defense	Euronext Paris	OTC	1:4
Allianz SE	Multiline Insurance & Brokers	Xetra	OTC	1:10
Anheuser-Busch Inbev SA	Bevrages - Brewing	Eurnoext Belgium	NYSE	1:1
ArcelorMittal	Iron & Steel	Euronext Amsterdam	NYSE	1:1
ASML Holding NV	Semiconductor Equipment & Testing	Euronext Amsterdam	NASDAQ	1:1
Astra Zeneca PLC	Pharmaceuticals	London Stock Exchange	NASDAQ	1:2
AXA	Life&Health Insurance	London Stock Exchange	OTC	1:1
Banco Santander SA	Banks	BME	NYSE	1:1
BASF SE	Diversified Chemicals	Xetra	OTC	1:4
BAYER AG	Pharmaceuticals	Xetra	OTC	1:4
Bayerische Motoren Werke AG	Auto&Truck Manufacturers	Xetra	OTC	1:3
BBVA	Banks	BME	NYSE	1:2
BNP Paribas	Banks	Euronext Paris	OTC	1:2
CRH PLC	Building Materials	Euronext	NYSE	1:1
Danone SA	Consumer goods	Euronext Paris	OTC	1:5
Deutsche Bank AG	Banks	Xetra	NYSE	1:1
Deutsche Post AG	Integrated Freight & Logistics	Xetra	OTC	1:1
Deutsche Telekom AG	Integrated Telecommunications Services	Xetra	OTC	1:1
ENEL Spa	Utilities	Borsa Italiana	OTC	1:1
Eni Spa	Oil&Gas Refining and Marketing	Borsa Italiana	NYSE	2:1
Essilor Luxotica	Medical Instruments&Supplies	Euronext Paris	OTC	1:1
Ferrari NV	Auto&Truck Manufacturers	Borsa Italiana	NYSE	1:1
Hermes International	Personal Goods	Euronext Paris	OTC	1:10
Iberdrola SA	Electric Utilities	BME	OTC	4:1
Industria De Diseno Textil SA	Apparel Retail	BME	OTC	1:1
Infineon Technologies AG	Semiconductors	Xetra	OTC	1:1
ING GROEP NV	Banks	Euronext Amsterdam	NYSE	1:1
Intesa SanPaolo Sa	Banks	Borsa Italiana	OTC	6:1
Kering	Luxury goods	Euronext Paris	OTC	1:10
Koninklijke Ahold Delhaize N.V	Consumer goods	Euronext Amsterdam	OTC	1:1

L'oreal	Personal Products	Euronext Paris	OTC	1:5
LVMH	Apparel & Accessories	Euronext Paris	OTC	1:5
Mercedes Benz Group AG	Auto&Truck Manufacturers	Xetra	OTC	1:1
NOKIA OYJ	Integrated Telecommunications Services	Nasdaq Helsinki	NYSE	1:1
Pernod Ricard	Consumer goods	Euronext Paris	OTC	1:5
Roche Holding AG	Pharmaceuticals	Swiss Exchange	OTC	1:1
Safran	Aerospace & Defense	Euronext Paris	OTC	1:4
Sanofi	Pharmaceuticals	Euronext Paris	NASDAQ	1:2
SAP SE	Software	Xetra	NYSE	1:1
Schneider Electric SE	Electronal Components & Equipment	Euronext Paris	OTC	1:5
Siemens AG	Electronal Components & Equipment	Xetra	OTC	1:2
Stellantis NV	Auto&Truck Manufacturers	Borsa Italiana	NYSE	1:1
Telefonica S.A.	Integrated Telecommunications Services	BME	NYSE	1:1
Total Energies SE	Integrated Oil&Gas	Euronext Paris	NYSE	1:1
Unicredit SPA	Banks	Borsa Italiana	OTC	1:2
VINCI	Construction & Engineering	Euronext Paris	OTC	1:1
Volkswagen AG	Auto&Truck Manufacturers	Xetra	OTC	1:10
Vonovia SE	Real Estate services	Xetra	OTC	1:2

Notes: Table 7 shows the sample of cross listed companies included in the analysis report. The names of companies are reported as taken from the underlying listing indexes. Column 5 shows the ADR ratios used in the conversion of American listings into a European equivalent: for example, one share of Air Liquide in Paris is monetary equal to 5 shares in the U.S.