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Studies of time-series versus cross-sectional correlations in Eastern and Western European stock markets

Abstract

Title   Studies of time-series versus cross-sectional correlations in Eastern and Western European stock markets

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Keywords   Cross-sectional correlation, time-series correlation, Eastern Europe, Western Europe, financial market correction, correlation breakdown

Reducing the risk exposure in investment portfolios is a constant topic in financial literature. This thesis aims to discuss and compare the risk level in portfolios of only Eastern or only Western European market indices by studying the correlation within each one of the portfolios. The correlation is estimated with two different methods: the traditional time-series and Solnik and Roulet's (2000) cross-sectional method. The analysis focuses on how the correlation in each one of the regional portfolios changes over time as well as during a financial market correction.

The study and all calculations are based on historical stock markets indices from September 1997 to February 2007 from five Eastern, forming the Eastern portfolio, and five Western European countries, forming the Western portfolio. A deep-dive is made into a five-month period in 2006 when Sweden saw large drops in its market index and a financial market correction took place.

The results of the time-series method show that the Western European countries are more correlated than the Eastern ones. However, the cross-sectional correlations are almost equal in the two regions, but with the Western portfolio showing higher correlation volatility. Western Europe is therefore considered more risky to invest in from a correlation perspective.

During the financial market correction both regions' data are less significant and the Eastern portfolio's risk exposure is higher than during the full period. During this selected five-month period the Western European portfolio has much larger correlation volatility. There are no signs of correlation breakdown or reversed correlation breakdown.

The cross-sectional correlations have increased over time in both regions; Eastern European markets are slightly less correlated with one another than those in the Western portfolio. Eastern Europe is therefore the region with the lowest risk exposure from a correlation perspective and the best investment portfolio in this study.

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1

Introduction

The first chapter introduces the reader to the topic of the thesis. Further follows a summary of how the study was conducted; including the purpose, questions asked, the methodology and the restrictions needed to be done.

Europe is expanding. Ten Eastern European countries joined the European Union in 2004; another two in 2007 and the borders between the nations of the continent are becoming vaguer and less important. [1] As people as well as governments get closer to each other, money also does. Major investors are looking for greater pay-offs outside the borders of their own countries. The "new" markets in Eastern Europe have become more and more appealing from an investment perspective as they have developed at a rapid pace in the past few decades. The large economic growth that many of these emerging markets have shown has also affected the countries' stock markets, which in turn have grown significantly. In turn, investors have made great profits here. The problem with the Eastern European stock markets is the lack of historical data, which makes all analyses and forecast estimations harder to make. Less precise market predictions lead to risk avert financial actors reluctant to invest in the Eastern market indices. However, there are methods to reduce the risk exposure to investors of these unpredictable markets. One of them is to create investment portfolios of uncorrelated or little correlated stock indices from several different nations. By doing so, the investors reduce their risk exposure compared to if they had invested in one market only.

This thesis aims to discuss the risk level in portfolios of only Eastern or only Western European market indices by studying the correlation within each one of the portfolios. [2] The thesis also aims to compare two different methods for estimating correlations and further to study how the correlations between the indices in the two regional portfolios change during a financial market correction as well as over time.

The main question to be answered throughout the study is whether one of the regional portfolios is less risky than the other one. This question generates several other questions as well: Is the new cross-sectional correlation method preferred to the traditional time-series one? How does the correlation change during the market correction? Are there regional differences? Are there traces

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[1] 2004: Cyprus, Estonia, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Czech Republic and Hungary.
2007: Bulgaria and Romania.
Source: http://europa.eu/abc/european_countries/index_en.htm , 25th August 2007
[2] Each geographical region forms a portfolio of five countries each.
East: Czech Republic, Estonia, Hungary, Poland, Romania.
West: France Germany, Italy, Norway and Sweden.

of correlation breakdown? Does the correlation change over time? Does it change more in one region than another?

Hence, the purpose of the thesis is to investigate whether an investor is better off investing in Eastern or Western Europe considering numerous circumstances.

The data set starts on the 19th of September 1997 and ends on the 7th of February 2007. The time period is set to these specific dates because some of the emerging markets do not have any previous data. Since the data collecting in Datastream occurred on the 8th of February 2007, data could not be gathered after this date either. Although the time frame might seem short, the daily price observations give 2448 returns for each country. The stock market returns are calculated from the daily prices of all countries' general market indices.

The correlation is the risk measurement used in the study and is estimated using a time-series as well as a cross-sectional method. The two ways of measuring the correlation are analysed and compared to each other to see if they show similar results. The cross-sectional method is not as well-known as the time-series, but it has the advantage of being instantaneous and implementing it makes it possible to track changes in the correlation coefficients over time; which is not possible with the time-series method. The cross-sectional correlation is also measured between several markets, whereas the time-series correlation only covers the relationship between two markets.

The regions' correlations are analysed more deeply during a period of five months, starting in May 2006 when Sweden faced a financial market correction, and stretching until September the same year. The financial market correction represents a minor crisis in Western Europe in this thesis. This time period was chosen in order to compare how the correlation reacts within the Eastern and Western European portfolios during a crisis.

The thesis contributes to the financial research with further studies of the cross-sectional correlation, which is still a new method of measuring correlations. This is especially true for emerging markets. The market correction that started in Sweden in May 2006, and its effects on foreign markets, has not been analysed before. Therefore this thesis adds value to the research area of emerging versus developed markets before and during a financial market correction. The topic of the thesis is of interest to all actors on the stock market as well as to financial economists with a broad spectrum of backgrounds and levels of experience.

This first part of the thesis is followed by a section outlining past research conducted in the field. In section 3 the theories and models used in the study are introduced. The data is presented in

section 4, the method in section 5, and the results and analysis are presented in section 6. The thesis is concluded in section 7.

2

Literature Review

Previous studies in the field of correlations in mature and emerging markets are summarised and presented in this section. Some research conducted on stock markets in times of crises is also shown in this chapter.

Studying emerging countries in general, particularly those in Eastern Europe, is not a new practice. In fact, during the last couple of decades several articles have been published where different behaviours of these countries' stock markets have been analysed; such as volatility, responses to external information and risk-return relationships.

Divecha, *Drach* and *Stefek* (1992) studied 23 countries defined as emerging and three as mature, all of them spread around the world, and came to the conclusion that emerging markets have higher stock return volatility than mature markets. High stock return volatility generally mean high risk exposure for the investors, but Divecha et al also saw that the correlation between the two kinds of countries' stock markets was low. The same was said for the correlation between different emerging countries, [3] while the relationship between the developed countries was much stronger. The increased risk that investors of emerging markets face in terms of return volatility could therefore be reduced by creating well-diversified portfolios of the uncorrelated emerging market indices. Divecha et al explained the low correlation in the non-developed markets with lack of trade and therefore less economic integration.

Harvey (1995) examined more than 800 equities in Latin America, Asia, Europe, Africa and the Middle East. [4] Like Divecha et al, Harvey found evidence of low correlation between emerging and developed market returns and advised international investors to include assets of emerging countries in their portfolios to reduce the risk exposure. Harvey also stated that emerging markets are more reactive to local than to global information. In the context of this thesis it would imply that a financial crisis occurring in Sweden would have less of an effect on Hungary, for example, than a local crisis in Hungary would have on the Hungarian market.

Numerous comparisons and correlation studies of mature and emerging stock markets have been done within the field of financial economics. However, studying the European markets in an Eastern versus Western context has not been done before to a large extent. It has especially not

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[3] Exceptions were Malaysia, Hong Kong and Singapore
[4] Argentina, Brazil, Chile, Colombia, Mexico, Venezuela, India, Indonesia, Korea, Malaysia,
Pakistan, Philippines, Taiwan, Thailand, Greece, Portugal, Turkey, Jordan, Nigeria and Zimbabwe

been done by comparing different methods of estimating correlation coefficients, such as time-series versus cross-sectional correlations.

The cross-sectional method which was developed by *Solnik* and *Roulet* (2000) is relatively new and not utilised by many financial researchers yet. Instead, the time-series correlation is still the most commonly used. The cross-sectional correlation is based on the relationship between the portfolio's variance at every *t* and the portfolio's variance in the full sample. When the two standard deviations deviate largely from each other the correlation at *t* is low.

Many of the disadvantages of the time-series correlation can be avoided with Solnik et al's method: correlations can be estimated between more than two countries, long estimation windows are not needed and since the cross-sectional correlation can be estimated at each *t* it is possible to track instantaneous changes in the correlation over time. Solnik et al showed that the dispersion of their 15-country-sample, [5] stretching from 1971 to 1998, decreased over time. As a result, according to their cross-sectional correlation model, the markets had moved together and the correlation between them had increased over the time period. Solnik et al also compared the cross-sectional correlation to the time-series and the outcomes of the different methods were similar.

Byström (2003) analysed how stock market behaviours change over time and during financial crises. Byström examined the correlation between industry indices and several general markets indices in major European countries. The correlation between the markets had increased since the seventies and especially since the October crash in 1987. Byström brought up the phenomenon of correlation breakdown, which refers to increasing correlations between countries when absolute returns are high (which happens in moments of financial crises). Byström also discussed the cases of "false" correlation breakdowns caused by a statistical bias appearing when splitting the sample ex-post into high and low return periods. This spurious correlation breakdown is present when calculating both time-series and cross-sectional correlations and can therefore not be avoided by changing method. Byström found evidence of reversed correlation breakdown in the cross-sectional correlation when adjusting the original formula slightly. The same adjustment has been made to the formula in this thesis and I therefore expect to see signs of reversed correlation breakdown.

There are no published studies about the small financial depreciation that occurred in Sweden in 2006. This thesis contributes with new results and conclusions to the present financial research by

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[5] Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Norway, the Netherlands, Spain, Sweden, Switzerland, UK, USA.

covering this market correction. However, other crisis studies have been conducted. For example, *Michelfelder* and *Pandya* (2005) compared the volatility of six Asian emerging countries' stock markets with those of the United States and Japan. [6] The daily returns of the indices were both from the crisis and from the post-crisis periods: from July 1997 to October 2001. During this time frame, the indices of the emerging markets showed short term reactions to the financial shocks while the mature markets suffered from long-term impacts.

Patel and *Sarkar* (1998), on the other hand, saw that the effect of a crisis was smaller in the developed than the emerging markets. The latter were more sensitive to external shocks, but both kinds of countries usually needed approximately three years to recover from a decrease in the stock prices caused by a crisis. The emerging markets also suffered from a larger index dip. The sample included developed stock markets as well as those of Asia and Latin America during a period of almost thirty years and therefore covered nine stock market crises worldwide. However, Patel et al concluded that international investors can make larger profits by diversifying their Western portfolios with stocks from emerging countries.

Yang, Hsiao, Li and *Wang* (2006) also studied market behaviours during times of financial crises. More precisely, their study concerned the relationship between the stock markets in four countries in Eastern Europe, [7] the US [8] and Germany [9] before and after the Russian financial crisis of 1998. The data consisted of daily closing prices from the countries' stock indices. Some of the conclusions drawn from the study include a stronger correlation between the US and the four emerging markets as well as several emerging countries being more integrated into the world economy after the crisis. Germany was uncorrelated to the emerging stock markets before the crisis, but slightly correlated after the crisis.

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[6] India, Hong Kong, South Korea, Malaysia and Taiwan
[7] PI50 (Czech Republic), BUX (Hungary), WIG (Poland) and Moscow Times (Russia)
[8] S&P500
[9] DAX

3

Theory

The theory which the study is based on is explained in this section. The chapter starts with an introduction and moves on to explaining different methods of calculating correlation coefficients, covering the concept of event studies and some theory around crises.

Risk avert investors want to make profits on the stock markets without exposing themselves to large amounts of risk. However, traditional economic theory implies that the risk exposure increases as the value of the expected stock returns increase. [10] In order to make profits and minimise the risk exposure, the investors need to diversify away the risk in their asset portfolios. This is done by combining the right weights of the different assets in a portfolio: *asset diversification*. Since risk exposure is measured in terms of correlation coefficients, the assets in a portfolio should be as negatively correlated as possible. If one asset faces decreasing returns, an uncorrelated asset increases and, as a consequence, the value of the portfolio consisting of these two assets will be kept stable.

Recent financial research has proven that stock markets tend to become more correlated as time goes by and when the volatility on the stock markets increases. [11] As the return volatility increases in times of crises, one expectation of this thesis is that the correlation in Eastern and Western Europe respectively increases during the Swedish market correction, given that the Swedish market correction affects all other countries in this study as well.

3.1 Time-series correlation

The traditional way of calculating correlations is with a time-series method. The time-series correlation measures the relationship between two different variables, for example employees' level of education and their salaries, the supply of goods and their price or, which has been done in this thesis, between different stock market returns over a determined period of time. The time-series correlation is limited to measuring the relationship between two different variables at the time. Thus, correlations between several markets are not possible to calculate with this method. The limitation is seen in formula (3.1), which is the definition of the time-series correlation between variables x and y. [12]

$$\text{Corr}_{x,y} = \frac{\sum_{t=1}^{n}[(x_t - \overline{x})(y_t - \overline{y})]}{(n-1)\,\sigma_x\,\sigma_y} = \rho_{x,y} \qquad\qquad (3.1)$$

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[10] Campbell, Lo and MacKinlay (1997): Mean-variance efficient portfolios
[11] Byström (2003)
[12] Wooldridge (2003)

In formula (3.1) $\bar{x}$ is the average value of the x-sample and $\bar{y}$ is the average value of the y-sample.

The time-series correlation, $\varrho_{x, y}$ in formula (3.1) results in a number between negative 1 and positive 1:

$-1 < \varrho_{x, y} < +1$

A correlation coefficient of zero means that variables x and y are uncorrelated and that there is no linear relationship between them. When the correlation equals +1 the variables are perfectly correlated and follow each others' movements completely. On the other hand, when the correlation is -1 there is a perfectly negative linear relationship between the variables: i.e. when x increases, y decreases with the same percentage. Both of these extreme values, -1 and +1, are quite rare, but correlation coefficients close to either -1 or +1 indicate a strong linear relationship between the variables as well. [13]

Formula (3.1) is unconditional and based on all historical observations in the sample for variables x and y. The correlation value, $\varrho_{x, y}$, is the overall estimation of the relationship between x and y over the whole time frame. Since the time-series correlation contains all historical data and estimates the overall relationship between two variables, variations in the correlation over time cannot be spotted unless the data set streches over a long time horizon and over-lapping estimation windows are used. [14]

The problem with the large data set and the overlapping estimation window is that each observation in the sample contributes very little to the time-series correlation coefficient. The data set used for measuring the correlation at time t is almost the same as the data set for the correlation estimated at $t + 1$, with the exception of two observations: one observation is added and one is dropped since t. When working with large data sets, adding and removing two observations does not affect the correlation coefficients significantly. So even if it is possible to estimate differences in the correlation over time, the differences are often too small to be used in any analysis. [15]

Instead, the most appropriate way to use the time-series correlation measurement is when wanting to state the overall, average correlation between two variables over a certain time period.

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[13] Woodridge (2003)
[14] Solnik and Roulet (2000)
[15] Ibid

3.2 Cross-sectional correlation

Solnik and Roulet (2000) introduced the cross-sectional method for estimating correlations between stock markets. The cross-sectional method is recommended to substitute the traditional time-series when analysing stock markets before investing. The cross-sectional correlation method allows several stock market returns to be compared to each other, whereas the traditional time-series correlation by definition only measures the co-movement between two markets. [16]

When the time-series method results in one overall correlation, independently of the sample size, the cross-sectional correlation estimates the correlation at each t. The cross-sectional correlation is based on the returns at t, the mean returns in the full sample, the variances at t and the variance in the full sample. Figure 3.1 shows how this is done in Excel at t = 1997-09-22.

			Var West		
2			Var West		
3	**WEST**		0,0001338		
4	return	mean	std dev	var	correlation
5	1997-09-22	0,005703	0,000360	0,005343	0,000029	0,907819
6	1997-09-23	-0,001926		-0,002285	0,000005	0,981036
7	1997-09-24	0,016458		0,016098	0,000259	0,583523

Figure 3.1. The cross-sectional correlation measured at t = 1997-09-22.

Thus, the dynamic cross-sectional correlation measurement can be used to track instantaneous changes in the stock markets' correlations over time. It is the ability to compare several markets to each other at different moments in time that, without any doubt, is the greatest advantage of the cross-sectional method. [17]

The cross-sectional correlation measurement is based on how the return at t deviates from the mean return of the full sample, also known as the variance or the *dispersion*. In this thesis we compare the time-varying dispersion of either Eastern or Western Europe at t ($\sigma_{t,x}^2$) to the constant, average dispersion (σ_x^2) in each geographical region. Hence, the constant dispersion is used as a benchmark to study how much the dispersion at each t differs from the average dispersion and the result is t correlation coefficients. [18]

When the markets grow in the same direction and face alike returns, the dispersion is small. In turn, the correlation between the markets is high. On the contrary, when markets do not move together, the dispersion is large and the correlation is low.

The formula for the cross-sectional correlation is seen in (3.2).

[16] Solnik and Roulet (2000)
[17] Ibid
[18] Ibid

12

$$\rho_{t,x} = \cfrac{1}{\sqrt{1 + \left(\cfrac{\sigma_{t,x}{}^2}{\sigma_x{}^2}\right)}} \qquad\qquad (3.2)$$

x = either Eastern or Western Europe

Since the cross-sectional correlation is not based on historical data, but on contemporary data, the problem with dependent variables is non-existing. Each correlation is independent from both previous and succeeding ones. Thus, long time periods with similar correlation coefficients are rarely caused by biases in the data. It also means that the cross-sectional correlation coefficients can be quite volatile because new data is used at every t in formula (3.2). [19]

The disadvantage of the cross-sectional method is that a large number of countries are needed to be able to see significant results. This study is based on two groups of five markets each, which is the minimum amount of markets one should use. A sample of closer to ten markets in each portfolio, as first planned, would have been more reliable, but due to lack of data this was not feasible. The accuracy of the measurement can therefore also be slightly questioned.

3.3 Correlation breakdown

Several researchers have found evidence of increasing correlations in times of high market volatility. [20] The behaviour is called correlation breakdown. [21] High market volatility happens when absolute returns are remarkably high: either positively or negatively, without following a stable trend, during a certain period of time.

The correlation breakdown implies that in times of crises, when investors to a larger extent seek to create well-diversified portfolios with as uncorrelated assets as possible, the correlation between the assets increases, which is an issue to financial actors who want to stay protected against large losses. [22] However, Loretan et al showed in their article that in many of the cases where correlation breakdowns have been detected, poor data mining was the reason for the increased correlations. [23] Boyer et al proved that the correlation seldom increases with the increased volatility, but when splitting the sample into periods of high and low volatility ex-post, the correlation coefficients change and a "false" correlation breakdown seems to be present. [24] However, in reality it is simply the split in the sample that causes the correlation to rise.

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[19] Solnik and Roulet (2000)
[20] Longin & Solnik (1995), Karolyi & Stulz (1996), Bookstaber (1997), and Ramchand & Susmel (1998)
[21] Byström (2003)
[22] Ibid
[23] Loretan & English (2000)
[24] Boyer, Gibson and Loretan (1999)

The correlation breakdown has empirically been proved by Byström to be present when using both time-series and cross-sectional correlation methods. Thus, it is not possible to remove or reduce the "false" correlation breakdown, also known as the *spurious correlation break down*, by simply changing estimation method. Nevertheless, Byström stated that the spurious correlation breakdown was larger when the studied time period was shorter. [25] By extending the time period one can prevent some of the spurious correlation to appear.

On the other hand, if the correlation decreases when the absolute market returns are high, a *reversed correlation break down* is present. Reversed correlation breakdowns have been found in cross-sectional correlations based on formula (3.2). [26] A reversed correlation breakdown and hence decreasing correlations during the financial market correction are therefore expected in this study.

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[25] Byström (2003)
[26] Ibid

4

Data

In this section the study's data set is treated. The development of the data over time is shown in graphs and commented in text. All calculation definitions are explained.

The daily prices of all general market indices are gathered from Datastream. The studied Western European countries are France, Germany, Italy, Norway and Sweden. The Eastern stock market prices come from the following countries: The Czech Republic, Estonia, Hungary, Poland and Romania.

Due to a lack of historical data in many of the Eastern stock markets the data set starts on the 19th of September 1997 and ends with the prices of 7th of February 2007, in order to have the same length of all the countries' observation periods. The late starting date is caused by Romania, which does not have any previous information available. In total, 2448 daily prices are used from each one of the countries in the sample. [27]
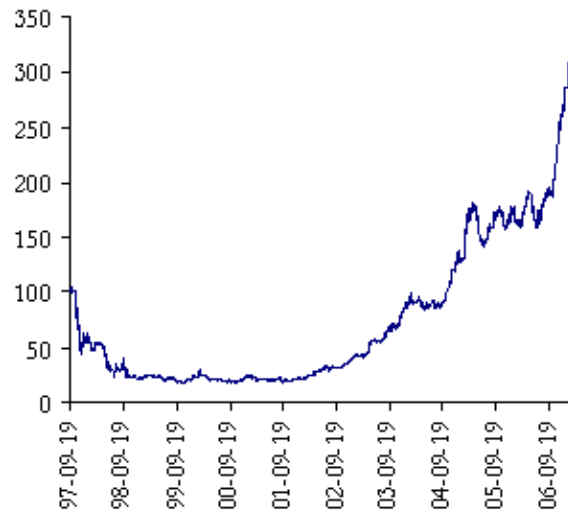
All the market indices are shown in figures 4.1 and 4.2 in US dollars.
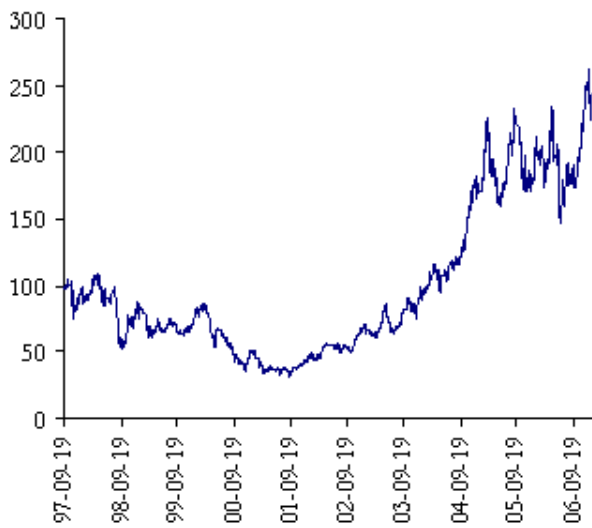
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[27] Due to the fact that all countries do not have the same amount of holidays, this number (which has been taken from the case of Romania) might differ slightly between the countries.
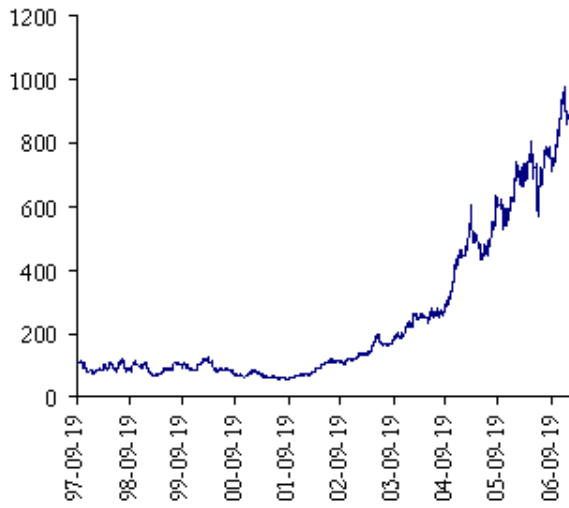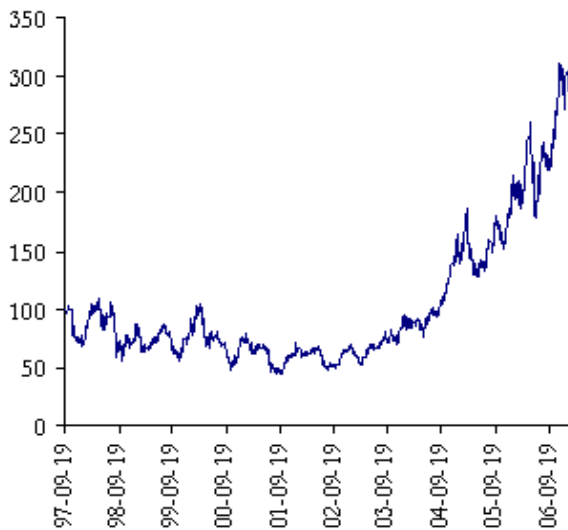
i. Czech Republic
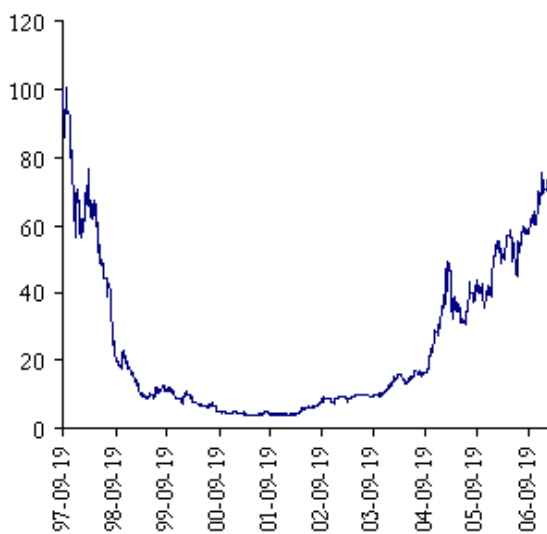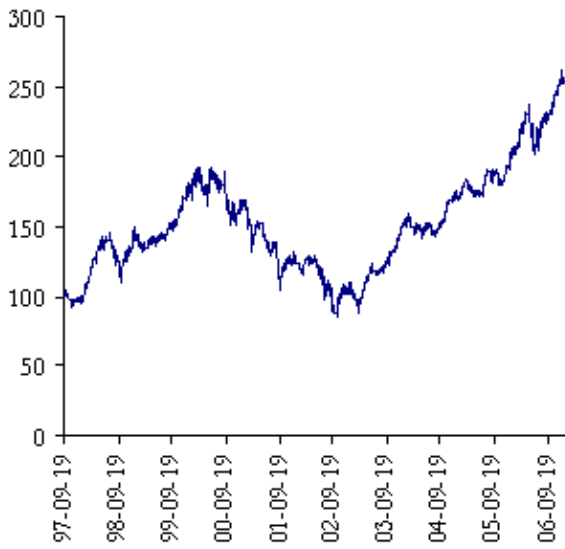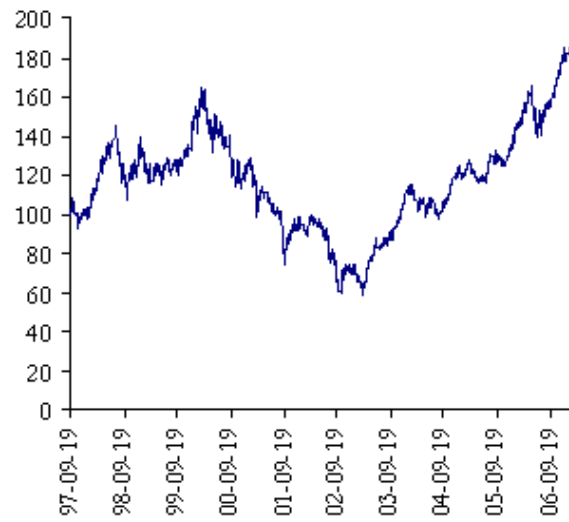

ii. Estonia

iii. Hungary

iv. Poland

v. Romania

Figure 4.1 Daily Eastern European stock indices in USD from 19th September 1997 – 7th February 2007.
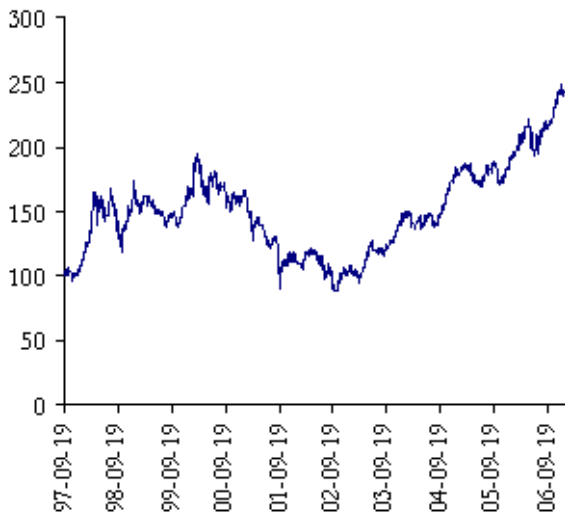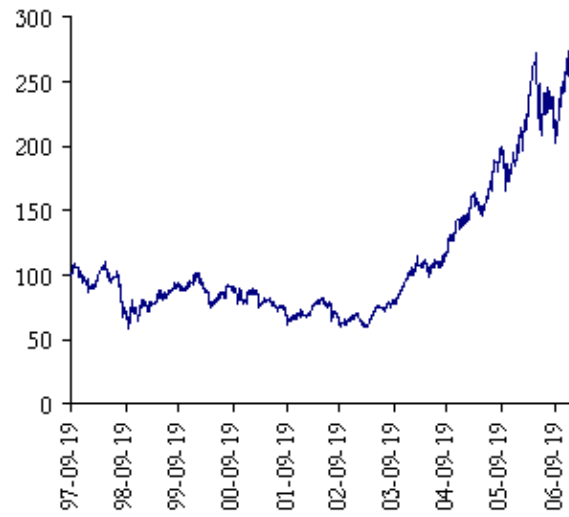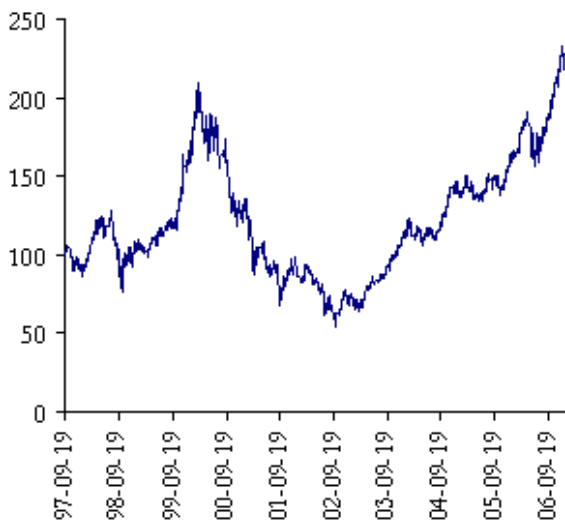
16

i. France

ii. Germany

iii. Italy

iv. Norway

v. Sweden

Figure 4.2 Daily Western European stock indices in USD from 19th September 1997 – 7th February 2007.

The general market index data in figures 4.1 and 4.2 have been downloaded from Datastream in both US dollars [28] and local currencies. [29] Since domestic indices measured in US dollars can fluctuate not only because of the stock markets' movements but also because of changes in the exchange rate between the local currency and the US dollar, currency data has also been collected.[30] In order to compare all countries' returns on the same basis, the indices in domestic currencies are converted into US dollars. The international investors trading in US dollars can therefore make comparisons of their investments across country borders more easily.

The currency data from Datastream originally come from JP Morgan for the Czech Republic, Estonia, Hungary, Poland, Romania and Sweden and from Bank of England for France, Germany, Italy and Norway.

It is not a problem finding data such as exchange rates and stock market prices for most Western European countries during the last 20 years, but the emerging Eastern European countries cause some limitations in the data set; either because some of the countries did not exist 20 years ago or because they did not have stock markets or official statistics. Thus, the sample of emerging countries turned out to be smaller than first expected; ten Eastern European countries became five due to a lack of data which limited the study.

The time period of the financial market correction stretches from 1st of May to 29th September 2006. All the countries' stock indices during this time period are presented in figures 4.3 (Eastern Europe) and 4.4 (Western Europe).

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[28] France, Germany, Italy, Norway and Sweden.
[29] The Czech Republic, Estonia, Hungary, Poland and Romania.
[30] The currency data is collected from Datastream
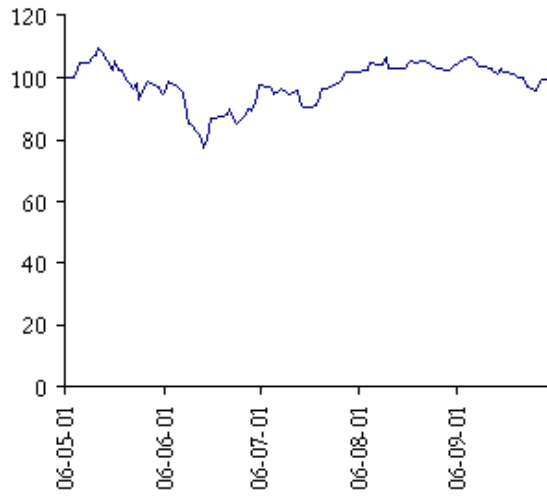
i. Czech Republic
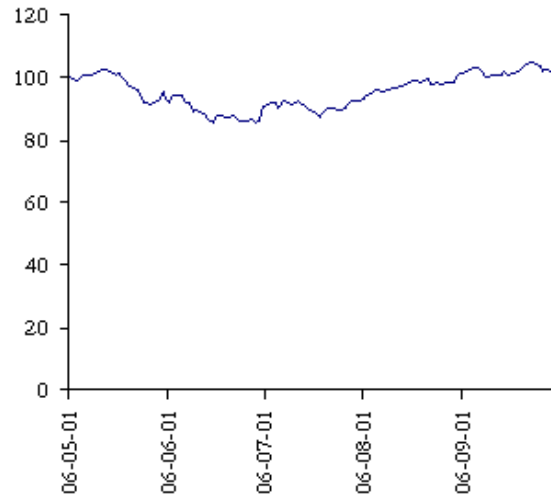
ii. Estonia
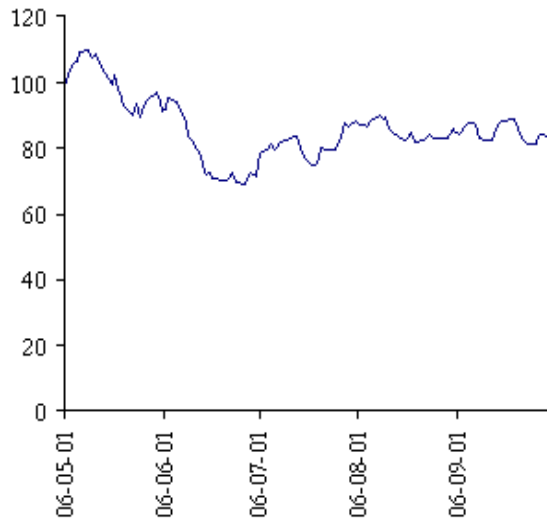
iii. Hungary
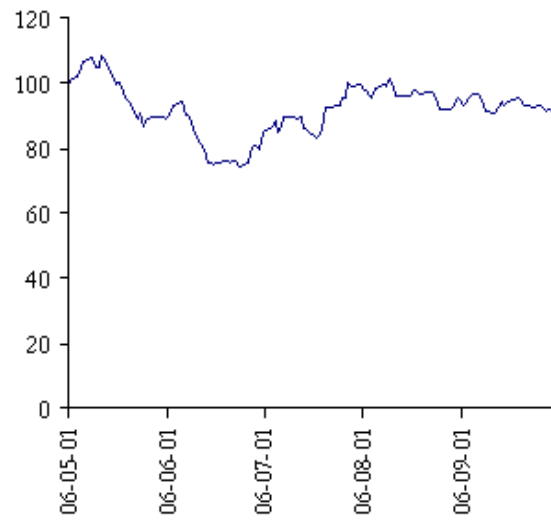
iv. Poland
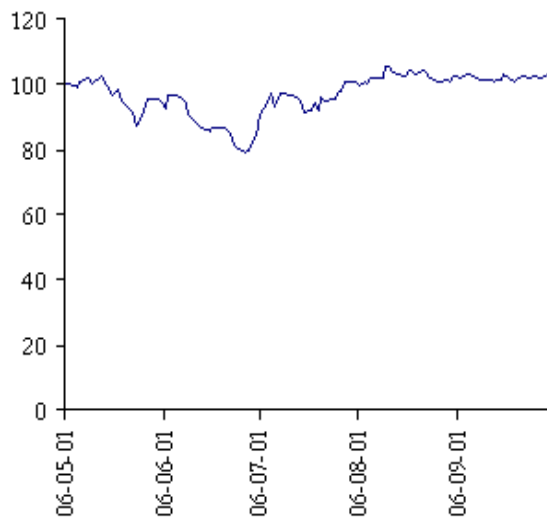
v. Romania

Figure 4.3 Daily Eastern European stock indices in USD during the period of the financial market correction.
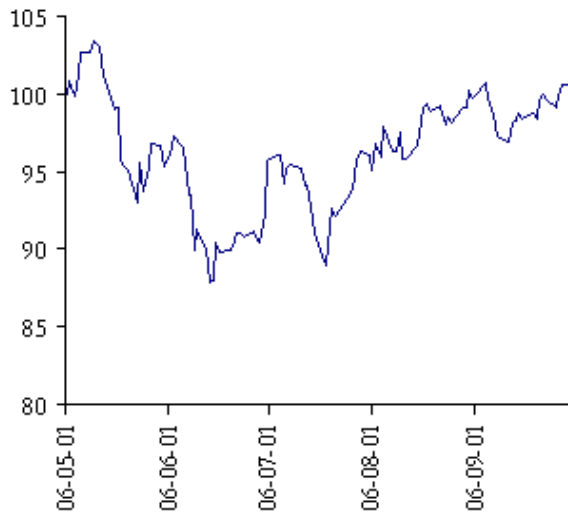
i. France
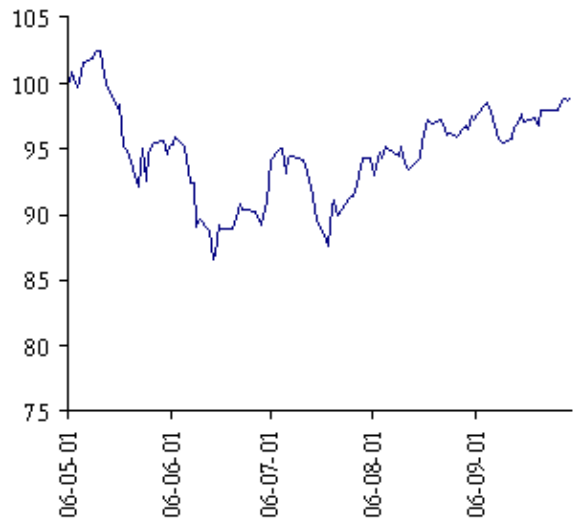
ii. Germany

iii. Italy
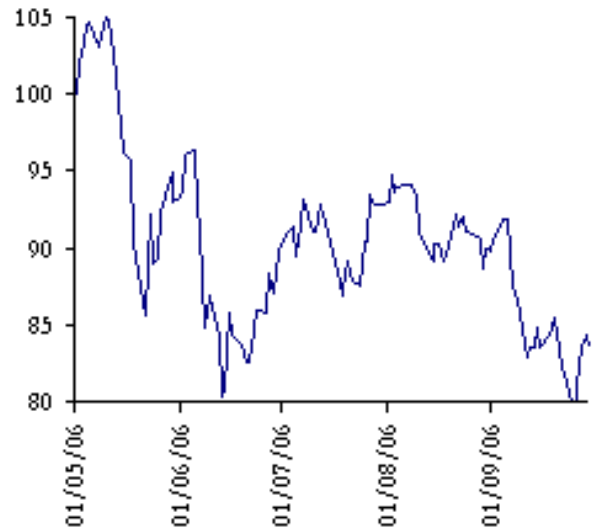
iv. Norway
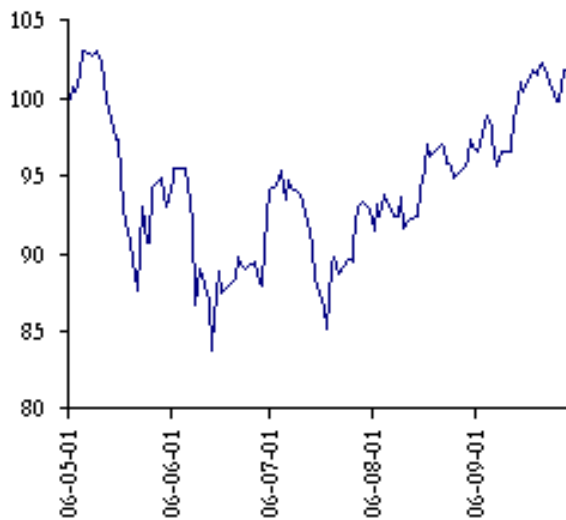
v. Sweden

Figure 4.4 Daily Western European stock indices in USD during the period of the financial market correction

5

Method

This section presents the methodology that the thesis has followed.

The starting point of this study is to see if international investors can reduce their risk exposure by investing in a portfolio of only Eastern or only Western European stock indices. The question we want to have answered is: which regional portfolio minimises the international investors' risk exposure the most?

The international investors are assumed to trade in US dollars, which means that they are faced with an exchange rate risk when investing in any of the countries selected for this thesis as none of them have US dollars as their official currency. To be able to measure the investors' total profit when investing in either Eastern or Western Europe, all indices must be converted into US dollar indices, as done in (5.1).

$$P_{t,USD} = \frac{P_{t,domestic}}{exchangerate_{t,domestic/USD}}$$
(5.1)

$P_{t,USD}$ = Stock market index at t in USD

$P_{t,domestic}$ = Stock market index at t in local currency

The fact that all country indices are in US dollars, does not imply that they are wholly comparable, since they are found on different index levels. The German stock index, for example, is 976 in September 1997, whereas the Italian index is approximately 520 during the same month. These index levels do not reveal anything about the country growths and hence, they are adjusted to start with the value 100 on 19th September 1997 and evolve from there. Formula (5.2) shows how the index adjustment was done. A graphical view of how the indices have grown over time can be found in figures 4.1 and 4.2.

$$P_{t,USD100base} = \frac{100}{P_{t,USD}}$$
(5.2)

$P_{t,USD\ 100base}$ = Stock market index at t in USD starting at 100 on 19th September 1997

$P_{t,USD}$ = Actual stock market index at t in USD

Further, I use the indices from formula (5.2) to calculate all stock returns in the sample. The stock

returns measure how much the markets have grown and since growth studies are usually based on log-returns, I calculate the log returns for all observations in the sample according to formula (5.3).

$$R_t = \ln(P_t) - \ln(P_{t-1}) \qquad (5.3)$$

One of the target points of the thesis is to calculate the cross-sectional correlation of Eastern and Western European stock returns respectively. The assumption that the five countries in each region are all equally important has been drawn and therefore all market returns are equally weighted in the two regional portfolios. The average returns within each portfolio has been calculated at every t resulting in t returns for Eastern and Western Europe respectively, which is shown in formula (5.4).

$$R_{t,x} = \frac{\sum_{i=1}^{n=5} R_{t,i}}{n} \qquad (5.4)$$

$x =$ Eastern or Western European portfolio

$i =$ Eastern or Western European countries, since there are five countries in each portfolio $n = 5$.

The cross-sectional correlation method requires that the conditional variances in Eastern and Western Europe are known at each t, resulting in t conditional variances for each regional portfolio. The average variance for these two regions during the full time period also needs to be calculated. The latter results in one unconditional variance for the Eastern and one unconditional variance for the Western sample.

The conditional variances are based on the standard deviations at each t, which are calculated by subtracting the mean of all returns, R_x, from the actual returns $R_{t,x}$ at each t. The variance is the squared standard deviation, as seen in formula (5.5).

$$Var_{t,x} = \frac{\sum_{t=1}^{n} \left(R_{t,x} - R_x\right)^2}{n} = \sigma_{t,x}^2 \qquad (5.5)$$

$R_{t,x} =$ actual return at t in either the Eastern or the Western portfolio

$R_x =$ mean of all returns in either the Eastern or the Western portfolio

$n =$ number of observations in the sample

The unconditional variance is calculated in Excel for the Eastern and Western European samples. It is not time-varying and therefore results in one figure that represents the total variance in each one of the regions' portfolios. The unconditional variance is used as a benchmark in the cross-sectional correlation formula, see σ_x^2 in (5.6). However, it should be emphasised that even if the variance is assumed to be stable over time, it is in reality more likely to vary. Since the cross-sectional correlation formula (5.6) does not require the benchmarked variance to be conditional, the constant unconditional variance is sufficient to use for this thesis' purposes. The cross-sectional correlation formula is presented in (5.6).

$$\rho_{t, x} = \frac{1}{\sqrt{1 + \left(\dfrac{\sigma_{t, x}^2}{\sigma_x^2} \right)}} \qquad\qquad (5.6)$$

x = Eastern or Western European portfolio

$\sigma_{t, x}^2$ = Time-varying conditional variance in either the Eastern or the Western European portfolio

σ_x^2 = Constant unconditional variance in either the Eastern or the Western European portfolio

The cross-sectional correlation in (5.6), $\varrho_{t, x}$, is estimated at each t and is further compared to the traditional time-series correlation measurement in each one of the two European regions. An analysis of the different correlation measurements as well as of the different geographical regions is presented in section 6.2.

The whole sample contains 2448 stock returns which result in 2448 individual cross-sectional correlations. Since the cross-sectional correlation equation contains new data at every t, the correlations between different moments in time can vary significantly. [31] In order to avoid daily correlations from fluctuating, the data has been smoothed into weekly average correlations during the full time period. By smoothing the data it becomes less sensitive to small deviations and gives more stable results. [32] See formulas (5.7) for how the smoothing was done.

$$\rho_{smoothed, x} = \frac{\sum_{t=1}^{n} \rho_{t, x}}{n} \qquad\qquad (5.7)$$

n = 5, since the stock markets are open five days a week

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[31] Solnik and Roulet (2000)
[32] Byström (2003)

$\varrho_{t,x}$ = Daily correlation in either the Eastern or the Western European portfolio

x = Eastern or Western European portfolio

Correlation regression equations were calculated in Excel and resulted equations (6.2) and (6.4). This is graphically shown in figures 6.1 and 6.3.

Another cross-sectional correlation analysis is done during the financial market correction. The analysis is again based on formula (5.6), but the time period is instead limited to the occurrence of the financial market correction that took place in Sweden. The data set starts in May and stretches to September 2006. Since the time period of the financial market correction is quite short, the data has not been smoothed. This way, daily correlation changes can be spotted more easily. The purpose of analysing the correlation specifically during the financial market correction is to see if there are any changes in the correlation coefficients when the markets are more volatile. Price decreases day over day as well as price decreases since 1st of May 2006 have been calculated at all t to see when the markets fell the most. This analysis results in conclusions about the behaviour of stock market correlations during a minor financial crisis. See section 6.3 for the analysis and appendix B for the data results.

There are many alternative ways of performing studies similar to the one of this thesis. Combining other Eastern and Western markets into portfolios as well as extending or shortening the time period are some suggestions. Looking at South East Asian or South American emerging markets instead of those of Eastern Europe would be one way and focusing on local financial crises in these areas is another.

In order to improve the study further, there are some crucial changes I would address in any future cross-sectional correlation study. The first one is the amount of markets included in each portfolio. Five countries, as were used in this study, are the minimum amount of markets to form a portfolio and to analyse cross-sectional correlations. Creating portfolios of larger geographical areas and weighting the market indices in the portfolios according to the individual market sizes in the world economy would be more reflective of the actual investment situation.

Forming dynamic portfolios, which are re-weighted at each t, depending on market behaviours or macroeconomic events would also be a way of improving the study and turning it into a real world comparison rather than a theoretical essay.

6

Empirical results and analysis

The results and the analysis of the study are presented in this section. The time-series and the cross-sectional correlations are compared during the full time period as well as during the financial market correction.

The results and the analysis chapter of the thesis is divided into sections bringing up the volatility in the index returns (6.1), the cross-sectional and time-series correlations in the regions (6.2), the index returns and the cross-sectional correlations during the financial market correction in the regions and comparisons between the full time period and the crisis period as well as comparisons between Eastern and Western European data (6.3).

6.1 Index return volatility

To be able to follow the discussion in this section it is crucial to understand the difference between the volatility of returns and the volatility of correlations. The focus of the thesis lies within the field of correlations between stock market returns and it is primarily the volatility of the correlations we study.

However, when talking of market volatility, it is the volatility of the stock returns which is intended. The returns can be very volatile, but the correlation does not necessarily have to fluctuate with it. The correlation can remain steady when the stock markets are experiencing a crisis and are not by definition following the volatility of the returns. An example of this is when all stocks show decreasing returns. The correlation between those stocks is, by definition, steady as all stocks move in the same direction. Whether or not the correlation stays constant during a crisis is one of the questions to be answered throughout the thesis.

As seen in appendix A1, the mean daily returns are similar in Eastern and Western Europe. The standard deviations, which measure the volatility, are larger in Eastern than in Western Europe though. Therefore, both the maximum and minimum returns are also larger in Eastern Europe over the whole sample. This means that Eastern European returns are more volatile and less predictable than those of Western Europe and the risk of investing in East is larger from a pure stock return perspective. It is therefore of great importance to point out the difference between return and correlation volatility for the reader to follow further discussions in section 6.

6.2 Cross-sectional and time-series correlations in the regions

The section starts with presenting the results of the cross-sectional correlation study in Eastern (chapter 6.2.1) and Western Europe (chapter 6.2.2) and moves on to comparing the two to each other (chapter 6.2.3). The time-series correlations are discussed in chapter 6.2.4 and a comparison

between the time-series and the cross-sectional correlation methods are followed in chapter 6.2.5.

6.2.1 Regression results of the cross-sectional correlation study in Eastern Europe

The null hypothesis is set up so that the coefficient b in equation (6.2) is zero, in order for us to investigate if an increase in the correlation is seen over time.

H_0: $b = 0$

H_1: $b \neq 0$

The graphical view of the smoothed cross-sectional correlations is presented in figure 6.1 and the regression equation is shown in (6.2).

Figure 6.1 Smoothed correlations in Eastern Europe from 19th September 1997 – 7th February 2007.

$$\rho_t = a + b\rho_{t-1} \tag{6.2}$$

$a = 0.564$

$b = 0.307$

The p-value is 1.26 % in regression equation (6.2), which means that the null hypothesis is rejected at the 5 % significance level and the coefficients are significant. Equation (6.2) reveals that the correlation between the Eastern European markets at t is 0.564 plus 30.7 % of the correlation at t - 1. This implies that if the correlation at time $t – 1$ is 0.8152, which is the average over the whole sample, the correlation at t would be 0.8314. A significant correlation increase is seen in Eastern Europe over the studied time period.

On the other hand, the R^2 value is small (9.59 %), which implies that little of the data set explains the coefficients in the regression equation. This is important to keep in mind when further analyses about equation (6.2) will be made in section 6.4.

The Eastern European average cross-sectional correlation is 0.8152 and the standard deviation is 0.0678.

6.2.2 Regression results of the cross-sectional correlation study in Western Europe

The same null hypothesis is set up for the Western European as for the Eastern one, i.e. coefficient b in equation (6.4) is set to be zero. If the coefficients are significant we face a growing correlation over the studied period.

H_0: $b = 0$

H_1: $b \neq 0$

The graphical view of the smoothed cross-sectional correlations is presented in figure 6.3 and the regression equation is shown in (6.4).
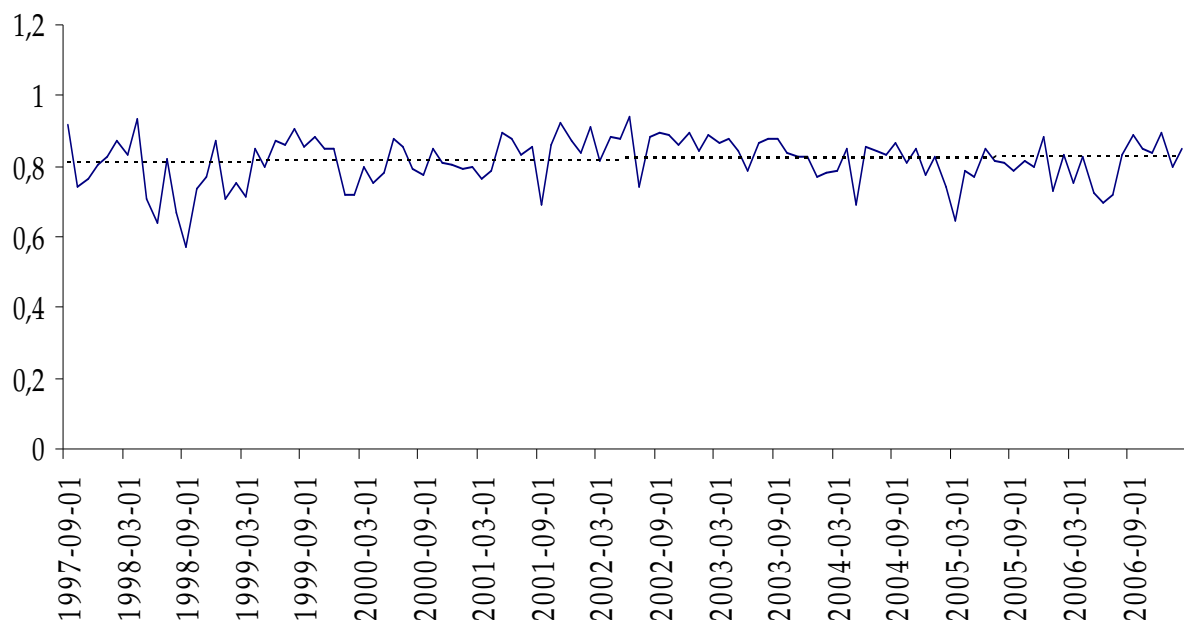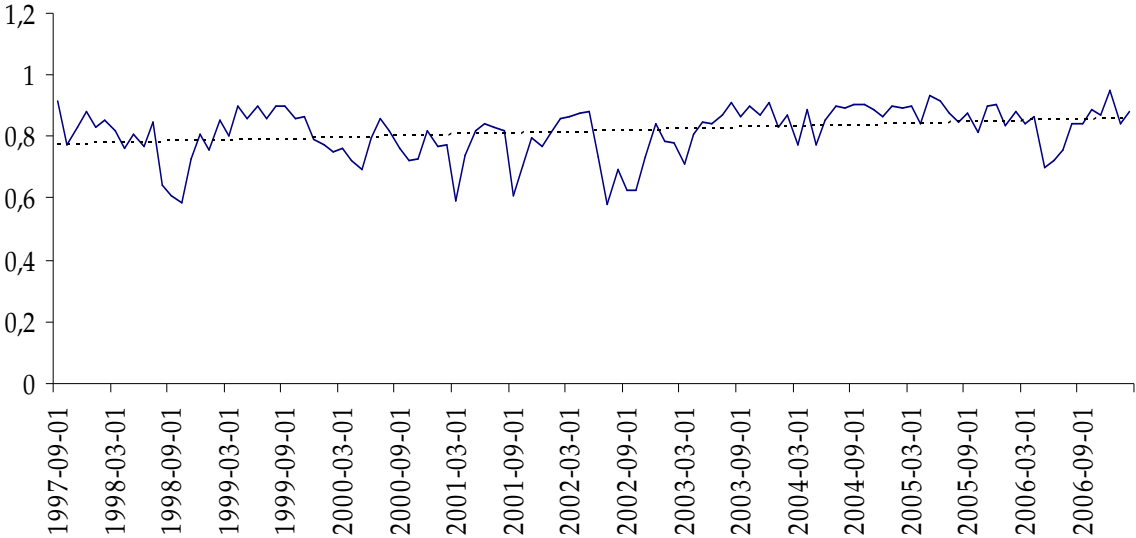

Figure 6.3. Smoothed correlations in Western Europe from 19th September 1997 – 7th February 2007.

$$\rho_t = a + b\rho_{t-1} \tag{6.4}$$

$a = 0.308$
$b = 0.621$

The p-value is low in the Western European regression equation as well, 1.53 %, and again the null hypothesis is rejected at the 5 % significance level. The correlation between the Western European countries' stock markets has increased significantly over the analysed time frame and is

growing faster than the Eastern European correlation. If we assume the correlation in $t-1$ to be equal to the sample average, i.e. 0.8145, the correlation at t would be 0.8138 according to (6.4). Thus, the Western European correlation coefficient at t is 0.308 plus 60.7 % of the correlation at t-1. The R^2 value is also larger for the Western sample (38.8 %) and hence, the Western data explains the Western stock market behaviours to a larger extent than the Eastern ones explain behaviours in East. The Western data is therefore also more reliable for further analyses and forecasts.

The Western European average cross-sectional correlation is 0.8145 and the standard deviation is 0.0824.

6.2.3 Comparing cross-sectional correlations between the regions

When comparing the two geographical regions with one another, the smoothed correlations are used. Figure 6.5 shows the movements of the markets' correlations and even if both regions move closely to each other, [33] Western Europe turns out to have both the highest peaks and the lowest troughs in whole data set. The correlation volatility in West is higher than in East (standard deviations of the correlations are 0.0824 and 0.0678 respectively), which implies that the markets representing East show more equal behaviours than the countries in West do over the time period. This is independent of positive and negative returns, of crises and booms; [34] the Eastern European countries are more stable in their correlations over the studied 10-year-period. However, the average correlations in Eastern and Western Europe are very similar to each other, with East just being slightly above West's value.

The higher volatility in the Western correlations can also be spotted when simply studying equations (6.2) and (6.4). The Western markets' weekly correlations have moved around the value 0.308, [35] which is much lower than the Eastern European ones which have been approximately 0.564. [36] The fluctuation in the correlation is captured in the coefficient b, which is much larger for West than for East in (6.2) and (6.4).

During the moments in time when the Western portfolio shows high correlations, the Eastern portfolio is preferred, because of the lower risk exposure to the investor. On the other hand, the high volatility in the Western correlations also makes West the region with the lowest correlations at other times. During those periods the Western portfolio is preferred. However, the instability of the Western portfolio makes this volatile region less predictable in terms of correlations,

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[33] The mean correlations are very similar: East 0.8152 and West 0.8145
[34] See the discussion in section 6.1 Volatility in the index returns
[35] a = 0.308
[36] a = 0.564

although the average correlation is lower in West. The active investors who change the content and asset weights in their portfolio on a very regular basis can still gain from investing in a Western portfolio as long as they reinvest often enough to spot the moments of high correlation in combination with negative returns in time. By diversifying the portfolio at those moments, the risk can be somewhat avoided. The correlations in Eastern and Western Europe during the full ten-year period are shown in figure 6.5.
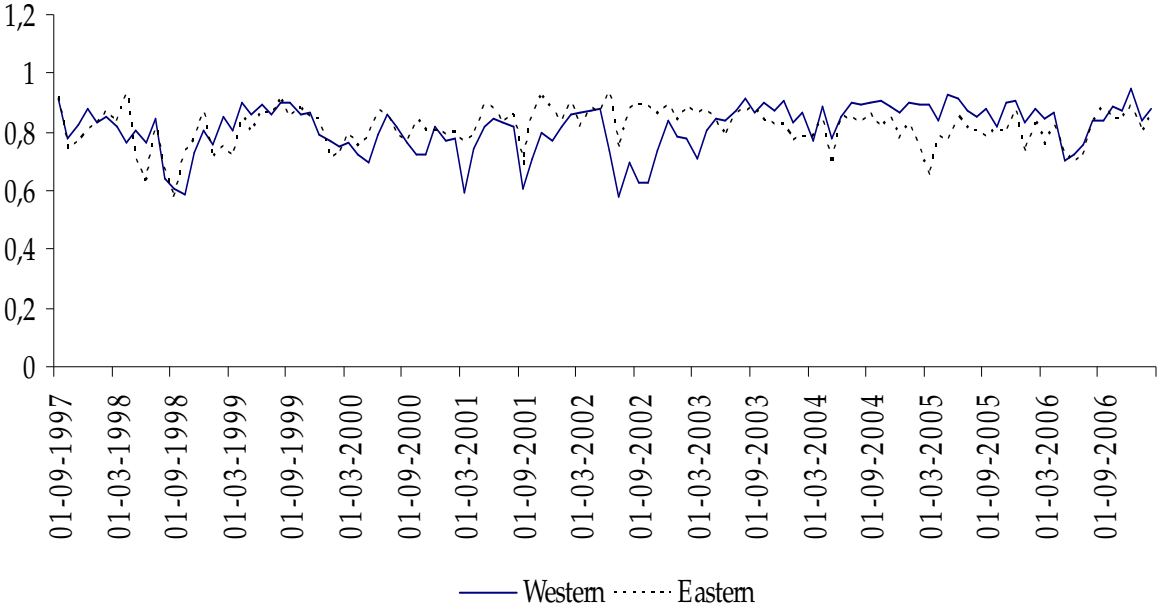
Figure 6.5. Smoothed correlations in Eastern and Western Europe from 19th September 1997 – 7th February 2007.

The R^2 value is significantly higher in West than in East which means that the Western regression equation explains more of the stock market behaviour in West than the Eastern one does in East. Hence, even if West has a larger variance than East, West's data set is still more accounted for in (6.4) than East's is in (6.3). Forecasts based on (6.4) are likely more precise than the ones based on (6.3) and being able to make accurate correlation forecasts is crucial for all investors as the investment portfolios can be rebalanced when needed and the risk exposure can be kept low to the investor. Thus, this can be done much more easily for the Western than for the Eastern portfolio.

This study only compares the Eastern and Western portfolios to each other, to see which one is preferred to an international investor. However, both geographical regions show high average correlations (approx. 0.81), which implies that it is relatively risky to invest in either place. In reality risk avert investors must therefore diversify their portfolio with other assets as well to avoid a large risk exposure. The additional assets should of course be uncorrelated with the already existing ones, in order to lower the correlation within the investment portfolio.

Since the risk avert investor of this thesis can only choose between the Eastern and Western portfolios, the preferred investment portfolio is the Eastern one which has a lowe correlation volatility.

6.2.4 Results of the time-series correlations

The traditional measure of correlations, the time-series one, gives values seen in tables 6.6 and 6.7.

	CZECH	ESTONIA	HUNGARY	POLAND	ROMANIA	**AVERAGE**
CZECH	1.00	0.32	0.48	0.40	0.16	**0.34**
ESTONIA	0.32	1.00	0.26	0.23	0.09	**0.23**
HUNGARY	0.48	0.26	1.00	0.55	0.18	**0.37**
POLAND	0.40	0.23	0.55	1.00	0.16	**0.34**
ROMANIA	0.16	0.09	0.18	0.16	1.00	**0.15**
TOTAL						**0.28**

Table 6.6 Time-series correlations in Eastern Europe from 19th September 1997 – 7th February
2007.

	FRANCE	GERMANY	ITALY	NORWAY	SWEDEN	**AVERAGE**
FRANCE	1.00	0.85	0.83	0.55	0.75	**0.74**
GERMANY	0.85	1.00	0.77	0.53	0.71	**0.72**
ITALY	0.83	0.77	1.00	0.51	0.67	**0.70**
NORWAY	0.55	0.53	0.51	1.00	0.54	**0.53**
SWEDEN	0.75	0.71	0.67	0.54	1.00	**0.67**
TOTAL						**0.67**

Table 6.7 Time-series correlations in Western Europe from 19th September 1997 – 7th February
2007.

As seen in tables 6.6 and 6.7, it is only possible to calculate correlations between two countries at the time. The calculated value in a time-series correlation is an average of the whole time period. There is not any possibility to tie the correlation to certain moments in time or events on the stock market or in the macro economy.

Despite these disadvantages of the time-series correlation measure, it is possible to see that the Western countries are more correlated to each other than the Eastern countries are. All Eastern European markets show average correlations lower than 0.5 (0.28), but the Western European markets show a correlation higher than 0.5 (0.67). The international investor who aims to create a portfolio with as little risk exposure as possible is better off by doing so with market indices from Eastern Europe when studying time-series correlation data.

Romania is the country that is least correlated to the rest of the Eastern markets and Norway is least correlated to the Western markets. The risk exposure is minimised when creating portfolios consisting of either one of these two markets, in combination with one other market from tables 6.6 and 6.7 in East and West respectively. For example, the combination of Norwegian and Italian

assets results in a portfolio with lower risk exposure than a portfolio of Italian and French assets would have.

Of all the Eastern countries, Romania was the last to join the European Union and Norway is not even a member. Investigating whether this is a coincidence or if the economic markets in the E.U. actually are more integrated with each other is not the purpose of this thesis, but it is still an interesting aspect and possible explanation to the lower correlations in these countries. This explanation would correspond to the findings of Divecha et al's study. [37]

6.2.5 Comparisons between cross-sectional and time-series correlations

The cross-sectional correlation method results in average correlations close to 0.8 in both regions. Due to the Western correlation being more volatile, the correlation in this portfolio deviates significantly from 0.8 at times. The cross-sectional correlation between the five Eastern European markets is more stable, but the time-series data show correlation values quite different from 0.8. See tables 6.6 and 6.7.

The results from tables 6.6 and 6.7 are similar to those of Divecha et al. [38] Divecha et al found evidence of lower correlation between emerging than developed markets, both in portfolios of assets from several different emerging markets and in portfolios consisting of assets from both emerging and mature markets. The latter study has not been done in this thesis, but the first study's results coincide with this thesis' results. The conclusion of lower correlations between the emerging markets can be drawn from the cross-sectional correlation results where, despite similar correlation means, the correlation volatility is much lower in Eastern Europe. According to Divecha et al the low correlation between the emerging markets is explained by lack of trade between these countries and, as a consequence, little economic integration. However, even if the emerging markets in Divecha et al's sample were little correlated with each other, the study emphasised that because of more volatile returns, there was still risk associated to investing in the emerging countries. This thesis has also shown that Eastern European asset returns are more volatile than the Western European ones. [39]   Hence, even if the cross-sectional correlation in Eastern Europe is less volatile, the investors in this region are still exposed to risk through its fairly instable and little predictable assets returns.

The results of this thesis imply that the countries within the two different regions are more correlated when using a cross-sectional rather than a time-series method. Since the cross-sectional correlation, see (3.2), is calculated with independent data at each *t*, and the time-series measures

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[37] Divecha et al (1992)
[38] Ibid
[39] See section 6.1

one market's data over time, the cross-sectional data will always be more volatile. However, the cross-sectional method is still more suitable when studying correlation changes over time as well as across several different markets and is hence the preferred method for estimating correlations in this study.

6.3 Analysis of the financial market correction

The section introduces the results of the specific crisis period, starting with return volatility (6.3.1) and cross-sectional correlations (6.3.2), making a deep-dive into Eastern (6.3.2a) and Western (6.3.2b) cross-sectional correlations, followed by a comparison between the regions' data and results (6.3.3).

6.3.1 Return volatility during the financial market correction

The mean returns in the sample stretching from 19th September 1997 to 7th February 2007 are similar in the Eastern and Western regions, but during the financial market correction in Sweden the Eastern region showed a lower daily mean return. [40] As mentioned in section 6.1 the maximum and minimum returns in the East were higher than in the West, which means that the Eastern European returns were more volatile during the full 10-year period.

Interestingly enough, neither the maximum nor the minimum returns seen in the full sample in either region are to be found during the crisis; but occurred either before or after the crisis. The largest return deviations are therefore only present outside the time spectrum of the financial market correction in Sweden. One can ask whether this is a sign of the crisis only being present in Sweden, but there is evidence of the market correction affecting other countries as well. The Hungarian, Polish, Romanian and Norwegian general indices all decreased more than the Swedish market did during the time period. [41] The drop in the remaining market indices during the same period was significantly smaller and the effect of the financial market correction was not very strong here. France was the only country with a very large daily price decrease, but the decrease was in July, i.e. probably not connected to the financial market correction in Sweden. Estonia, Czech Republic and Italy were the three countries where the effect of the financial market correction was minimal. [42]

Patel et al (1998) concluded their study by stating that emerging markets suffer more from a crisis than mature markets do. When studying figures 4.4 and 4.5 of Eastern and Western European index prices in US dollars during the crisis, Eastern Europe faced larger losses than Western Europe did and the Eastern stock returns were more volatile than the Western ones during the

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[40] See appendix A2
[41] See appendix A2
[42] See figures 4.4, 4.5 and appendix B.

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crisis. Hence, Patel et al's statement that a crisis affects emerging markets more than mature markets applies for this study as well when analysing stock returns.

However, the stock indices in Eastern Europe recovered from the price drop faster than the Western European did. Patel et al's conclusion can therefore not completely be transferred to this thesis as the long-term effect was much stronger in the Western portfolio. Instead this study shows the same results as Michelfelder et al (2005): it took longer for the developed markets to get back to the price levels seen before the crisis occurred. The Eastern Europe region had recovered from the stock index drop 80 days after the 1st of May 2006, but Western Europe had not caught up to old index levels until approximately 96 days after. [43]

Yang et al (2006) stated that emerging markets are more integrated with the world economy after a financial crisis. Since the time period studied after the Swedish market correction is very short, this kind of analysis is not feasible for the thesis.

6.3.2 Cross-sectional correlations during the financial market correction

The thesis also has the aim of investigating the correlation between the markets during a smaller financial crisis: a financial market correction. Figure 6.8 shows the daily cross-sectional correlation over the so-called crisis period for Eastern and Western Europe and their trend lines. The reason why daily correlations, and not smoothed weekly ones, are used during the crisis period is because the cross-sectional correlations in this specific period are analysed at a deeper level than the ones in sections 6.1 – 6.3, and using daily data is more explanatory in this section. The data were smoothed though, in order to see if there was a significant difference in the results when smoothing. Since there was no difference, the daily correlations were used in the analysis.

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[43] See figures 4.4, 4.5 and appendix B.
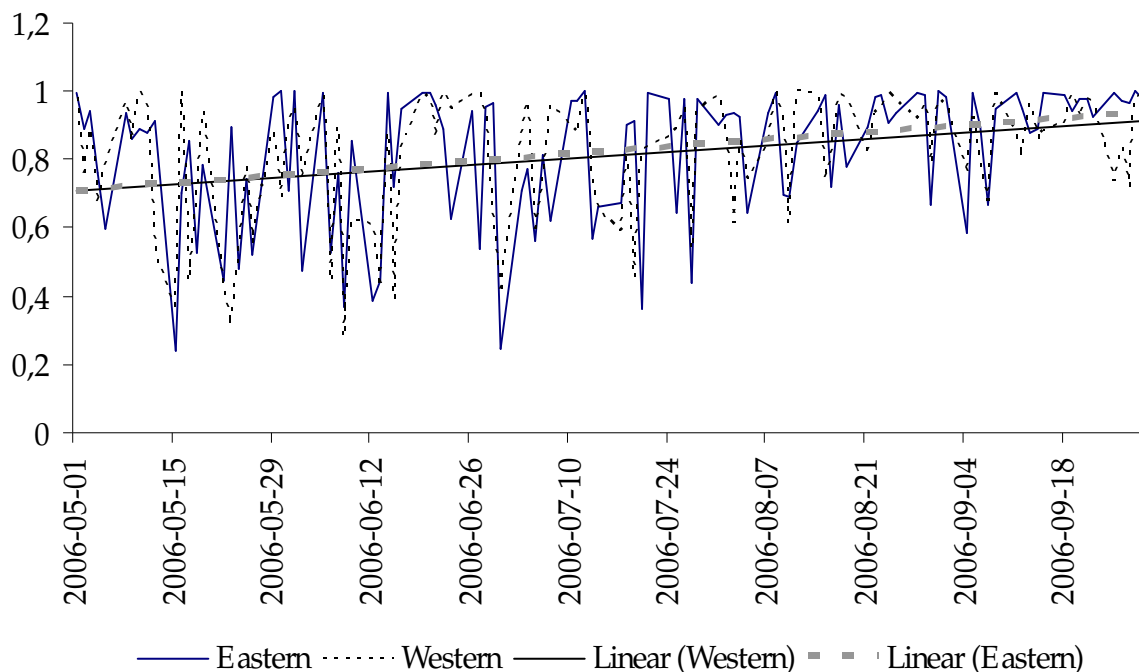
Figure 6.8. Daily cross-sectional correlations and trend lines for Eastern and Western Europe from 1ˢᵗ May 2006 – 29ᵗʰ September 2006.

The first real depreciation in the Swedish stock market was spotted in mid-May: On May 17th the Swedish market fell 4.45 % and a week later the market fell another 4.31 %. [44]

In mid-May both Eastern and Western Europe also showed more volatile cross-sectional correlations than at any other point during the crisis period, which is illustrated in 6.8. The cross-sectional correlation became less stable as the crisis hit the market and the countries in the two regions stopped co-moving. As the financial market correction died out throughout the succeeding months, the cross-sectional correlation also became less volatile and started increasing in both regions.

6.3.2.a Eastern European cross-sectional correlations during the financial market correction

The null hypothesis stating that the coefficient b is zero is set up for Eastern Europe.

H_0: $b = 0$

H_1: $b \neq 0$

The regression equation for the Eastern European sample during the crisis is seen in equation (6.9).

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[44] See figure 4.5 for Sweden

$$\rho_t = a + b\rho_{t-1} \qquad\qquad (6.9)$$

a = 0.834

b = -0.016

The R^2 value is 0.03 %. The mean cross-sectional correlation in East during this period is 0.8221. The standard deviation is 0.1066. The p-value of the regression equation is 5.14 % and we fail to reject the null hypothesis of the equation. The coefficients are therefore not statistically significant with the 95 % confidence interval and with the small R^2 value the data are not reliable enough to base any analysis on. We can conclude that the cross-sectional correlation has not changed during the crisis if we choose to use a 95 % confidence interval like we have done throughout the rest of the thesis.

6.3.2.b Western European cross-sectional correlations during the financial market correction

The null hypothesis stating that the coefficient b is zero is set up for Western Europe.

H_0: b = 0

H_1: $b \neq 0$

The regression equation for Western Europe during the crisis is shown in equation (6.10). The null hypothesis remains the same as in sections 6.2 and 6.3.

$$\rho_t = a + b\rho_{t-1} \qquad\qquad (6.10)$$

a = 0.664

b = 0.181

The R^2 value is 3.28 %. The mean cross-sectional correlation in West during this period is 0.8089. The standard deviation is 0.1216. The p-value of the equation is 5.86 % and again, we fail to reject the null hypothesis and the coefficients are insignificant at the 5 % significance level. However, the p-values in East and West are both close to the critical value of 5 %. There is no significant change in the cross-sectional correlation during the financial market correction.

6.3.3 Eastern and Western cross-sectional correlations during the financial market correction

When comparing equations (6.2) with (6.9) and (6.4) with (6.10), we notice that the coefficients of ρ_{t-1} are larger for the whole sample than for the crisis period. Eastern and Western European correlations at t are therefore less dependent on correlations at $t-1$ during the financial market correction than during the full ten-year period and hence they are also more volatile.

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As Harvey (1995) stated that countries are more sensitive to local rather than global information, a crisis in a Western European country would affect Western more than Eastern Europe. However, we see that the Eastern correlation is slightly higher than the Western during the Swedish crisis, which means the Eastern countries are more equally affected by the crisis, while the Western European countries all react differently to it. This is certainly a surprising result as we would expect the markets closer to Sweden to react more like the Swedish market.

The mean cross-sectional correlations during the crisis are about the same size as those seen when studying the whole sample. Eastern Europe shows a slightly higher average correlation [45] and Western Europe a slightly lower one [46] during the crisis. However, the differences are so small that accusing them of being examples of correlation breakdown (Eastern) or reversed correlation breakdown (Western) is redundant. The R^2 values are much lower during the crisis than for the whole sample. [47] The low R^2 values can most probably be explained by the large volatility in the crisis correlation.

In fact, both regions see large increases in the correlations' standard deviations during the crisis period compared to during the whole sample. The Eastern European correlation standard deviation increased with 57% during the financial market correction. The equivalent growth figure in Western Europe is 48 %.[48] This means that the correlation is much more volatile during the crisis. It is especially true for West, which is the most volatile region from a cross-sectional correlation perspective, even during the crisis. Byström (2003) explained that cross-sectional correlation volatility quite frequently increases in studies containing many independent observations, which is the case for the unsmoothed crisis sample. When smoothing the daily correlations into weekly averages the volatility usually decreases. In this thesis, the volatility decrease seen when smoothing the crisis sample was minimal though, and therefore neglected. The conclusion that the cross-sectional correlations are more volatile during the crisis period than during the full time period is therefore drawn.

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[45] Crisis: 0.8221. Full sample: 0.8152
[46] Crisis: 0.8089. Full sample: 0.8145
[47] Eastern crisis: 0.03 %, Eastern full sample: 9.59 %. Western crisis: 3.28 %, Western full sample: 38.8 %.
[48] Eastern crisis: 10.7 %, Eastern full sample: 6.8 %. Western crisis: 12.2 %, Western full sample: 8.2 %.

7

Conclusions

This section wraps up the thesis and points out the key results of the study.

The thesis aimed to discuss and compare the risk level in portfolios of only Eastern or only Western European market indices by studying the correlation within each one of the portfolios. Two correlation methods were used: the traditional time-series and Solnik and Roulet's cross-sectional correlation. The cross-sectional correlation has proven to be more suitable than the traditional time-series correlation for this thesis' purposes. When the aim is to compare several markets to each other over a time period and tracking specific events in time, for example a financial market correction, the cross-sectional correlation definitely out-performs the time-series correlation.

The thesis has resulted in the Eastern and Western European portfolios having similar cross-sectional correlations between their assets during the full ten-year period. Since the cross-sectional correlations in both regions are very high, the risk exposure is high as well. [49]

Although the time-series correlation is not the most suitable measurement for this thesis, it is higher in the Western than in the Eastern portfolio. In previous correlation studies, like Divecha et al (1992), mature markets have proved to be more correlated than emerging markets, which is also the result of this study. However, the portfolios should ideally be mixed with assets that are less correlated to further decrease the portfolios' risk exposure.

The cross-sectional correlation volatility is higher in the Western than in the Eastern sample. It implies that predictions of future outcomes in the Western portfolio are harder to make and will result in less precise forecast estimations. The Eastern portfolio is therefore preferred when studying the portfolios' correlation forecasts.

On the other hand, for investors solely studying stock returns, and not correlations, it is of interest to know that the Eastern European portfolio is more volatile in the stock returns. However, neither the maximum nor the minimum index prices in either of the portfolios are found during the financial market correction. Instead, the portfolios have been more volatile before or after this specific time period. This does not mean that there has not been any effect of the market correction on the countries in the sample. Especially Hungary, Poland, Romania and

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[49] The correlations are approximately 0.81. Eastern Europe is only slightly higher than Western Europe.

Norway have suffered from large drops on their stock markets. It was only in Estonia, Czech Republic and Italy that the crisis had a minimal effect. Even if the Eastern portfolio suffered more from large index drops, it recovered faster from the decrease seen in May 2006. This result is aligned with Patel et al (1998) who stated that emerging markets suffer more from the occurrence of a crisis, but when Patel et al saw that emerging and mature markets got back to old price levels at the same moment in time, I did not. In this thesis Western Europe recovered after a longer time period, which was also concluded by Michelfelder et al (2005) in their study.

The Eastern European correlation during the financial market correction is higher than that of the Western markets: the Eastern countries react more similarly during the crisis than the Western countries do. Since the crisis took place in Sweden this is a surprising result. According to Harvey (1995), markets which are geographically closer to the event should react more alike. Instead, both regions have increased volatility during the five-month period, and it is Eastern Europe which is the most correlated region during the market correction. Western Europe, on the other hand, shows higher correlation volatility. All data during this time period are less significant than during the full time period.

Due to previous studies by Byström (2003) resulting in reversed correlation breakdown when basing all calculations on formula (3.2), I expected to see some reversed correlation breakdown in this study as well. However, there is no significant evidence of that being the case during the crisis period. None of the mean portfolio correlations change remarkably during this specific time period. Both portfolio correlations do however increase over the ten-year period.

The study takes the perspective of international investors trading in US dollars, basing their decisions on the amount of risk, i.e. the portfolio correlation, they are exposed to. Both portfolios have similarly high correlations during the full ten-year period as well as during the financial market correction, but since the correlation volatility in the Eastern portfolio is lower and future correlations are easier to predict, the investors are better off investing here. However, the best investment choice would be to form a new portfolio of even less correlated assets to decrease the high portfolio correlation. The volatility should also be kept low.

Any researcher that aims to replicate this study should preferably take other and more markets into account, weight the markets in the portfolios according to their importance in the world economy and re-weight at every t to make sure the study represents the real world.

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Appendix A

1. Descriptive statistics

1.1   Daily returns, table with whole period and crisis.

1.1	CRISIS		WHOLE SAMPLE	
Daily returns	**EAST**	**WEST**	**EAST**	**WEST**
Mean	- 0.0006	- 0.0001	0.0004	0.0004
Standard error	0.0018	0.0015	0.0003	0.0002
Standard deviation	0.0176	0.0144	0.0130	0.0116
Kurtosis	2.3594	1.4903	3.0812	2.2094
Skewness	0.4237	- 0.2296	-0.3240	-0.2786
Max value	0.0689	0.0425	0.0689	0.0585
Min value	- 0.0446	- 0.0492	-0.0955	-0.0535
P-value	0.0035	0.0029	0.0005	0.0005

1.2   Cross-sectional correlations: smoothed and not smoothed during the crisis as well as smoothed during the whole sample.

1.2	CRISIS not smoothed		CRISIS smoothed		WHOLE SAMPLE	
Correlations	**EAST**	**WEST**	**EAST**	**WEST**	**EAST**	**WEST**
Mean	0.8221	0.8089	0.8216	0.8116	0.8152	0.8145
Standard error	0.0245	0.0279	0.0239	0.0253	0.0064	0.0077
Standard deviation	0.1066	0.1216	0.1095	0.116	0.0678	0.0824
Kurtosis	- 1.0446	0.3625	-0.8446	0.7496	0.8141	0.6755
Skewness	- 0.2008	- 0.9498	-0.4211	-1.0489	-0.8587	-1.0445
Max value	0.9811	0.9576	0.9811	0.9576	0.9381	0.9479
Min value	0.6187	0.5149	0.6187	0.5149	0.5707	0.5797
P-value	0.0514	0.0586	0.0499	0.0528	0.0126	0.0153

Appendix B

Price decreases during the financial market correction in Eastern and Western Europe.

EAST	Largest daily price decrease	Date	Largest total price decrease since 1st May 2006	Date	Date of price recovery	No. of days to recover
Czech	-8%	8/6	-15%	23/6	27/7	34
Estonia	-3%	8/6	-15%	15/6	30/8	76
Hungary	-6%	12/6	-30%	20/6	13/11	146
Poland	-7%	15/5	-26%	23/6	13/10	112
Romania	-6%	15/5	-21%	26/6	27/7	31
AVERAGE						**80**

WEST	Largest daily price decrease	Date	Largest total price decrease since 1st May 2006	Date	Date of price recovery	No. of days to recover
France	-10%	24/7	-12%	13/6	30/8	78
Germany	-4%	9/6	-13%	13/6	4/10	113
Italy	-3%	8/6	-10%	22/5	13/6	22
Norway	-7%	8/6	-19%	13/6	4/12	174
Sweden	-6%	8/6	-16%	13/6	13/9	92
AVERAGE						**96**