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Depositary Receipts and their underlying shares: A study on volatility

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Abstract

In this paper we examine the volatility dynamics of cross-listed stocks. Specifically, we study deviations in volatility between a sample of Swedish stocks listed on the OMX Stockholm 30 Index (OMXS30) with Stockholmsbörsen (SSB, the Stockholm stock exchange) as their home market, and their corresponding DRs listed on Frankfurter Wertpapierbörse (FWB, the Frankfurt Stock Exchange). The main question we seek to answer is; Are there differences in volatility for DRs on the FWB and their underlying shares traded on SSB?

We use an EGARCH model to estimate volatility for the Swedish stocks trading on SSB and their corresponding DRs traded on FWB. In contrast to the Efficient Market Hypothesis and the LOP theory, we find significant differences in volatility both on an individual and collective basis. In particular, volatility is higher for DRs traded on the FWB.

According to our results this finding is not merely a consequence of higher relative expected returns for DRs. In fact, our results indicate that risk adjusted returns are higher in Stockholm. Thus, investors considering investing in Swedish cross-listed companies should evaluate the risk-return relationship between DRs and the home market shares. We further discuss potential theoretical explanations, for example the bid-ask spread, of the divergence in volatility and leave for future research to empirically investigate the impact of the mentioned reasons.

Key words: Volatility, EGARCH, Cross-Listing, Depositary Receipts.

Acknowledgements

We would like to thank our supervisor Göran Andersson for valuable input and feedback during this master thesis project. We would also like to thank the professors of the masters in finance programme for providing us with the necessary tools to complete this project.

1. Introduction

We are going to present the foundations of this essay by introducing the reader to the subject and discuss the problem, purpose and limitation.

1.1 Background

Some companies chose to cross list their equity shares on multiple stock exchanges in addition to its domestic exchange. Common instruments for cross listing are different kinds of Depository Receipts (DRs) also known as Depository Shares (DS) such as; American Depositary Receipts (ADRs), European Depository Receipts (EDRs), or Global Depository Receipts (GDRs). DRs differ to the extent on which exchanges firms intend to list their shares and they can be capital raising or non-capital raising. However, they can all be used by companies as means of accessing foreign equity markets. They represent the underlying shares and enable foreign investors to trade in the issuing companies' shares without the potential problems associated with custody and settlement in foreign markets. For example, "*ADRs are US dollar denominated negotiable instruments issued in the US by a depository bank, representing ownership in non-US securities, usually referred to as the underlying ordinary shares*."[1] ADRs are issued at a fixed multiple relative to the underlying shares and, as such, they tend to trade in a very limited range around the price of the underlying share after adjusting for exchange rate effects.[2] According to the U.S. Securities and Exchange Commission; the equity shares of most foreign companies that trade on the U.S. markets are trade as ADRs. EDRs represent the European equivalent of ADRs. These shares are traded on the Euromarkets and may or may not be Euro denominated, depending on the currency of the market the EDR is trading on. A GDR will access two or more markets, usually the Euromarkets, like and EDR, and the U.S., like and ADR. These securities are quoted and traded in U.S. dollars.[3]

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[1] Deutsche Bank, Depository Receipts Handbook,
[2] Grammig Joachim, Michael Melvin & Christian Schlag, (2005), "Internationally cross-listed stock prices during overlapping trading hours: price discovery and exchange rate effects, "in *Journal of Empirical Finance 12,* pp. 139-164.
[3] London Stock Exchange, Global Depositary receipts, Deutsche Bank, Depository Receipts Handbook, URL=<http://www.londonstockexchange.com/traders-and-brokers/security-types/gdrs/gdrs.htm> (2011-05-20)

There are several potential advantages of cross-listing and many studies have been conducted on the topic. Brockman and Chung suggest that "*cross listing can reduce the firm's cost of capital by increasing the investor base, improving the firm's liquidity, and providing greater access to alternative sources of capital*."[4] In their study on cross listing and liquidity they found that cross listed firms exhibit significantly higher levels of liquidity the non-cross listed firms. Furthermore, Sundaram et al (1996) found that "*cross listing by foreign firms using sponsored ADRs on the New York Stock Exchange and the American Stock Exchange increases the firm's equity values and thereby lowers their cost of capital by simply mitigating the adverse effects of international capital market segmentation."*[5]

According to the law of one price (LOP) identical goods should have identical prices given competitive markets without transaction costs and barriers to trade. DRs provide a means of practically testing the LOP theory as they represent the same cash flows as the underlying stock. Thus, Rabinovitch et al. noted, "*although trading ADRs in the US is US dollar denominated, it should be equivalent to trading the foreign firms' shares without actually trading them in their respective local markets*."[6]

However, imperfections in financial markets exist to varying extent and markets are not completely frictionless. In fact, there is extensive research on the issue of international barriers to trading and financial segmentation. In general there seems to be a trend towards integration of financial markets, however, studies on the degree of financial integration have conflicting results. In his econometric study on equity market integration in the Nordic markets, Oxelheim showed that "*the Nordic markets as a whole are not perfectly integrated, but a segment of the market consisting of large companies exposed to detailed scrutiny on the global market, comes very close to it."*[7] Yeyati et al. used the cross-market premium (the ratio between the domestic and the international market price of cross listed stocks) as a measure of international financial integration.[8] The study found that price deviations across markets are rapidly arbitraged away which was interpreted as an indication of financial integration. The

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[4] Brockman Paul and Dennis Y. Chung, (1999), "Cross- Listing and Firm Liquidity on the Stock Exchange of Hong Kong," in *Journal of Managerial Finance 25*, pp. 64-88.
[5] Anant K. Sundaram, (1996), "Valuation Effects of Foreign Company Listings on U.S. Exchanges," in *Journal of International Business Studies, 27,* pp. 67-88.
[6] Rabinovitch Roman, Ana Cristina Silva & Raul Susmel, (2003), "Returns on ADRs and arbitrage in emerging markets," in *Emerging Markets Review 4,* pp. 225-247.
[7] Oxelheim Lars, (2001), "Routes to equity market integration – the interplay between politicians, investors and managers," in *Journal of Multinational Financial Management 11*, pp. 183-211.
[8] Yeyati Eduardo Levy, Sergio L. Schmukler & Neeltje Van Hooren, (2009) "international financial integration through the law of one price: The role of liquidity and capital controls," in *Journal of Financial Intermediation 18*, pp. 432-463.

paper also showed that integration is stronger for more liquid stocks and that transaction costs are likely to be smaller for those stocks.

Rabinovitch et al. mention, as sources of differences between return distributions of ADRs and locally traded shares, transaction costs, the distribution of foreign exchange return between the firm's home market and the foreign stock exchange, lead-lag time between the market where the ADR is listed and the local market and liquidity.[9] Moreover, Grammig et al. noted in their study that ADRs are not perfect substitutes for the underlying shares.[10] Conversion fees, presence of intermediary banks, and potential differences in voting rights and other corporate control rights between holders of the underlying shares and the holders of the ADRs are mentioned as additional explanations why DRs and their underlying shares might not be perfect substitutes.

These imperfections could, on a collective or individual basis, create deviations between return distributions on DRs and their underlying shares, although the prices of the two assets could be expected to move in tandem over time.

Some studies have shown that returns are not identical for ADRs and the underlying equity, leaving potential opportunities for arbitrage. In their 1990 paper on arbitrage opportunities between ADRs and their underlying stocks, Kato et al. found evidence consistent with the LOP and no arbitrage existed between the international capital markets investigated.[11] Some recent studies on arbitrage opportunities and deviations from the LOP have generally shown that arbitrage opportunities do exist from time to time. For example, using a data set for three major capital and foreign exchange markets over several months at tick frequency, Akram et al. showed that "*the LOP price holds on average, but numerous economically significant violations of the LOP arise*."[12] Suarez investigated the price discrepancy between ADRs and their underlying shares using high frequency data on French and American stocks.[13] He showed that large deviations from the LOP are present in the data and that profits could be made using arbitrage strategies.

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[9] Rabintovich et al., (2003)
[10] Grammig et al., (2005)
[11] Kato Kiyoshi, Scott Linn & James Schallheim, (1990), "Are there Arbitrage Opportunities in the Market for American Depository Receipts?," in *Journal of International Financial Markets, Institutions & Money 1,* pp. 73-89.
[12] Akram Q. Farooq, Dagfinn Rime & Lucio Sarno, (2009), "Does the law of one price hold in financial markets? Evidence from tick data," in *Journal of Banking and Finance 33,* pp. 1741-1754.
[13] Suarez E. Dante, (2005), "Arbitrage opportunities in the depository receipts market: Myth or reality?," in *Journal of Financial Markets, Institutions & Money 15,* pp. 469-480.

Given discrepancies between returns on DRs and returns on the home market securities, there will consequently exist deviations between return volatility of these pairs. Relations between DRs- and underlying stock return means and resulting arbitrage opportunities have been covered in the literature. Differences in volatility of returns between DRs and the underlying have not been investigated before.

1.2 Problem discussion

DRs and their underlying stocks facilitate an ideal setting for studying the LOP theory and potential differences in return distributions across exchanges as they are virtually the same security trading on different exchanges. In this paper we examine the volatility dynamics of cross listed stocks. Specifically, we study deviations in volatility between a sample of Swedish stocks listed on the OMX Stockholm 30 Index (OMXS30) with Stockholmsbörsen (SSB, the Stockholm stock exchange) as their home market, and their corresponding DRs listed on Frankfurter Wertpapierbörse (FWB, the Frankfurt Stock Exchange).

Hence, the main question we seek to answer in this paper is; are there differences in volatility for DRs on the FWB and their underlying shares traded on SSB?

Returns are closely related to volatility and as a consequence, we simultaneously investigate differences in returns and the risk-return relationship between home market shares and their corresponding DRs listed on the FWB. In particular, we use a volatility adjusted measure to compare returns between SSB and FWB.

Thus, related to our main question our secondary question is as follows; are differences in volatility simply compensated with a higher return?

1.3 Purpose

The purpose of this study is to test if there are significant differences in volatility between DRs listed on FWB and their underlying shares listed on SSB. We thereby implicitly test the theory of the Efficient Market Hypothesis and the LOP theory since, according to these theories, such differences should not exist. Also, using volatility as a risk measure, the risk-return relationship between DRs and the home market shares is analyzed and compared using

a volatility adjusted measure for returns. We further analyze potential theoretical explanations for differences in volatility between DRs and the underlying stock.

Volatility is an important risk measure and any differences in volatility of cross listed stocks, which represent the same underlying asset, should be of interest to fund managers and arbitrageurs. Discrepancies could be exploited through volatility arbitrage and/or by simply investing in the instrument with favorable risk-return relationship.

DRs and underlying stocks have been used in several studies that focus on investigating mispricing and return dynamics across exchanges. Recent literature on the topic of international equity market integration has used cross listed stocks to investigate the LOP theory. The volatility transmission process between markets and the impact of DR listings on return and volatility has been another topic of recent research using cross listed stocks. However, there is no study that explicitly examines the differences in volatility between DRs and their underlying shares.

1.4 Limitations

We have chosen to study a sample of 14 Swedish cross listed OMXS30 stocks with DRs traded on FWB. With Swedish stocks we mean stocks that have the Stockholm exchange as their home market. By this definition we do not focus on where the majority ownership are (for example stocks like Volvo that are from the beginning traded in Sweden and now are Chinese in majority).

There are several reasons why we selected FWB as the foreign market, first of all we noted that FWB was the most common exchange for cross listing of companies with Sweden as their home market, second it is in the same time zone as Stockholm and third SSB and FWB have identical trading hours. By choosing to compare only two exchanges, in the same time zone and with overlapping opening hours, we thought that related problems of unnecessary noise and spurious relationships could be eliminated to some extent. This will allow us to focus on obtaining a volatility that could be compared between the exchanges and to draw significant conclusion from our study.

2. Methodology

In this chapter are going to describe and clarify our methodological choices and methods of the research. We will also define the most important concepts and how we will perform the empirical tests.

2.1 Volatility

Volatility is a widely used risk measure and arguably one of the most important concepts in finance. Brooks (2008) uses the following definition to define volatility as a risk measure; "*Volatility, as measured by the standard deviation or variance of returns, is often used as a crude measure of the total risk of financial assets*."[14]

Volatility can be calculated/estimated by different methods. We are going to discuss pros and cons of the three volatility measures; historical volatility and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model.

2.1.1. Historical Volatility

One of the main advantages of historical volatility is that it is simple to calculate. Historical volatility is obtained by calculating the variance or standard deviation over some historical period. This then becomes the forecast for future volatility. The risk measure has historically been used for input into option pricing models but has been replaced by methods perceived as more accurate, such as GARCH models. However, historical volatility is still useful as a benchmark for comparing the forecasting ability of more complex models.[15]

[14] Brooks Chris (2008) *Introductory Econometrics for Finance* (Cambridge University press, Cambridge) second edition, pp. 406
[15] Brooks, (2008)

2.1.2. GARCH Models for Volatility Estimation

The GARCH model was introduced in 1986 by Bollerslev.[16] A GARCH(1,1), σ_n^2, is a specific form of a more general GARCH(p,q), and (1,1) indicates that we have the most current residual and variance. The GARCH(1,1) is expressed as follows.

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2 \tag{1}$$

Where $\omega = \gamma V_L$, and V_L is the long-term variance and can be calculated by $V_L = \omega/\gamma$, α, β & γ are weights and follows therefor by $\gamma + \alpha + \beta = 1$. When we aim for a stable GARCH it has to follow the properties $\alpha + \beta < 1$ or else we have a negative long-term variance.

Time-varying volatility GARCH

In his 1981 paper Shiller highlighted the problems of estimating variability of stock returns.[17] Conditional heteroscedasticity models such as ARCH and GARCH models are used to produce forecasts of conditional variance. Variations of GARCH models are often claimed to produce accurate estimates of future volatility and they are motivated by volatility clustering that often appears in asset return series. Hence, the notion that if we have high volatility today the volatility tomorrow is likely to be high as well.

Asymmetric GARCH models can take leverage effects, i.e. that a negative shock to a financial time series has a larger effect on volatility than a positive shock of the same size, into account. Exponential GARCH (EGARCH) was proposed by Nelson (1991).

We have used an EGARCH model, for our volatility measure, mainly because of its ability to account for volatility clustering and leverage effects.

By doing a daily EGARCH over two years we thought that we had enough data to draw conclusions in our study. As mentioned before, the EGARCH provides the advantage that even if a parameter is negative the σ^2 is going to be positive and therefore non-negativity

[16] Bollerslev Tim, (1986), "Generalized autoregressive conditional heteroscedasticity," *Econometrics Reviews, 5,* pp. 1-50.
[17] Robert J. Shiller, (1981), "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?," *The American Economic Review, 71,* pp. 421-436.

constraints of the conditional variance are not violated. It is also allowing asymmetries between return and volatility. The model is specified as below.[18]

$$\ln(\sigma^2) = \omega + \beta ln(\sigma_{t-1}^2) + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] \quad (2)$$

2.2 Data

After reviewing Swedish companies trading on the Stockholm stock exchange we find that 14 companies fit the criteria we set out in section 1.4 (Limitations). Thus, 14 of the stocks have Stockholm as their home market while they have DRs traded on the Frankfurt stock exchange as well.

By choosing companies that have their equity shares traded on exchanges in the same time zone, we think that we will be able to increase comparability and remove unnecessary noise associated with time differences. For example, additional information could be incorporated into the price of an ADR trading on an exchange that close later than the home market of the stock, and it would thus be unreasonable to expect that the two assets would have the same price at closing.

The dataset consists of ten years of daily price observation for the underlying stocks traded on the SSB and DRs traded in FWB. Daily price observation or more frequent data is most interesting as discrepancies in price and volatility, if present, is less likely to remain over the long-term. We obtain the data from Thomson Reuters Datastream which is according to the company "the world's largest financial statistical database,"[19] containing more than 3.5 million instruments and indicators. To make fair comparisons between the instruments through time the price quotes are adjusted for currency, dividends and splits.

[18] Brooks, (2008)
[19] Thomson Reuters,
URL=<http://online.thomsonreuters.com/datastream/> (2011-05-21)

2.3 Problems

The main problem is measuring and accounting for factors associated with an imperfect market. According to the efficient market hypothesis and the LOP, volatility should be identical in both markets investigated.

By choosing two closely related exchanges in the same time zone, the potential problem, as mentioned in section 1.1 (Background), of lead-lag time between markets is eliminated. Furthermore, companies that chose to cross list are usually large international companies with potential customers and investors present in the foreign market where the DR is traded. The shares of these companies are typically characterized as large- or midcap stocks with a fairly high level of liquidity and associated transaction costs are thus moderately low.

However, as mentioned in the background section and as highlighted by Grammig et al., DRs are not perfect substitutes for the underlying securities. Conversion fees, the presence of intermediary banks, and potential differences in voting rights and other corporate control rights between holders of the underlying shares and the holders of the DRs could cause discrepancies in prices and volatility between the two securities.

The owner of a DR has the right to convert the DR into a fixed amount of underlying shares. However, most investors chose to simply hold the DR as they are virtually the same instrument as the underlying. The structure of DRs are nonetheless something we need to keep in mind when conducting or study.

2.4 Hypotheses

Hypothesis for the essay is based under the assumptions of the LOP, and that there should not be any differences in price and consequently the volatility for the same stock at different exchanges. Our primary hypothesis is that the volatility on a stock cross listed on a foreign market does not differ from the home market. This can be formulated as the null hypothesis below.

$$H_0: \sigma^2_{i,Stockholm} - \sigma^2_{i,Frankfurt} = 0$$
$$H_1: \sigma^2_{i,Stockholm} - \sigma^2_{i,Frankfurt} \neq 0$$

The main hypothesis suggest that there should not be any difference in volatility for company i, so therefore we consider if this could be tested in general terms with a mean value over the whole sample, with a null hypothesis below (hypothesis 2), where $\bar{\sigma}^2$ is the mean value for all companies in the study. We use the EGARCH model as well as historical volatility estimation method to compare the results. The purpose of testing this in general terms with a mean value (hypothesis 2, 3 & 4), is to make it possible to draw any general conclusions, despite the statistical approach of sample reduction when we do not have as large a sample as desirable.

$$H_0: \bar{\sigma}^2_{Stockholm} - \bar{\sigma}^2_{Frankfurt} = 0$$
$$H_1: \bar{\sigma}^2_{Stockholm} - \bar{\sigma}^2_{Frankfurt} \neq 0$$

We further hypothesize that returns in the two exchanges are equal to each other. This is formulated in hypothesis 3, where $\bar{r}$ is the mean value of return for all companies.

$$H_0: \bar{r}_{Stockholm} - \bar{r}_{Frankfurt} = 0$$
$$H_1: \bar{r}_{Stockholm} - \bar{r}_{Frankfurt} \neq 0$$

Our last hypothesis is that the "risk-adjusted return"[20] does not differ between SSB and FWB. Again, volatility estimation from the EGARCH and historical volatility measures are compared. Our fourth hypothesis looks like below, where λ is the mean value for the return-volatility-ratio across all companies in the sample.

$$H_0: \lambda_{Stockholm} - \lambda_{Frankfurt} = 0$$
$$H_1: \lambda_{Stockholm} - \lambda_{Frankfurt} \neq 0$$

2.5 Empirical Implementation

Data for our research is collected from Thomson Reuters Datastream in the form of daily stock price observations. As an initial step we need to transform the price observations into returns. We calculate the stock returns as differences in log prices, also called continuously compounded return, using the formula in equation (3) for each stock. We further assume that

[20] This "risk-adjusted return" (λ) is a return-volatility-ratio similar to the Sharpe-ratio. However, real returns are used as opposed to excess returns.

P_t follows a lognormal distribution and we thereby avoid violating the limited liability rule associated with the assumption of normally distributed prices.

$$r_{i,t} = \ln(P_t) - \ln(P_{t-1}) \tag{3}$$

Our objective is to create a volatility measure which is achieved by running regressions on the returns for the specific EGARCH model as we describe in 2.1. The estimation window for the EGARCH runs from the period 2001-04-16 to 2009-04-15 and is used for the forecast period 2009-04-16-2011-04-14. It is during the forecast period we test our model and also calculate returns and historical volatility to make comparisons. Historical volatility is calculated by the ordinary variance formula.

After obtaining volatility measures for each stock at both exchanges we calculate the differences between the two exchanges according to the primary hypothesis. We can then test whether significant differences in volatility are present. In accordance with our second hypothesis, we test if the difference in mean volatility is significant for all companies in the sample jointly. These two tests are conducted for the volatility obtained from the EGARCH model as well as the historical volatility.

To obtain an overview of the results and see patterns we run an OLS regression (outside the main study) between the volatility in Frankfurt and the volatility in Stockholm, with the EGARCH model volatility. We use the underlying stock's volatility as the dependent variable, since it is listed on the home market. From the regressions we collect the beta values for each company.

When having a result over volatility differences, is it necessary to account for the returns to investigate if there is consistency in the relationship between the return for both exchanges. We start by calculating the difference in returns and test if they are jointly significant different from zero in mean. This is tested by hypothesis 3.

To get a comparable measure and find out if the returns in relative terms differ between the exchanges, we calculate a return-volatility-ratio which gives us a measure of the "risk-adjusted return." The calculated differences between the exchanges are tested according to hypothesis 4. This test tells us if the differences in volatility are reflected in the returns.

After these four hypothesis tests we analyze the results using a theory framework.

2.6 Reliability and Validity

The quality of the essay depends on its relation to the reliability and validity of the empirical tests. The essence for this study is to measure the volatility, which means that it is of importance to focus on how to obtain an accurate method if estimating volatility.

The reliability of this essay is depending on that we capture the "true" volatility by using the EGARCH model. Since the EGARCH model accounts for time-varying volatility and captures clustering effects in volatility, we have chosen a model which enables us to estimate volatility with a high level of accuracy. By using this model it is possible to repeat and imitate this study at any time by any researcher. We remove randomness in our study, as we have an estimation period of eight years which includes the full business cycle. The forecasts consist of two years of daily data. Further, we use relatively large and established companies for our study and therefore eliminate noise associated with small cap stocks.

The problem faced related to validity is that we have a limitation on how many units we can use in a possible general conclusion. We have limited our sample to consist of Swedish stocks cross listed on FWB. Thus, our sample consisting of 14 stocks might seem small which could have implications for drawing significant conclusions from our study. However, by limiting the study to examine Swedish cross listed stocks in Frankfurt we also reduce noise associated with differences in opening hours between exchanges. On the individual firm level we have more than enough data to confidently draw conclusions from our results. Thus, an average of the individual firm data will give us a reasonable result in our joint test, despite the lack of firms.

3. Theoretical Framework and Previous Research

This chapter describes the theoretical framework on which this essay is based on. It is the theories used to explain and understand the results of the study. We are going to present the law of one price theory (LOP) and the efficient market hypothesis. In addition to this we also present some theories as possible explanations for differences in volatility.

3.1 The Law of One Price

The *LOP* is a proposition regarding prices in different countries taking the exchange rate into account. There are a few assumptions to the *LOP*, first the free market have no transportation costs and no official barriers to trade. This proposition says that identical goods should be sold at the same price in different countries when the price is expressed in same currency. We can formulate the *LOP* as following.[21]

$$P^i_{Germany} = X_{€/SEK} * P^i_{Sweden} \tag{4}$$

Where:

$P^i_{Germany}$ is the price in Germany.

P^i_{Sweden} is the price in Sweden.

$X_{€/SEK}$ is the Euro/SEK exchange rate.

The exchange rate can be written as below from the formula above.

$$X_{€/SEK} = \frac{P^i_{Germany}}{P^i_{Sweden}} \tag{5}$$

[21] Krugman Paul & Maurice Obstfeld, (2009), *International Economics: Theory and Policy* (Boston, Pearson education inc.), s.384

The LOP is useful for us when we expect the prices, of the same stock on different exchanges, to be the same. This is a fundamental theory for us when looking at the volatility that we expect to be equal for each firm's stock at the two different exchanges.

3.2 Efficient Market Hypothesis

The basic theoretical framework for the essay is based on the Efficient Market Hypothesis (EMH). Where prices in an efficient capital market reflect all available information. This is discussed by Fama and French from the early 60's. They find that the efficiency of a market can be categorized into three categories, weak, semi-strong and strong efficiency. Using the understanding of efficient market hypothesis we can follow up to study the *LOP,* which is of real importance when looking at cross-listed stocks.[22]

3.4 Market microstructure

In his 2005 survey, Madhavan defines market microstructure as "th*e area of finance examines the process by which investors' latent demands are ultimately translated into transactions."*[23] Simply put, market microstructure deals with the design and properties of markets and resulting implications. According to Campbell et al., *"the very process of trading can have an important impact on the statistical properties of asset returns."*[24] Madhavan classifies previous research on the topic of market microstructure into four categories: (1) Price formation and price discovery, (2) Market structure and design issues, (3) Information and disclosure, (4) Informational issues arising from the interface of market microstructure with other areas of finance.[25]

For the purpose of this study we are focusing on some particular characteristics of mechanics and design of markets, categories (1) and (2). Of particular interest is the bid-ask spread as it may cause spurious volatility in returns. Furthermore, we will discuss the price

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[22] Elton Edwin J, Gruber Martin J, Brown Stephen J & William N Goetzmann (2007) *Modern Portfolio Theory and Investment Analysis* (Hoboken, John Wiley & Sons Inc.) s.402

[23] Madhavan Ananth (2000), "Market microstructure: A survey," in *Journal of Financial Markets 3,* pp. 205-258.

[24] Campbell John Y., Andrew W. Lo, A. & Craig MacKinlay, (1997), "the Econometrics of Financial Markets," (New Jersey, *Princeton University Press)*

[25] Madhavan (2000).

discovery process and whether it takes place on SSB or FWB, and its potential implications on volatility of DRs and underlying stocks.

According to Comerton-Forde & Rydge, there has been a convergence in trading structure across the largest and most influential global stock markets. They further claim that the change has been driven by technological developments and the demands of institutional investors.[26] SSB and FWB are similar in their structure to the extent that they operate hybrid trading systems, meaning that trading is conducted through electronic trading systems as well as floor trading and trading through designated market makers. The majority of trading at the exchanges is processed through their respective electronic trading systems, SAXESS and XETRA. Comerton–Forde & Rydge considers both SSB and FWB "influential stock markets" however, FWB is considered the world's second largest stock exchange after the NYSE.[27]

Trading mechanisms, rules and design of stock exchanges are complex and to provide an in depth explanation of the structure of SSB and FWB would go beyond the scope of this paper. To investigate and link differences in volatility between SSB and FWB exchange structure and design would be a topic for future research.

3.4.2 Bid-Ask Spread

According to Campbell et al. "*one of the most important characteristics that investors look for in an organized financial market is liquidity, the ability to buy or sell significant quantities of a security quickly, anonymously, and with relatively little price impact*."[28] To ensure market liquidity most exchanges have designated market makers. Market makers buy when investors want to sell and sell when they want to buy. For providing liquidity market makers obtain monopoly rights on price differential. They sell at ask price and buy at bid price. The bid-ask spread can then be interpreted as measure of liquidity of a financial market.

[26] Carole Comerton-Forde and James Rydge, (2004), "A Review of Stock Market Microstructure," Supported by Capital Markets CRC Limited. SIRCA.
[27] Comerton-Forde and Rydge, (2004).
[28] Campbell et al. (1997)

Campbell et al. mentions three primary economic sources of the bid-ask spread:

- Order processing costs: operating costs of trading and record keeping.

- Inventory costs: costs associated with holding undesired inventory subject to risk.

- Adverse selection costs: costs resulting from information asymmetry between informed traders and market makers. The responsibility of market makers is to provide liquidity and trade with whomever desires to do so. Informed traders might have an informational advantage on market makers. Market makers will then on average lose from trading with informed traders and must be compensated accordingly. Thus, as market makers can't distinguish between informed and uniformed traders a portion of the bid-ask spread can be viewed as a compensation of taking the losing side of a trade with informed traders.

The recent literature on the bid-ask spread has focused on the adverse selection component. For example, Glosten & Milgrom showed in their 1985 paper that "*adverse selection, by itself, can account for the existence of a spread between the ask and bid prices."*[29] Menyah & Paudyal (2000) investigated the components of the bid-ask spread on the London Stock Exchange and found evidence in line with Glosten & Milgrom. They showed that on average 30 percent of the spread is order processing cost, 23 percent is inventory cost and 47 percent is adverse selection costs stemming from asymmetric information.[30] Earlier research, by e.g. Ho & Stoll (1981) and Amihud & Mendelson (1980) have focused on the management of inventory of a market maker and the consequences on the bid-ask spread. Furthermore, Shen & Ross (2002) showed that there is an evident relationship between the spread and inventory costs; "*market liquidity decreases (spread increases) with increasing absolute value of market makers' security inventories*."[31]

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[29] Glosten Lawrence R. & Paul R. Milgrom, (1985), "BID, ASK AND TRANSACTION PRICES IN A SPECIALIST MARKET WITH HETEROGENOUSLY INFORMED TRADERS," in *Journal of Financial Economics, 14,* pp. 71-100.

[30] Menyah Kojo & Krishna Paudyal, (2000), "The components of bid-ask spreads on the London Stock Exchange," in *Journal of Banking & Finance, 24*, pp. 1767-1785.

[31] Shen Pu & Ross M. Starr, (2002), "Market-makers' supply and pricing of financial market liquidity," in *Economics Letters, 76*, pp. 53-58.

Roll (1984) showed that the existence of designated market makers and the bid-ask spread can cause spurious volatility and serial correlation in returns. For the purpose of this paper, the spreads impact on volatility is the focus. Roll states that we might think of the value of an asset as the center of the spread. When news arrives at the market the bid and ask prices fluctuate and the average is still the equilibrium value. However, observed market price changes are no longer independent as the transactions occur at either the ask or bide prices, not the average, causing the price to bounce between bid and ask even if the economic value of the security is constant. Roll proposes a simple model where all transactions are with the market maker and the spread remains constant at *s*.[32] We are replicating the model of Campbell et al. (1997) which is grounded on the original model of Roll (1984).

If the fundamental value of a security in a frictionless market is denoted by P_t^* at time *t,* the observed market price, P_t, can be expressed as below.

$$P_t = P_t^* + I_t \frac{s}{2} \tag{6}$$

$$I_t \ \ IID \begin{cases} +1 \ with \ probability \ \frac{1}{2} \ (buyer \ initiated) \\ -1 \ with \ probability \ \frac{1}{2} \ (seller - initiated) \end{cases}$$

Where I_t is and order type indicator, indicating whether the transaction is at the ask or bid price. The expected value of I_t is zero as P_t^* is the fundamental value of the security. If the fundamental value of the security remains constant through time, the following process describes the change in price.

$$\Delta P_t = P_t^* + (I_t - I_{t-1}) \frac{s}{2} = (I_t - I_{t-1}) \frac{s}{2} \tag{7}$$

[32] Roll Richard, (1984), "A simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market," in *The Journal of Finance, 39,* pp. 1127-1139.

The variance of the observed price change is then defined as below.

$$
\begin{aligned}
var[\Delta P_t] &= E\left[\left((I_t - I_{t-1})\frac{s}{2}\right)^2\right] - \left(E\left[(I_t - I_{t-1})\frac{s^2}{2}\right]\right)^2 \\
&= \frac{s^2}{4}E[(I_t - I_{t-1})^2] \\
&= \frac{s^2}{4}(E[I_t^2] + E[I_{t-1}^2]) \\
&= \frac{s^2}{2} \qquad (8)
\end{aligned}
$$

Even though the fundamental price of the security is fixed, variance increases with the size of the spread.

3.4.3 Price discovery

When new information arrives at the market, buyers and sellers interact to determine the equilibrium price of a security. This dynamic is known as the price discovery process and is defined by Hasbrouck (1995) as "*the impounding of new information into security prices*."[33] Furthermore, Walsh (1997) asserts that *"the price discovery process is the microstructure study of market efficiency."*[34]

There is differing opinions as to where price discovery occurs for cross listed stocks. For example, Hasbrouck (1995) conducts a study on securities traded in multiple markets. The results suggest that price discovery is concentrated to the home market.[35] Pérez Aquino and Poshakwale found that *"movements in the underlying shares are the most influential factor affecting ADR prices."*[36] In contrast, findings of Wu & Xu (2000) indicates that there is a significant correlation between volatility and trading volume and markets with higher volume

[33] Hasbrouck, Joel, (1995), "One security, Many Markets: Determining the Contributions to Price Discovery,"in *The Journal of Finance, 50,* pp. 1175-1199.
[34] Walsh, David M., (1997), "Price reaction to order flow 'news' in Australian equities," in *Pacific-Basin Journal, 5*, pp. 1-23.
[35] Hasbrouck, (1995)
[36] Pérez Aquino, Katty & Poshakwale, Sunil, (2006), "Price determinants of American Depositary Receipts (ADR): a cross-sectional analysis of panel data," in *Applied FinancialEconomics*, 16, pp. 1225-1237.

contribute more to price discovery.[37] Furthermore, Phylaktis & Manalis (2005) found that price discovery for Greek stocks, traded in Greece and Germany, took place in Germany.

3.4.4 Investors

Investors on financial markets differ in characteristics and objectives of their investments. As Citanna et al. (2005) puts it:

> *"The basic idea is well-known: when financial markets are incomplete, risk averse individuals cannot perfectly smooth consumption across time and states. Heterogeneity across individuals makes wealth distribution matter even though aggregate wealth does not vary across states. This causes fluctuations in aggregate endogenous variables across states of the world, or over time, and asset prices show excess volatility."*[38]

There are two broad definitions of investors on equity markets; institutional and individual investors. Institutional investors are i.e. banks, pension funds and hedge funds. Individual- or retail investors could be classified as anyone investing on their own behalf, independently from an institution. It is intuitive that these two types of investors have different objectives and capabilities when it comes to investing. As documented by several empirical studies, e.g. Bae et al. (2008) and Odean (1998), individual investors tend to trade in a contrarian fashion.[39] Institutional investors, on the contrary, engage in momentum trading. In their study on mutual fund stock purchasing strategies, Grinblatt et al. (1995) found that *"77 percent of the mutual funds were 'momentum investors,' buying stocks that were past winners."*[40]

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[37] Chnuchi Wu and Xiaqing Eleanor Xu, (2000), "Return Volatility, Trading Imbalance and the Information Content of Volume," *Review of Quantitative Finance and Accounting, 14,* pp. 131-153.
[38] Citanna A & K Schmedders (2005) "Excess price volatility and financial innovation*",* In *Economic theory*, 26,
[39] Bae, Kee-Hong, Yamada, Takeshi and Ito, Keiichi, (2008), *"Interaction of investor trades and market volatility: Evidence from the Tokyo Stock Exchange,"* Pacific-Basin Financial Journal, 16, pp. 370-388.
Odean, Terrance, (1998), *"Are Investors Reluctant to Realize Their Losses?,"* The Journal of Finance, 53, pp. 1775-1798.
[40] Grinblatt, Mark, Titman, Sheridan and Vermers, Russ, (1995), *"Momentum Investment Strategies, Portfolio Performance, and Herding: A Study of Mutual Fund Behavior,"* The American Economic Association, 85, pp. 1088-1105.

The different trading patterns of various investor types affect volatility on equity markets. Bae et al. found evidence consistent with this notion in their 2008 study and showed that "*market volatility increases by more than 50% from the average level when there are greater buy trades by momentum investors that demand liquidity and there are less trades by contrarian (or profit-taking) investors that supply liquidity*."[41]

Friedman (1953) proposed the rational speculation hypothesis. He argues that rational investors attempt to buy assets at a low price and sell at a higher price to make profits.[42] Thus, speculators help keeping markets in check, ensuring that prices do not deviate from fundamentals. In contrast to the rational speculation hypothesis, Hart and Kreps (1986) suggest that speculators can in fact destabilize markets when they are faced with the pressure of inventory.[43] When prices drop and inventory is high speculators will sell to reduce their inventory which might lead to further price drops and destabilization of the market.

Hsin et al. (2003) examine the impact of speculative trading on the Taiwanese Stock Exchange and find mixed results on the impact of speculative traders on return volatility. According to their results, speculative day trading increases the intraday price volatility, which is consistent with the inventory hypothesis. However, they also show that an increasing level of margin debt, which measures the accumulative level of speculative trades, reduce volatility, confirming the rational speculation hypothesis.[44]

To sum up, investor type and behavior can have a material effect on the volatility in stock markets.

3.4.5. Other Factors Affecting Volatility of Stock Returns

There are some other important factors influencing volatility that has to be accounted for in this paper to properly explain for volatility differences, e.g. the relationship between trading volume and volatility and the impact of market anomalies. Ying (1966) finds that higher trading volume results in higher return volatility. Karpoff (1987) shows that there is a positive relationship between trading volume and volatility that holds over different holding period horizons, for individual equities as well as indexes. Furthermore, Wang et al. (2005) study the relationship between information flow and return volatility and conclude that volatility and

[41] Bae et al. (2008)
[42] M.J. Friedman, *Essays in positive economics.* , Univ. Chicago Press, Chicago (1953), 1970, pp. 3-43.
[43] O.D. Hart and M.D. Kreps, Price destabilizing speculation. *Journal of Political Economy* **94** (1986), pp. 927–953.
[44] Chin-Wen Hsin, Wen-Chung Guo, Seng-Su Tseng and Wen-Chih Luo, (2003), *the ipact of speculative trading on stock return volatility: the evidence from Taiwan."* Global Finance Journal, 14, pp. 243-270.

trading volume are driven by the same underlying latent information flow variable and should be positively correlated.[45]

Stock market anomalies, such as the January effect, have been documented and these anomalies might have an effect on return volatilities. Keim (1983) found evidence of a January effect for common stocks trading on the NYSE and AMEX.[46] Arsad et al. (1997) finds evidence consistent with Keim's conclusions on the London Stock Exchange. Chen et al. (1997) study a sample of US assets, including stocks, over the period 1926-1990 and find evidence of a January effect on returns.

The compositions of domestic industries vary across nations and the industrial structure is mirrored in stock markets. Roll (1992) notes that there are large differences in volatility across equity markets and provides as a possible explanations differences in the country's industrial structure.[47] Furthermore, in his 2004 study, Xing investigates the time-series relationship between market industry concentration and market volatility on 21 developed markets. He finds that the relationship is significant and positive in 61 percent of the markets.[48]

[45] Ping Wang, Peije Wang and Aying Liu, (2005), "Stock Return Volatility and Trading Volume: Evidence From the Chinese Stock Market," Journal of Chinese Economic and Business Studies, 3, pp. 39-54.
[46] Donald B. Keim, (1983), "SIZE-RELATED ANOMALIES AND STOCK RETURN SEASONALITY," Journal of Financial Economics, 12, pp. 13-32.
[47] Richard Roll, (1992), "Industrial Structure and the Comparative Behavior of International Stock Market Indices," *the Journal of Finance, 47, pp. 3-41.*
[48] Xuejing Xing, (2004), "A note on the time-series relationship between market industry concentration and market volatility," *Journal of International Financial Markets, 14, pp. 105-115.*

4. Result & Analysis

In this chapter we present the results from the earlier described empirical study. We systematically describe and analyze the results and later in the section we give a couple of different theoretical explanations for the results obtained from the study.

4.1 Results

As mentioned before an EGARCH model is used for the volatility estimation. After estimating a volatility measure for our forecast period of two years, we calculate the differences between the underlying stocks and their corresponding DRs as indicated by hypothesis 1.

Below is a table with the volatilities for the different exchanges and the difference between them for all stocks. We observe that the volatility is higher at FWB for all stocks in the sample. Furthermore, the t-statistics and the corresponding p-value is displayed, these are based on our primary hypothesis which is described in 2.6 Hypotheses.

Table 1. The result from the EGARCH model estimation

	Stockholm	Frankfurt	Difference	standard deviation	t-statistics	P-value
Atlas Copco	0,00048	0,00080	-0,00032	0,00020	-1,64807	0,09934
Electrolux	0,00057	0,00088	-0,00031	0,00017	-1,80954	0,07036
Ericson	0,00047	0,00053	-0,00006	0,00009	-0,67624	0,49888
H&M	0,00026	0,00033	-0,00007	0,00005	-1,43164	0,15224
Hexagon	0,00064	0,00099	-0,00035	0,00035	-1,01441	0,31038
Husqvarna	0,00048	0,00084	-0,00036	0,00020	-1,78535	0,0742
Lundin	0,00072	0,00088	-0,00016	0,00029	-0,54512	0,58568
Sandvik	0,00052	0,00086	-0,00034	0,00026	-1,29780	0,19436
Scania	0,00052	0,00086	-0,00034	0,00026	-1,29780	0,19436
Skanska	0,00032	0,00059	-0,00027	0,00012	-2,23775	0,02524
SKF	0,00039	0,00073	-0,00035	0,00015	-2,33515	0,01954
SSAB	0,00057	0,00093	-0,00036	0,00047	-0,77632	0,43756
Swedish Match	0,00017	0,00052	-0,00035	0,00014	-2,46933	0,01354
Volvo	0,00050	0,00076	-0,00026	0,00027	-0,94438	0,34498

From table 1 we note that the volatility in FWB is consistently higher than in SSB. Even though we can't say that this difference is significant for all companies, it is undoubtedly an obvious pattern. This results gives us an indication that the LOP does not hold for Swedish cross-listed firms on FWB. It leads us to test if this holds in general by taking the average of difference and make a jointly significance test.

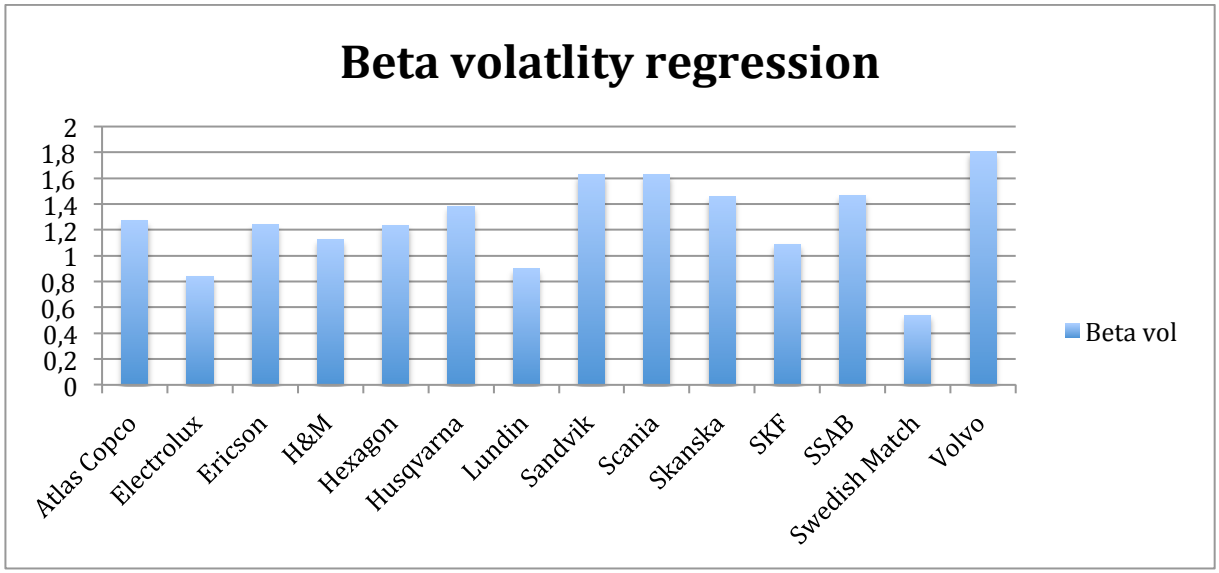
Table 2. Joint test on EGARCH volatility.

Mean value Differences	-0,00028
Std. In differences	0,00011
T-statistics	-2,64282
P-value	0,00822

The results from testing hypothesis 2 are presented in table 3. A joint test for all stocks and DRs were conducted and we can conclude that the differences are significantly different from zero. From this result we can draw the conclusion that in general the volatility, as estimated by the EGARCH model, is higher in Frankfurt than on SSB for Swedish cross-listed firms. These results confirm the patterns we saw at the individual firm level. Hence, our results provide strong evidence for a higher volatility in FWB.

To illustrate our result we run OLS regressions on each stock, with the volatility of the underlying DRs as the dependent variable. The betas from these regressions are presented in graph 1 below.

Graph 1. Betas from OLS regression between the two exchanges' volatility, FWB DRs as dependent variable.



As we can see are almost every beta above one, and the mean value for all companies are 1,26, which indicates that the FWB volatility is in mean explained by 126 percent of the SSB volatility. We interpret this as DRs listed on FWB respond stronger to market information.

Table 3. Mean values for Beta estimation from OLS regressions.

Mean beta volatility	1,257578286
Mean beta returns	0,531239214

To confirm our results and test the validity of our approach we also calculate the volatility as the historical variance of returns, and consequently calculate the differences for the different exchanges. The result from these calculations can be viewed below in table 4.

Table 4. Historical volatilities result.

	Stockholm	**Frankfurt**	**Difference**
Atlas Copco	0,00047	0,00069	-0,00021
Electrolux	0,00054	0,00088	-0,00035
Ericson	0,00030	0,00038	-0,00008
H&M	0,00022	0,00031	-0,00010
Hexagon	0,00065	0,00108	-0,00043
Husqvarna	0,00044	0,00075	-0,00031
Lundin	0,00056	0,00079	-0,00022
Sandvik	0,00053	0,00078	-0,00025
Scania	0,00053	0,00078	-0,00025
Skanska	0,00026	0,00047	-0,00021
SKF	0,00039	0,00078	-0,00039
SSAB	0,00048	0,00072	-0,00024
Swedish Match	0,00014	0,00046	-0,00032
Volvo	0,00048	0,00069	-0,00021

As evident from table 4 the difference using historical volatility estimation also results in negative values for all firms, which means that we have a higher volatility on the FWB than on SSB. We perform a joint test as when testing hypothesis 2 and find that the difference in mean is significantly different from zero as you can se in table 5 below.

Table 5. Joint test on historical volatilities.

Mean value Differences	-0,00024
Std. In differences	0,00010
T-statistics	-2,46365
P-value	0,01376

The results from the historical volatility confirm the result we got from the EGARCH volatility estimation. Thus, using the historical volatility approach to estimate volatility, we find evidence consistent with previous results using the EGARCH model – there are differences in volatility for Swedish cross-listed firms between SSB exchange and FWB exchange.

To investigate whether the higher volatility in Frankfurt simply is an effect of higher expected return we study the returns for the two exchanges for each stock in the sample. The notion that return should be higher in Frankfurt as an effect of higher volatility seems reasonable according to risk-return relationships such as the Sharpe-ratio proposed by William F. Sharpe (1966).[49]

We calculate the expected returns for the same period as the EGARCH (2009-04-15 – 2011-04-14), by taking the mean value of the daily returns. The expected returns for both exchanges and the difference between them are listed in table 6.

Table 6. Daily returns in mean for both exchanges.

	Stockholm	**Frankfurt**	**Difference**
Atlas Copco	0,00161	0,00195	-0,00034
Electrolux	0,00140	0,00170	-0,00030
Ericson	0,00006	0,00045	-0,00039
H&M	0,00048	0,00087	-0,00038
Hexagon	0,00222	0,00270	-0,00048
Husqvarna	0,00057	0,00094	-0,00036
Lundin	0,00156	0,00194	-0,00039
Sandvik	0,00150	0,00195	-0,00046
Scania	0,00150	0,00195	-0,00046
Skanska	0,00102	0,00140	-0,00038
SKF	0,00144	0,00180	-0,00036
SSAB	0,00037	0,00077	-0,00040
Swedish Match	0,00108	0,00151	-0,00043
Volvo	0,00135	0,00174	-0,00039

[49] William F. Sharpe, (1964), "Mutual Fund Performance," *The Journal of Business, 39,* pp. 119-138.

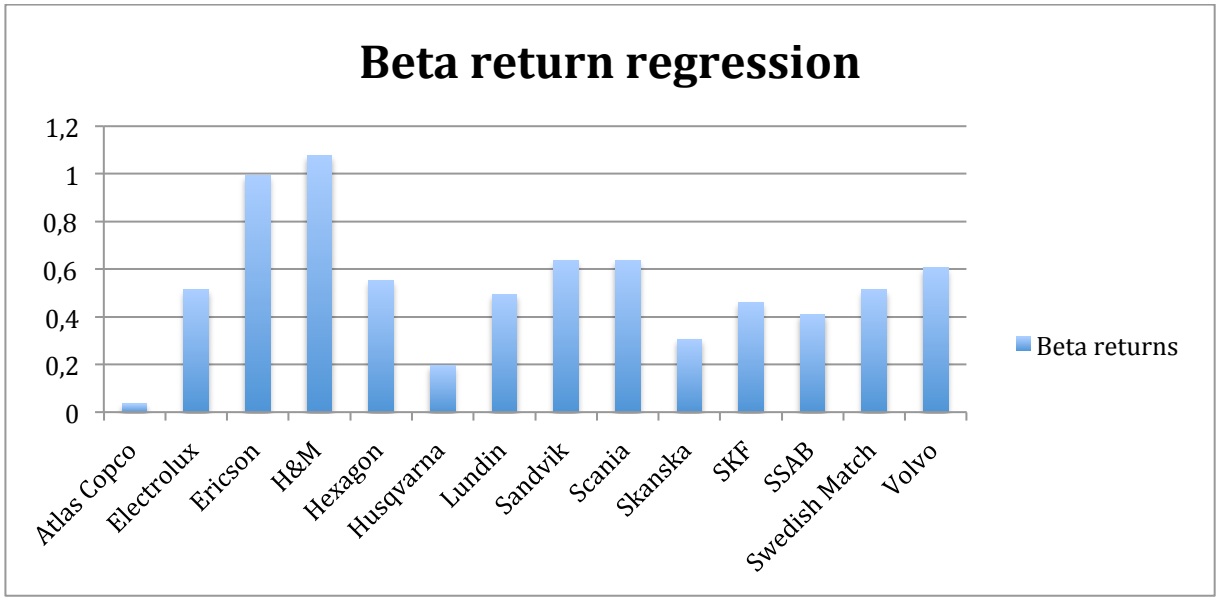
From table 6 we can observe that return is indeed larger in Frankfurt for all firms. After performing a joint test for the differences, we can find out if they are significantly different from zero (table 7). Thus, we reject he null hypothesis associated with our third hypothesis, that returns are equal for SSB and FWB.

Table 7. Statistic test of return differences.

Mean value Differences in returns	-0,00039
Std. In differences	0,00005
T-statistics	-8,21018
P-value	0,00000

The result from the hypothesis test above clearly indicates that the expected return on the FWB is significantly higher than on SSB. To get a better idea about our return data we run an OLS regression on the returns from the two exchanges, with the DR return on FWB as the dependent. We can now view the relationship between the exchanges for the cross-listed firms from a different perspective.

Graph 2. Betas from OLS regression between the two exchanges returns, FWB DRs as dependent variables.



In graph 2 the beta values from the regressions between the underlying instrument and the DRs are displayed. As we can see the betas vary a great deal for the different companies, but they are in general below 1. The mean value for the betas, from table 3, is 0,53 which tells us that the return in Frankfurt is in mean effected by returns on SSB, but not to 100 percent. There is something in the FWB return that is explained by some other variable or noise.

After establishing that both expected return and volatility is higher in Frankfurt we further investigate mean return, and specifically if it is proportionally larger in relationship to its higher volatility. To test our fourth hypothesis we calculate a ratio between the return and the variance for each stock, using EGARCH and historical volatility estimations.

Below is a graph for the differences in volatility adjusted returns between the two exchanges. As we can see is the difference positive for all stocks for the EGARCH model and it varies for the historical volatility, but have a positive mean value as you can see in table 8. This result tells us that volatility adjusted returns are higher in Stockholm. Thus, the higher expected return in Frankfurt does not compensate for the higher volatility of stock returns.

Graph 3. Differences in return-volatility-ratio between the two exchanges.

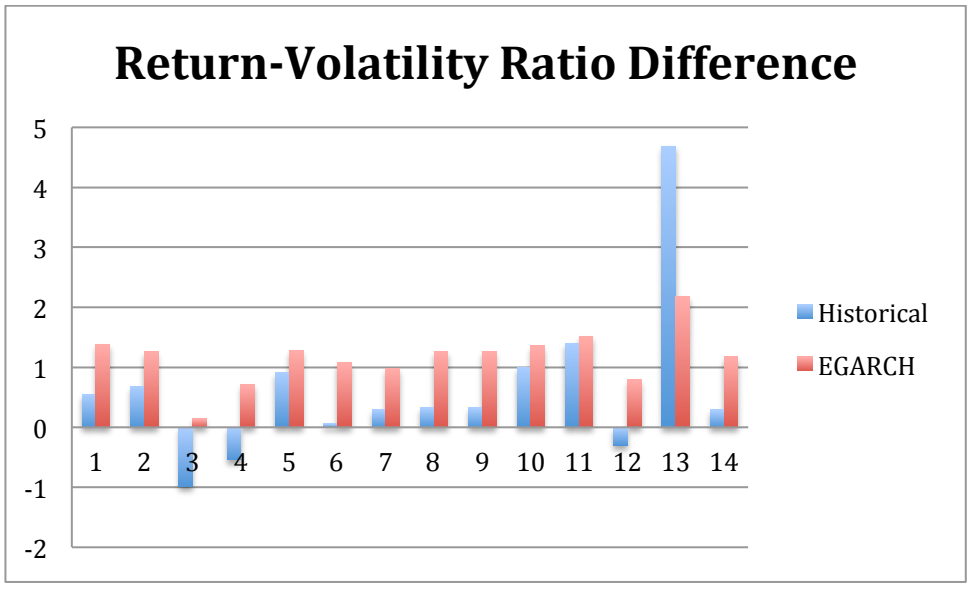


Table 8. Joint test for the return-volatility ratio for both historical and EGARCH volatility

	Historical	**EGARCH**
Mean value Differences	0,30927	1,093085558
Std. In differences	0,64910	0,3662172
T-statistics	-0,47646	-2,98480
P-value	0,63374	0,00284

From table 8 can we se that we got significant result for the EGARCH but not for the historical volatility. It is possible that we experience one of the drawbacks of the historical volatility, specifically the non-time-varying property.

To sum up our result, our empirical testing indicates that the volatility is higher for cross-listed firms in a foreign market. We find in our result, where we focus on Swedish firms cross listed at the FWB, that the volatility is generally higher in Frankfurt than in Stockholm. This difference in mean in volatility is also significantly different from zero as proven by a joint test. Volatility for the individual stocks is not consistently significantly higher, but we find the difference negative for every stock which shows a strong pattern. The higher returns in Frankfurt do not compensate for the higher variation as evident from the volatility-adjusted measure.

According to economic theories such as the efficient market hypothesis and the LOP, this kind on patterns in differences should not exist. We will analyze economic concepts further to look for theoretical explanations for our findings.

4.2 Analysis

The purpose of this study is to measure differences in volatility between DRs of Swedish stocks traded on FWB and their underlying stocks trading in SSB. As evident from our results, we can identify a difference in volatility and return between the exchanges in Stockholm and Frankfurt. We also find that higher return does not compensate the higher volatility, as it should. These findings are in contrast to the efficient market hypothesis and the LOP theory, which has to have an explanation, because of the significant pattern that we find. In the following part we present some reasons that could explain the, according to our hypotheses, unexpected results.

4.2.1 Market Microstructure

4.2.1.1. Bid-Ask Spread

Comerton-Forde & Rydge mention that there has been a convergence in trading mechanisms across exchanges.[50] SSB and FWB exchanges are in many ways similar in structure except that FWB is much larger than SSB. Both exchanges have fully automated order driven trading systems, XETRA in Frankfurt and SAXESS in Stockholm, through which the bulk of trades are conducted. We find it unlikely that differences in inventory holding- and order processing costs for market makers should differ between DRs and underlying shares.

As mentioned in the theoretical framework section, the adverse selection component of the bid-ask spread exists because of the fact that market makers can't distinguish between informed and uniformed traders. This portion of the spread can be viewed as a compensation for taking the losing side of a trade with informed traders. Adverse selections costs makes up a material part of the spread as proved by Menyah & Paudyal. If the amount of informed traders increases the spread should increase as a consequence. Furthermore, if the share of informed traders trading in a DR on FWB versus an underlying share in a particular Swedish company is significantly different, the spread and hence the volatility, could differ between the two instruments.

We have not been able to find any empirical evidence suggesting that inventory-, order processing- and adverse selection costs should differ between SSB and FWB and neither does our study provide any direction on the matter. However, if spreads were found to be different between SSB and FWB it could further be analyzed as a cause of discrepancies in volatility.

4.2.1.2. Price Discovery

There are different opinions about where the price discovery process takes place for cross listed stocks. Hasbrouck suggested that price discovery is concentrated to the home market. However, Wu and Xu shows that return volatility is significantly correlated with trading volume and suggest that this is an indication of price discovery concentrating in more heavily traded stocks. Hence, if DRs on the FWB are traded more heavily than the underlying shares in Stockholm price discovery might be concentrated to FWB. Therefore, price discovery as

[50] Comerton-Forde and Rydge (2004).

indicated by trading volume could help to provide a part of the explanation for differences in volatility of Swedish stocks cross listed in Frankfurt.

The market where the price discovery happens leads the other markets. If we assume that price discovery is concentrated to the home market (SSB) then the investors of DRs of Swedish companies listed on the FWB trade on a combination of price changes on SSB and their own subjective perception of information. However, our study does not provide any direction on where price discovery for DRs and their underlying stocks occur. For all we know price discovery could be shifted occasionally between the two exchanges and at any point in time FWB could be the leading market. We believe that the price discovery process could help explain differences in volatility between Swedish SSB shares and FWB DRs to some extent as the direction of information flow is more complex and investors to some extent have more information to trade on which then impacts prices and volatility.

4.2.2 Investors

As we discuss in 3.4.4 so is the investors a reason to the volatility. Like Bae et al draw the conclusion that "*market volatility increases by more than 50% from the average level when there are greater buy trades by momentum investors that demand liquidity and there are less trades by contrarian (or profit-taking) investors that supply liquidity*"[51], they found a difference between individual and institutional investors. Which make us think that a reason could be that, we have different kind of investors at the two exchanges that we study. This is not anything that we can prove, but we believe that it is reasonable to believe that there are not exactly the same investors at the different exchanges. So we can't exclude this explanation and it could be examined by study the composition of investors at each exchange.

Hart & Kreps separate the different investors into speculators or not in there inventory hypothesis. They are finding that the level of speculator impacts the market in the way that the volatility increases. This can as in the individual/institutional investor case draw the same conclusion, that the level of speculators on the two exchanges probably isn't exactly the same. Which will lead to a reasonable explanation to our volatility difference. Hsin et al find in the same way that the speculative day trading increases the intra day volatility in consistency with

[51] Bae et al (2008)

inventory hypothesis. They also find that tan increase level of margin debt will decrease the volatility, which verifies Friedman's rational speculator hypothesis. This could in the same way explain the differences in volatility.

Our individual reflections about the different types of investors

With out any deeper research or intention to tell the truth here, are we going to present our intuitive feeling how the investors can differs between the two markets. An Idea is that there are a larger part of emotional investors of Swedish companies in Sweden than in Germany on Swedish companies. It could also be so that we have more strategic investors in Sweden that care about the companies and the Swedish industry than in Germany. In contraire to Sweden could you maybe say that German investors in general are more likely to focus on returns than for development and industrial goals for Sweden.

An example is the Swedish company Investor, that put money in to for example Swedish companies for more than the short perspective expected return, they looking for a long-term solution by taking an active investment role. You could assume that this kind of behavior is more common for Swedish companies in Sweden, and in Germany are these investors investing in German companies in corresponding way.

If it relates in this way, so are the explanations about the investors effect on the volatility, a reasonable explanation.

4.2.3 Other Factors Affecting Volatility

Here we present a couple of theories, which relate to each other, under the name other factors affecting volatility.

As both Ying and Karpoff finds, that the volatility depends on trading volume. They mean that the volatility goes up with the traded volume. Without any research on this, can we say that it is absolutely possible that the trading volume is different on in our case with the Stockholm and Frankfurt exchanges. They are possibly more likely to be different then being equal to each other. According to this assumption can we not say that this is not an explanation, to our result. It is an explanation that could be tested by running a regression between the traded volume and the differences in volatility.

The January effect could as well be a reason to differences that we observe. Like Keim, Arsard et al, etc finds that the January effect have an impact on the volatility. It is possible to think that this together with other market anomalies affects the volatility on both Exchanges that we have focused on in our essay. But to explain the differences, these anomalies have to be different or affect the different exchanges differently. It is highly likely that they do not, what we mean is that what ever that cause the January effect and other anomalies, so should not that be the same. For example if the January effect causes of the liquidity on the exchange or stock, so is the liquidity possibly different at different exchanges at the same time. By this argument can we not neglect this as a possible explanation, but it is also difficult to prove in a future research.

Roll means that the industrial composition varies along different nations and that this mirrors in the stock market. This together with that Xing finds a significant relationship between industry concentration and market volatility, makes a reasonable explanation to the differences we observes. As earlier arguments is this thinkable that the industries in Sweden and Germany is different, even thou they are reminding of each other. The truly effect has to be studied secluded, if it has enough impact to make such patterns as we have viewed in our essay. But we can not exclude it as explanation at this point, it has possibly a small effect. This is as the previous explanation quite hard to test in a future study, but therefor not said that it is not true.

According to our own observations about the composition of the different industries, we note one similarity between Sweden and Germany. Most of the Swedish companies cross listed at FWB are related to engineering and also have several potential competitors listed at the exchange. This could be a result of two countries with related industrial background. Some relevant German competitors are for example Volkswagen, Audi, Mercedes and BMW. They are of course competing with the Swedish companies VOLVO and Scania. Other examples include Siemens, Bosch as competitors for Electrolux, Atlas Copco, Sandvik and Husqvarna. Hence, as Sweden and Germany to some extent have similar industrial compositions this factor should not be a chief cause for differences in volatility.

What we in the other hand thought about is that the industrial compositions could be related to the different kind of investors and their impact on the volatility. The German investors at the FWB face the choice of domestic industry or the cross-listed Swedish competitors.

4.3 Conclusion

In this thesis we examine differences in volatility for a sample of Swedish stocks cross listed on the FWB. In contrast to the Efficient Market Hypothesis and the LOP theory, we find significant differences in volatility between Swedish companies traded on the SSB and DRs traded on FWB, both on an individual and collective basis. In particular, volatility is higher for DRs traded on the FWB. According to our results this finding is not merely a consequence of higher relative expected returns for DRs. In fact, our results indicate that risk adjusted returns are higher in Stockholm. Thus, investors considering investing in Swedish cross-listed companies should evaluate the risk-return relationship between DRs and the home market shares.

We do not simply draw the conclusion that the LOP price is violated or that markets are inefficient but further discuss potential reasons for our results. As mentioned in the previous section there are several theoretical explanations of the differences in volatility between the two instruments. In the theoretical framework we list several potential theories that could have an impact on the volatility.

As Roll points out the spread could have an impact on the volatility of a security even though the fundamental value of the security does not change. In particular, there is a positive relationship between the spread and the volatility of a security. There is no reason to believe that the spread for DRs and the underlying should be significantly different. However, if differences in the spread were to be found, the different components of the spread could be analyzed individually and compared for the DRs and the underlying. We suggest differences in spreads as a reasonable cause for the discrepancies in volatility. Suggestion for future research is to analyze to which extent the spread explains the differences in volatility that we find in this study. This could be tested through a multifactor regression with differences in volatility as the dependent variable and differences in the three components of the spread as independent variables.

It is hard and not our intension to find one and only one explanation to the pattern we witness. We try to give a picture of the possible reasons. In our opinion is the truth probably a mix of these chosen reasons, and other reasons not included in this essay. One way to follow up this result is to select the most likely explanations for differences and run regressions with these reasons as independent variables.

The last explanation that we have not discussed earlier (of obvious reasons) is the possibility that the assumption of that the LOP holds in general is incorrect. It is only under this condition our result becomes unreasonable.

5. Summary

Cross-listing is a way for companies to raise capital in a foreign market. This is achieved by listing Depositary Receipts such as American Depositary Receipts, European Depositary Receipts or Global Depositary Receipts. DRs are financial instruments with a stock as the underlying asset. DRs and their underlying shares represent the same cash flows and could thus be considered to be identical assets. According to the LOP theory the price of the two instruments should be identical.

This lead us to our main question for this essay; are there differences in volatility for DRs at FWB and the underlying share at SSB?

The purpose for this essay is to examine volatility differences, to test the efficient market hypothesis and the LOP. This hypothetical difference will be analyzed by evaluating theoretical reasons.

A limitation for this essay is to focus on Swedish firms that are cross-listed at FWB. By Swedish firms we refer to firms with SSB as the home market. FWB is chosen as we find that it is a very common market to cross-list for Swedish firms. Than we do not want unnecessary noise, so we only want one foreign market to focus on.

Methodology choices we face are to find a volatility estimation technique to capture volatility as accurately as possible. After comparing different measures, we decide to use an EGARCH model that has the GARCH advantages of time-variety volatility and also takes care of non-negativity constraints and asymmetry problems. An ordinary historical volatility measure is calculated as a comparison to the EGARCH.

To eliminate noise we use data within the same time-zone and the same opening hours for the exchanges.

Hypothesis 1 is formulated as there are no differences in volatility for the two stock exchanges, this in consistency with law on one price. As main hypothesis do we look at the companies at individual firm level. For the other following up hypothesis do we in stead focus on differences in general, with average numbers for al companies in the sample. In these hypothesis do we study the volatility in general, then we look at the difference in returns and also difference in a constructed return-volatility ratio.

The essay is implemented by assuming log-normal distributed prices, which results in calculations of continuously compounded returns. The returns are the input in our EGARCH model in Eviews, where we use an eight year estimate period and a two year forecast period,

which are used for the empirical tests. From the outcome from Eviews does we calculate the difference and variance in difference to make it possible to test. From that could we examine the returns and se if they behaved in same way as the volatility patterns. The return and volatility is then calculated to a ratio to view the "risk adjusted" return, to clarify if volatility and return differences is related.

For accomplish as good research as possible is it of importance that we can capture the "true" volatility, which represents it is true value. This is being in mind when we chose our EGARCH, estimation- and forecast period. To ensure to get a reasonable result it is of importance to get as large sample as possible, where we chose the companies that we finds at has there cross-listed share at FWB. A focus on Frankfurt and not add more exchanges is to eliminate noise that could do more harm than good.

The essay has it is theoretical base in Efficient market hypothesis and the law on one price. These are the basic understanding for a comparison between the two Exchanges. The law on one price tell us that a goods price should be the same in different nations adjusted by the exchange rate. According to this should the volatility be the same at both exchanges.

Volatility can be effected by a lot of different things, but what explanations could there be for volatility differences when we are expecting a difference equal to zero. We focus on the bid-ask spread, price discovery, different types of investors, traded volume, January effect and industrial composition.

The result that we can observe is a pattern of a higher volatility at the FWB, this can be seen as the mean value of differences for each company is negative when we subtract the Frankfurt volatility from the Stockholm volatility, which is equal to higher volatility in Frankfurt in average. Even thou that all differences are not significant does it show a clear pattern. In average over all companies do we find that the difference is significant different from zero. When looking at result from the historical volatility, we find the same pattern as for the EGARCH model.

When study the outcome from return differences, we could as our expectations observe that the return at FWB is higher than at SSB in accordance to it is higher volatility. For more correctly comparison do we calculate a return-volatility ratio, for a measure of "risk-adjusted" returns. Like the other test do we calculate the difference for this ratio between the exchanges. Here does the significance differ between the two different volatility measures

(EGARCH and Historical), where EGARCH give us a significant difference between the two exchanges.

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