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BASIS RISK IN FINNISH STOCK INDEX FUTURES

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1 INTRODUCTION

One of the growing product groups in the field of finance are different derivative instruments. Stock index futures are part of the group of equity futures. For an investor holding a portfolio of Finnish stocks, one way the hedge the position is to use stock index futures.

If investor prefers to hedge the portfolio with futures, obtained futures position often requires a cross hedge, where futures contract doesn't mach the underlying portfolio. Another difficulty is to adjust the timing of the hedge; using futures this means taking short/long positions and closing the hedge before the delivery month of the contract. These difficulties expose investor to *basis risk*. This variety between futures and cash price is determined by futures market price minus current spot price (which should be the expected futures price). Increase in volatility of the underlying index, increases investors demand for hedge. Rise in volatility should increase open interest in futures contracts and therefore reflect into futures prices.

Several papers have studied relationships between stock and futures markets. Chen et al. (1995) studied effect of stock volatility to basis risk and open interest in S&P 500 futures contracts. Figlewski (1984) examined basis and different sources of basis risk also with S&P 500 data. The presence of basis risk where tested against hedging performance of futures contracts. Chan (1992) tested the lead-lag relationship between cash and futures market and how lead-lag patterns vary with changing conditions. General results of earlier study have shown that, futures lead cash market, unsystematic risk(basis) affects hedging performance, main sources of basis risk arises from duration of the hedge and time-to-expiration, basis decreases when volatility of underlying index increases whereas open interest increases with the volatility of cash index.

However, testing basis risk with Finnish data enables updated field of research. Hietala et al. (1994), (2000) studied Finnish stock index futures, offering explain to continuous under pricing of Finnish index futures compared to theoretical pricing. Different approaches have been used when explaining the differences like market restrictions and information lags. Puttonen (1992) tested put-call-spot parity and put-call-futures parity and the possibility of index arbitrage. In general, previous testing has been carried out with relatively old data. The data of previous testing have usually obtained from the end of the 1980's to beginning of 1990's. Regulations of Finnish capital markets have changed, making short sales possible compared to earlier studies. Basis risk is tested with newer data and more topical results are tried to obtain. Main results with Finnish data show that short sale constraint cause deviation in futures pricing and make stock prices less informative

In this paper, the behavior of the basis risk is studied in Finnish stock index futures. It's also examined how changes in volatility of the underlying index affect the basis risk. Magnitude of basis risk is tested as function of it's deviation from its own theoretical value and index change. Other testing measures the how basis risk is affected by index returns and possible lead-lag effect between futures and cash market.

Thesis is structured as follows, Section 2 covers theoretical background of futures pricing, explaining pricing models, index arbitrage, basis risk, price patterns and features of futures prices. In Section 3 we begin the empirical part of this thesis by presenting the data for testing basis risk. In Section 4 research methodology and results are introduced. Finally, Section 5 summarizes the different parts of this thesis.

2 THEORETICAL BACKROUND

To understand aspects behind basis risk, it's necessary to clarify theoretical futures pricing. This section covers the theoretical background of pricing of the futures contracts. Pricing of the contracts are illustrated by presenting *the cost of carry* – model. Other perspective is considering futures price trough *expected futures spot price* meaning the futures price today. In case of mispricing or market failure we define the possibility of *index arbitrage*. *The basis risk* gives an explanation of the deviation between futures and cash prices when the difference is not caused by mispricing.

2.1 Pricing of the futures contracts

The basic model for implementing the relationship between futures prices and spot prices is *the cost of carry*. The cost of carry model assumes no transaction costs, same tax rate for all investors, lending and borrowing can be done with the same risk free interest and investors take the opportunities for arbitrage profits as they occur. Using the model it is possible to define the theoretical price of the futures contracts. Model measures the storage cost of holding the asset and the interest for financing the asset with also the income earned during the holding of the asset (dividends etc.). For an asset that pays no dividend the cost of carry is simply *r* because there are either no costs of holding the asset or income earned. The cost of carry model for an investment asset can be modeled as follows (Hull, 2006):

(1) $$F_0 = S_0 \times e^{cT}$$

Where F_0 is the futures price when it's been purchased, S_0 is the spot price of the underlying asset at the same moment (t=0), *c* presents the cost of carry, and *T* is the futures maturity. Stock indices can be considered as an asset that pays dividends (except cross currency index derivatives, *quantos*[1]) so the cost of carry for stock index futures is $r - q$, where q is the dividend yield. The equation can be rewritten as:(Hull, 2006)

(2) $$F_0 = S_0 \times e^{(r-q)\times T}$$

The dividend yield q in the equation varies in practice within different maturities. Dividends are usually paid in certain dates of the year so the chosen value for q should be annualized dividend yield for the maturity of the contract. (Hull, 2006)

One approach which explains the relationship between futures prices and spot prices are the expectations concentrated on the futures spot price (S_t), in other words the futures price today (F_0). If the expected futures spot price diverges from futures price it creates opportunities for speculative investors. The connection between expected futures spot price and futures price can be written:
(Kolb et al., 2006)

(3) $$F_{0,t} \approx E_0(S_t)$$

Where $E_0(S_t)$ is the expectation at $t=0$ of the futures spot price at time t. If the relationship between prices doesn't hold true, two reasons can be expressed if the reason isn't mispricing of the futures contracts. *Transaction costs* and investors *risk aversion.* For investor entering the futures contract does always cause transaction costs and because of these costs futures price can diverge from expected futures spot price. Futures market participants can be categorized into hedgers and speculators. Hedgers enter the futures contracts to reduce risk of their position, while speculators enter the contracts for a hope of profit. Investors who are risk averse are

[1] For more information see Hull (2006)

willing to be exposed to the investment risk only if the expected profit of taking the position compensates the risk. Most of the investors can be considered as a risk averse investors. (Kolb et al., 2006)

2.2 Index Arbitrage

If the cost of carry model doesn't hold, mispricing gives a possibility for an *index arbitrage.* Before index arbitrage is conceivable, markets must contain certain liquidity. In theory, it must be possible for investor to trade both the index futures and the asset portfolio of the underlying index simultaneously with trading volume which matches the investor's position. (Hull, 2006) Replicating the index with selected portfolio is also a condition for successful arbitrage. In practice, this kind of a portfolio can be formed but changing the portfolio structure by buying and selling the securities can be difficult to carry out when it is necessary.

Considering the situation that investor has a long position in stocks of the underlying index. If $F_0 > S_0e^{(r-q)T}$ investor should short futures contracts and remain the obtained long position on stocks. If $F_0 < S_0e^{(r-q)T}$ arbitrage profits can be made in this case selling (or shorting) the stocks from the portfolio and taking the long position in futures contracts. For the portfolio that consist of a sample of stocks of the underlying index that has relatively large amounts of securities, index arbitrage can be made by trading relatively small portions of stocks whose returns replicates the most of the index returns. (Hull, 2006)

Puttonen(1991,1992) studied in index arbitrage with Finnish stock index derivatives. Tests were committed as ex-post tests and several deviations from theoretical futures value were reported. Lack of short sale possibility caused a possibility for arbitrage profits even after transaction costs.

2.3 Basis Risk

When investor takes a position in futures contract, few aspects of using futures make hedging in practice more complex than it seems. It may not be possible for hedger to obtain such a position in futures which matches exactly the underlying asset to be hedged. Timing of buy/sell decisions cause uncertainty and the position in futures may have to be closed before its expiration date. *Basis risk* is defined to be the risk that arises because of matching and timing problems in hedging with futures. The basis risk is difference between spot price of the hedged asset and the price of the futures contract. (Hull, 2006)

(4) ***Basis = Futures price – Spot price***

Equation 4 is the basic definition of the basis risk of a financial asset. When futures contract matches the underlying asset and the contract is closed in delivery date, basis risk should be equal to zero. Before the delivery date basis can fluctuate with the asset price movements and have negative and positive values. The longer the maturity left to time-to-expiration is, the more fluctuations is caused by the basis risk. *Basis strengthens* when spot price rises faster than futures price and on the opposite *basis weakens* when futures price rises faster than spot price. (Hull, 2006)

According to Figlewski (1984) basis risk is a result of mislinkage between spot and futures markets. The longer the holding period is the less basis risk should affect hedging performance. Also dividend risk has small meaning in hedging performance and basis risk. Figlewski also found that, basis risk had a remarkable effect in hedging performance

2.4 Price patterns of futures

It is important to understand the different operation models for different investors in context of futures pricing. Let us assume that speculative investors are rational. Speculators make assumptions on expected future price using the information available. Because of these expectations, speculators make infrequent mistakes in forecasting future spot price. If the prevailing future price would always equal price for expected future spot price, there would be no reason for investor to speculate in futures market. When futures price would equal the expected spot price, speculator wouldn't achieve any additional profit with increased risk by entering futures market with the possibility of expectation error. When comparing hedgers and speculators as a group, for every hedged position there must be an opposite position. This scene happens when futures price differs from spot price, rationalizing positions for hedgers and speculators. So if hedgers are on the short side of the contracts, speculators on the whole must hold the long side. (Kolb et al., 2006)

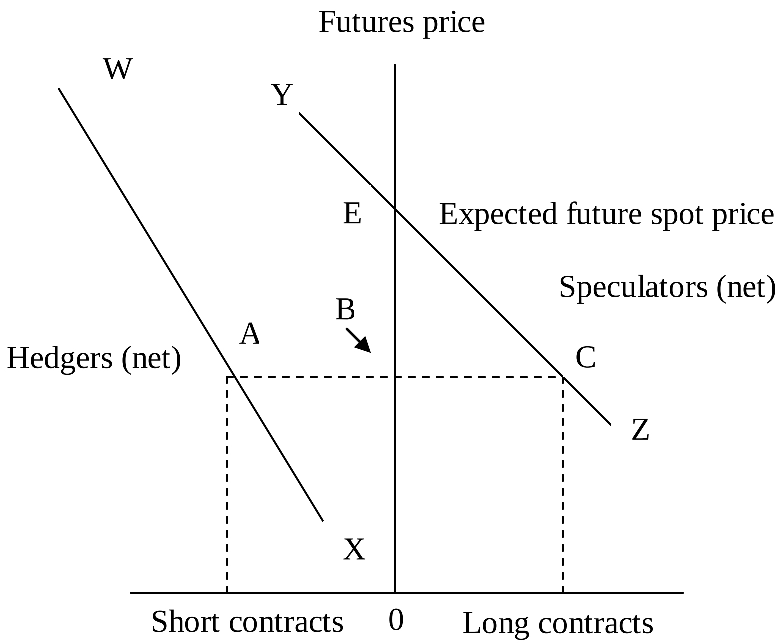

Figure 1 – Hypothetical Net Positions (Kolb et al., 2006)

Figure 1 shows the relationship between hedgers and speculators net positions due to changes in futures price. Price changes in futures leads to changes in the positions held by two groups. For hedger it's assumed that for reducing risk they hold net short positions. Hedger's position is shown in WX line. A rise in futures price leads to increase in short position and the lower the futures price the less hedgers hold short positions. Speculators on the other hand, hold long or short positions dependent of the situation. If futures price equals expected spot price, speculators on the whole hold neutral positions because expectations differences on average lead to neutral holdings. Speculators net positions are indicated in line YZ. When expected futures spot price is below futures price speculators are also net short(in line YE) and on the other hand speculators are net long when expected futures spot price exceeds current futures price. (Kolb et al., 2006)

Yet, all of the positions in Figure 1 are not possible because the number of short and long contracts must equal. For example, when futures price exceeds point E, both sides are net short. This leads to situation that market can clear only with price B. In Figure 1 distance between AB and BC are the same. The greater slope of hedgers line WX is due to greater risk tolerance on speculators. This is reasonable because speculators are accepting larger risk from the hedgers' side. And, it leads to situation represented by Keynes and Hicks, where hedgers are net short and futures price rise during the futures maturity, because basis must be zero at delivery date. (Kolb et al., 2006)

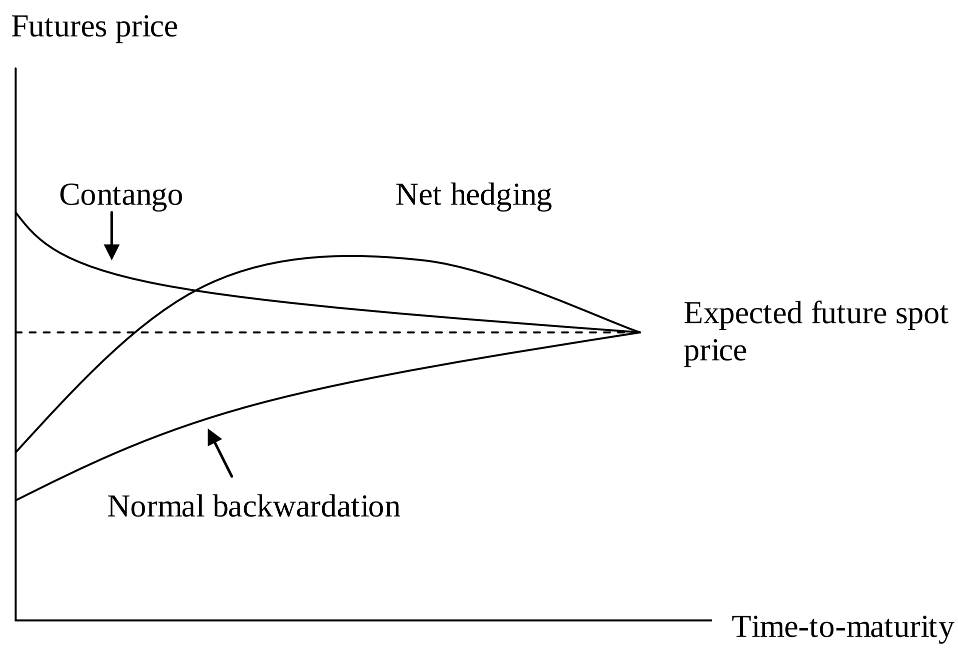

Figure 2 – Price patterns of Futures (Kolb et al., 2006)

Figure 2 shows different price patterns of futures. *Theory of normal backwardation* summarizes connection of rise in futures prices during time-to-expiration and hedgers aspiration of holding short positions as group. In case of hedgers hold long positions, futures price exceeds expected future spot price and futures price will decline to time-to-expiration. This reverse price pattern is called *contango.* However, hedger's positions can change during contracts maturity. In the beginning of the contract hedgers hold net short positions against speculators opposite ones. If the price of futures is less than expected future spot price, hedgers will adjust their position to be net long. Now, the speculators must adjust their positions to consist of short contracts. Futures price have to be now higher than expected future spot price so that speculators would gain return for the change in risk of their total position. This *Net Hedging Hypothesis* leads finally to same price pattern as contango. (Kolb et al., 2006)

Capital Asset Pricing Model can be involved with futures pricing. Systematic risk can be measured with the CAPM by β. Typical regression equation for β can be written:

(5) $$r_{j,t} = \alpha_j + \beta_j r_{m,t} + \varepsilon_{j,t}$$

Where $r_{j,t}$ is the asset return, $r_{m,t}$ is present market return in the same period, α_j is the constant term of the regression equation and $\varepsilon_{j,t}$ is the error term for residuals. Trading in futures market involves systematic risk, but no investment. Marginal payment requirements can't be considered as investment. Because lack of investment, risk-free rate can't be earned, so if futures have zero beta, the position should earn zero return. When futures beta is positive, holding long position should yield a positive return. On the whole, different values of betas have an effect to futures price expectations. Positive beta should present expected rise in futures price, zero beta should signal steady price expectations whereas negative betas should present expected fall in futures price. Results of beta testing in futures prices indicate that futures betas are close to zero. (Kolb et al., 2006)

2.5 Features of futures prices

Several factors can lead to diverge between future and spot prices without cross-hedging issues. Differences might cause deviations in taxation, transaction costs and required margins. Specific relationship between forward and futures prices can be defined trough interest rate correlation with spot prices. If interest rates have positive correlation with spot prices, futures prices should be higher than spot prices. If there is no correlation with interest rates and spot prices, futures price should equal spot price and negative correlation leads to higher spot price compared to futures price. (Kolb et al., 2006)

Futures price distribution is often assumed to be normally distributed. Yet, researchers agree that, in real world variety in futures prices is more leptokurtic than normally distributed. If observations don't follow normal distribution, general proposals are that the observations can follow Parentian distribution or be a combination of different normal distributions. Still, non-normality makes statistical interpretation more complex. Price changes of futures often involve statistically significant autocorrelations, especially with first order autocorrelation. Yet, magnitude of significant autocorrelation isn't large enough create profitable strategies. (Kolb et al., 2006)

Futures volatility can be divided to two categories, how futures trading affect volatility of underlying asset and second the price changes of the futures. Inconsistent opinions are that futures trading increases volatility of underlying asset in some cases, but on the other hand, don't affect or even decreases it. Volatility of futures contract increases to time-to-expiration. This increasing volatility is known as *Samuelsson hypothesis.* According to the hypothesis, following expected futures price should be the same as today's price, so the variation would equal zero following *martingale process.* (Kolb et al., 2006)

2.6 Statistical methods

All returns in empirical testing section are calculated using logarithmic returns. (Brooks, 2005)

(6) $$r_t = \ln(\frac{p_t}{p_{t-1}})$$

Regression equations are built to explain basis risk and method for ordinary-least-squares is used. As a least squares principle, estimated equation should fit in a line with data values as best as possible. Sum of squares of the vertical distance of each to the fitted line should be as small as possible. Squared distances are used to offset negative values. As a result, intercept and slope of this line are found. General regression equation can be written

(7) $$\hat{y} = b_1 + b_2 x_t$$

where values of b_1 and b_2 are coefficients, b_1 being the interceptor and b_2 is coefficient for explanatory variable. Equation is easily extendable by adding more explanatory variables. (Hill et al., 2001) Equation 8 shows the vertical distance from data values to regression line called as *least squares residuals*.

(8) $$\hat{e} = y_t - \hat{y}_t = y_t - b_1 - b_2 x_t$$

Ordinary least squares regression can be used when residuals shows no autocorrelation. Durbin-Watson statistic measures the first-order autocorrelation of residuals. Durbin-Watson test is showed in equation 9

(9) $$DW = \frac{\sum (e_t - e_{t-1})^2}{\sum e_t^2}$$

Where values of e_t stands for regression residuals. As a rule for interpretation of DW-stat, if test statistic is 2, there are no positive autocorrelation and if its 0 there are perfect positive autocorrelation and if its 4 there perfect negative autocorrelation. (Watsham et al., 2002)

3 DATA

Case data is obtained from *Datastream* – online database and using OMX25 (FFOX) – index futures with the time period of 9/1999 – 12/2002. Time frame is selected because of Finnish stock markets went trough large decline. Period known as *the techno bubble* – burst in the end of year 1999 and the decline of OMX25 – index lasted till the middle of the year 2003. Market conditions in Finnish stock market could be described as a bear market. In these market circumstances investor's motives to hedge their portfolio should have increased.

3.1 OMX25 futures series

Selected futures consist of 12 different futures contracts. OMX25 – futures are traded in Eurex – exchange which is located in Frankfurt, Germany. (Eurex-a) and contract specifications can be seen in Table 1;

Table 1 - Contract specifications of OMX25 futures

Contract specification's	
Maturity	Up to 9 months
Contract value	10 euros per index point
Minimum price change	0.1 point equals 1 Euro
Settlement	In cash by first trading day after closing
Daily settlement price	Derived from volume-weighted average of all transactions in last minute of trading

Logarithmic returns of futures series were calculated and descriptive statistics are shown in Table 2. Distribution of returns is tested with Bera-Jarque values. (Brooks, 2005) Statistic show that returns are not normally distributed as it's common according to theory section. Distributions seem more flat than normal distribution and are in some cases negatively skewed and on the other hand positively in some of the series. Futures returns also show negative mean returns, largest negative mean return is achieved with September 2001 series and only positive return with June 2002 series.

Table 2 – Descriptive statistic of futures series logarithmic returns

	Mean	St. Error	Variance	Kurtosis	Skewness	Size	Conf.I.(95%)	Bera-Jarque
MAR00	0,0000	0,0034	0,0006	1,0330	-0,8637	55	0,0068	15,7050
JUN00	-0,0010	0,0023	0,0007	0,4143	-0,3799	120	0,0046	36,3150
SEP00	-0,0012	0,0017	0,0005	0,7921	-0,4467	185	0,0034	43,7290
DEC00	-0,0017	0,0017	0,0005	0,7610	0,2410	194	0,0033	42,4000
MAR00	-0,0028	0,0016	0,0005	0,8438	0,3054	194	0,0031	40,5960
JUN01	-0,0026	0,0017	0,0005	0,5444	0,4313	194	0,0033	54,7550
SEP01	-0,0036	0,0015	0,0004	0,3981	0,2397	196	0,0030	57,1650
DEC01	-0,0004	0,0014	0,0004	0,5541	0,1973	199	0,0028	50,8980
MAR00	-0,0001	0,0013	0,0003	1,0050	0,2145	194	0,0025	33,6610
JUN02	0,0008	0,0010	0,0002	0,6982	0,4915	193	0,0020	50,3770
SEP02	-0,0015	0,0010	0,0002	0,5682	0,0215	191	0,0020	47,0800
DEC02	-0,0013	0,0011	0,0002	0,5178	0,1026	199	0,0022	51,4380

3.2 OMX25 Index

OMX25 –Index consist of 25 largest stocks measured with market value in OMXHelsinki- index. Performance of the OMX25 Price – index is shown in Figure 3. Index shows a large declining trend from the early of year 2000 until to near end of 2002. Index value decreases from approximately 3500 points to 1100 with a total price drop of 68.5%. Stock markets decline starts to balance in the beginning of year 2002.

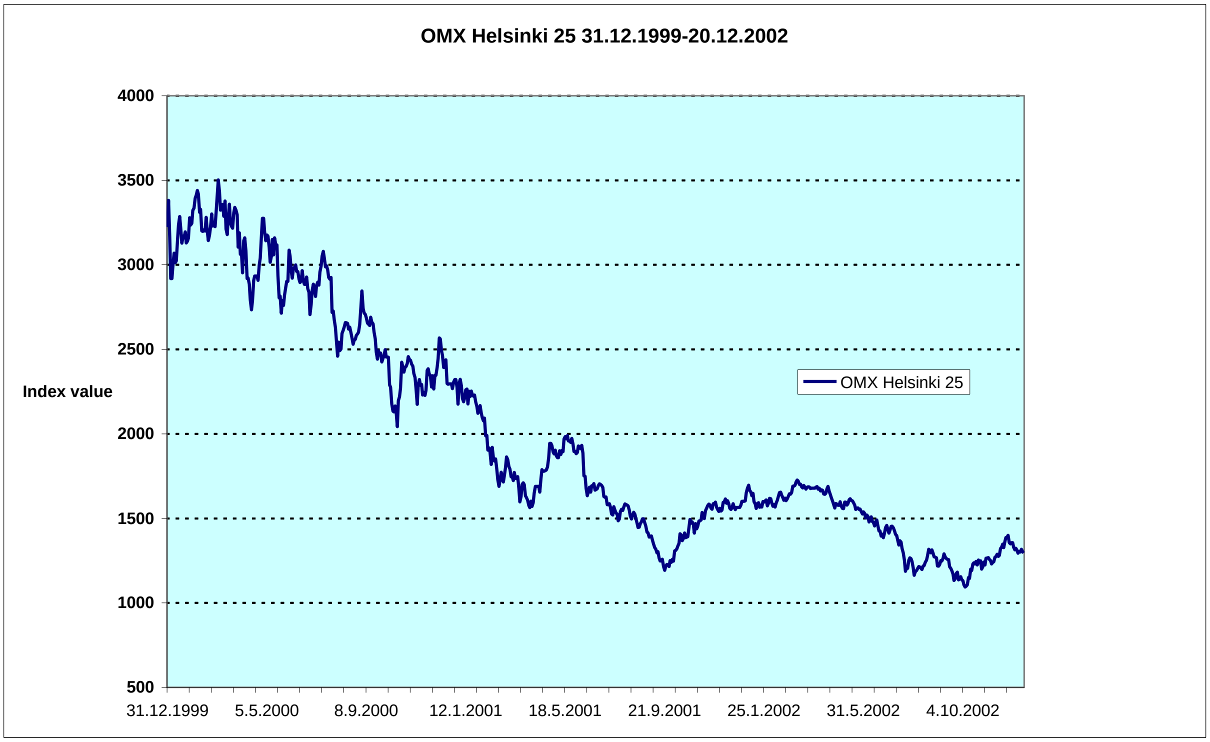

Figure 3 – Performance of OMX25 Index

Table 3 shows descriptive statistic from logarithmic returns of OMX25 Price Index returns. Mean return in selected time period has been -7.2% which is a relatively large decline. Index volatility is 184% which concludes the other evidence of market crash. Again, index returns are not normally distributed according to Bera-Jarque test statistics.

Table 3 – Descriptive statistic – OMX25 Price Index logarithmic returns

Descriptive statistic - OMX25 Price Index logarithmic returns	
Mean return	-0,0723
Standard Error	0,0006
Standard Deviation	1,8412
Sample Variance	0,0003
Kurtosis	1,7611
Skewness	-0,1396
Minimum	-0,0799
Maximum	0,0723
Bera-Jarque	31,4926
Confidence Level (95,0%)	0,0011

4 RESEARCH METHODOLOGY AND RESULTS

Performed tests for explaining the basis risk are taken from studies by Figlewski (1984) and Chen et al.(1995) and a part of these tests are replicated with Finnish data. Theoretical prices are needed for to calculate theoretical basis which is needed in testing. Objective is to test and view basis risk.

4.1 Cost of carry

Theoretical cost of carry –prices are calculated for each of the series using daily observations. Theoretical prices are needed later on with testing basis risk. OMX25 Price – index is used as an underlying index. Price index is picked because total return series are available for OMX Helsinki but not with this sub index.

Pricing equation includes a power component consisting of risk free rate r and dividend yield q. In calculations, daily values of 12 month Euribor is chosen and day counting actual/360 is used (Vaihekoski, 2004). Puttonen (1992) uses closest time-to-maturity rate in his paper. Although, it is stated that deviations are minimal. In this paper calculations are simplified by choosing 12 month rate with chancing day counting instead exact rate which is not available. Dividend yield is not included to calculations. Price index is used as a spot price so dividends are excluded because of complex measurement. Figlewski (1984) examines hedging performance and basis risk stating that dividend risk has a small affect in overall hedging performance and basis risk.

4.2 Basis risk

Basis risk is calculated futures price lessen the spot index price. Values of basis are calculated daily basis to all of the collected series. Correspondingly, theoretical basis is calculated by deducting index value from calculated cost of carry –values. Figure 2 presents the behavior of the price differences between futures and cash market. Continuous values of basis are formed using series closest-to-expiration.(Chen et al.1995) Trading of the next future contract after closet-to-expiration seemed to start less than 30 days on average before delivery date of current contract. Also to prevent thin trading, rolled-up basis is structured.

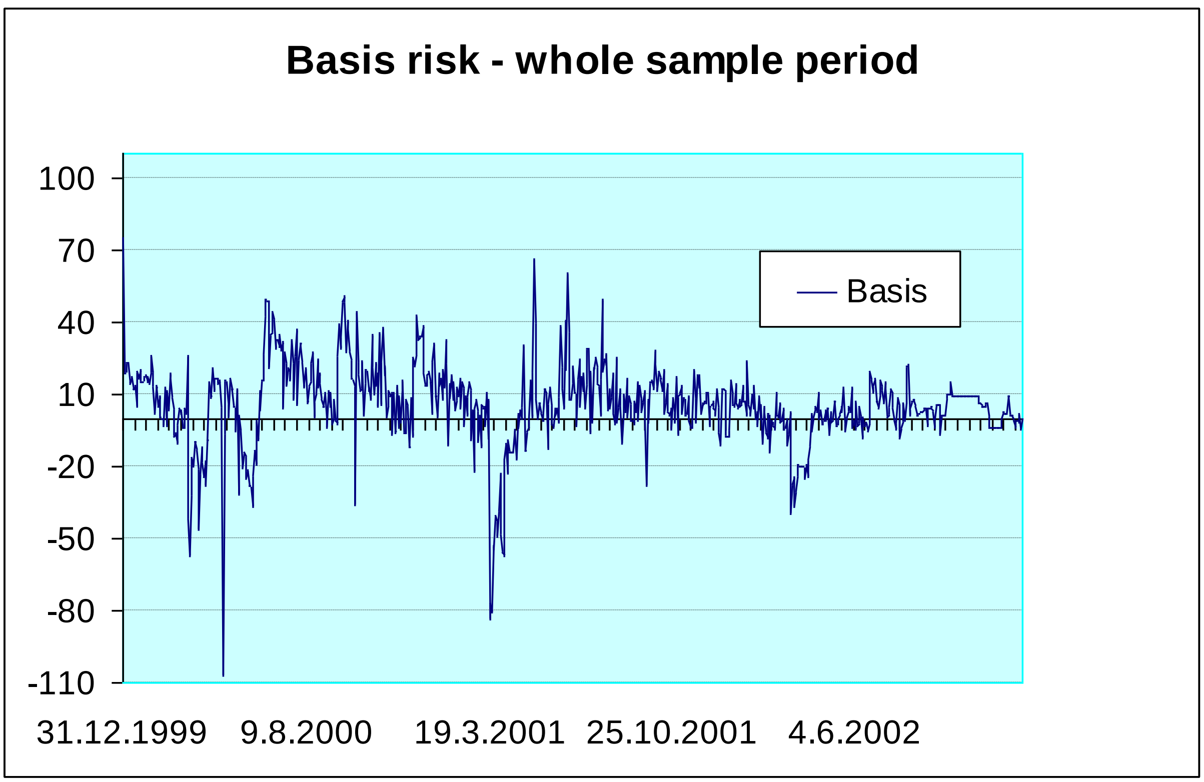

Figure 4 – Basis risk with whole sample period

As seen Figure 4, price difference fluctuates heavily, especially within first half of sample period. Largest deviations are around -110 index points to approximately +70 index points. For example, -110 points basis means -1100 € price difference per futures contract. Even though it's an outlier example, but as seen Figure 4 these kinds of fluctuations happened with very short timeframe. In Figure 5 theoretical basis is drawn for comparison.

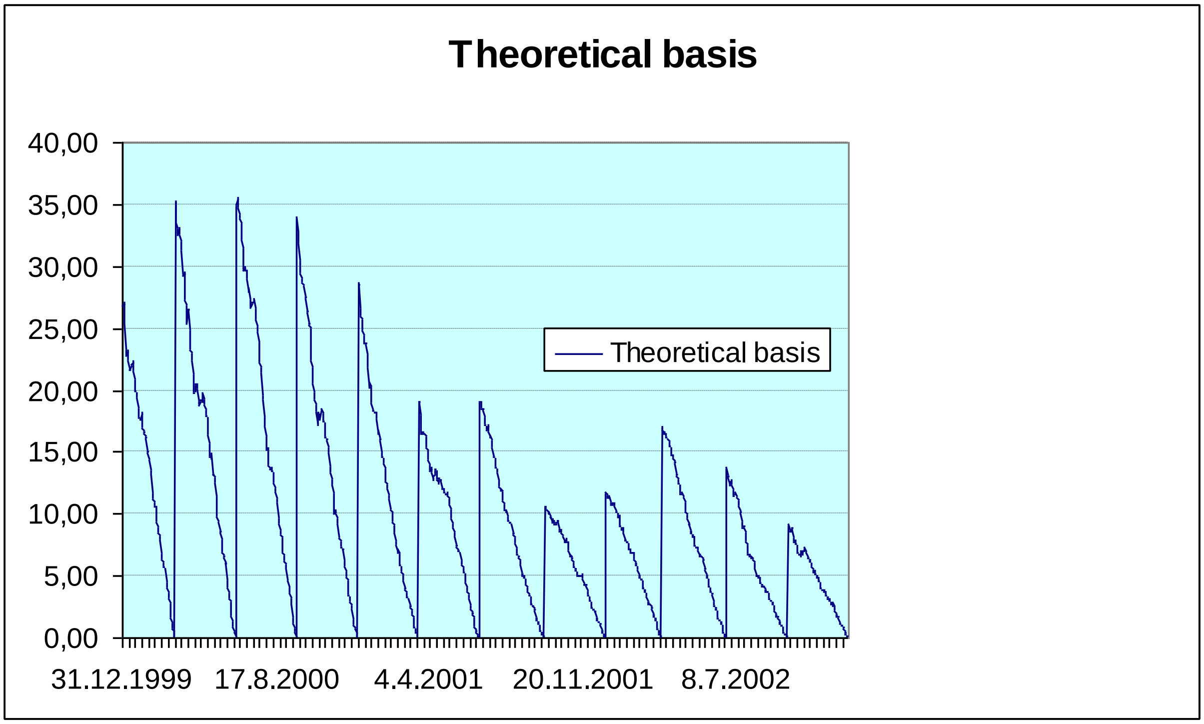

Figure 5 – Theoretical basis for whole sample period

In Figure 5, theoretical basis deviates totally of what seen in Figure 4 with real prices. First of all basis does not get any negative values, because of calculation formula used. Index was multiplied with *e* power of rate multiplied with maturity which leads values of futures with price pattern of contango as seen in theoretical section. Results are surprising compared to real deviations. With real basis, the price difference does not equal zero even in the end of maturity like with theoretical prices. Of course, some simplifications are included to calculations but this deviation can be due to transaction costs.

4.3 Explaining basis

We start building a test to explain basis by performing regression presented by Figlewski(1984). In his paper, Figlewski explains that basis tend to overreact due to changes in the cash market. Regression is built to test how basis is affected by change from its theoretical value and change in the underlying index.

(9) $$B_t - B_{t-1} = C_0 + C_1(B_t^e - B_{t-1}) + C_2(I_t - I_{t-1})$$

In equation 9, $B_t - B_{t-1}$ represents the change in basis risk from its last value, $B_t^e - B_{t-1}$ is the deviation of basis risk from its theoretical value to previous realized value and $I_t - I_{t-1}$ measures the affect of index change due to basis risk. Figlewski found explanatory variables to be very significant and basis increased with market and other way around. Basis changed approximately 40% from yesterday's level. Table 4 shows the results of regression.

Table 4 – Results of regression $B_t - B_{t-1} = C_0 + C_1(B_t^e - B_{t-1}) + C_2(I_t - I_{t-1})$

Variable	Coefficient	Std.Error	t-Statistic	Probability
Constant	-1.705	0.456	-3.736	0.0002
$B_t^e - B_{t-1}$	0.294	0.025	11.508	0.0000
$I_t - I_{t-1}$	-0.063	0.009	-6.653	0.0000
R-squared	0.198			
Adjusted R-squared	0.196			
Durbin-Watson	2.350			

Obtained test results do not reach the same level compared to Figlewski (1984). Adjusted R-squared drops to 19.8% which can be considered barely acceptable. All of the variables are statistically significant with satisfying t-Statistic. Durbin-Watson shows no residual autocorrelation. (Brooks, 2005) According to results, basis moved on average 29.4% from previous value to today level. Basis seems to have negative relationship to index movements, but value of coefficient is rather small. Still, constant term is found to be significant which takes away creditability of the results. Even though questions can be raised against explanatory power of results, guidelines are in line with Figlewski's interpretation. Cost of carry –calculations can be one reason causing drop with the explanatory level. Figlewski also tested hedging performance with different holding periods and basis risk effect on hedging. Basis risk affected within hedge duration and time-to-maturity of contracts.

Next we continue by testing relationship with volatility and market response between cash and futures market. Chen et al. (1995) claims that futures should present new market information and lead cash market. Because of this lagging reaction, basis should response with market moves. To examine this phenomenon, simultaneous index return and the following days return is included in regression. In addition, Chen et al. find in this same paper that increase in volatility of underlying index depresses values of basis. Original test is made with implied variance, but robustness is tested with using realized variance of cash index 5 days before $(t-5 \ to \ t-1)$ and 5 days after $(t+1 \ to \ t+5)$. Results show no significant difference so the method of realized variance is applied in the regression excluding the day when basis is measured. Equation is structured

(10) $$B_t = C_0 + C_1 B_{t-1} + C_2 B_{t-2} + C_3 B_{t-3} + C_4 Ir_t + C_5 Ir_{t+1} + C_6 \sigma_i^2$$

In equation 10 B_t represents basis risk, B_{t-1} are lagged values of basis within three lags, present index return is written Ir_t and next days index return is presented by Ir_{t+1} and σ_i^2 presents for implied variance. Autocorrelation statistic show significant autocorrelations within over three lags, so three lagged values of basis is included to regression as in Chen et al.(1995) paper. Regression results are shown in Table 5.

Table 5 – Results of regression $B_t = C_0 + C_1 B_{t-1} + C_2 B_{t-2} + C_3 B_{t-3} + C_4 Ir_t + C_5 Ir_{t+1} + C_6 \sigma_i^2$

Variable	Coefficient	Std.Error	t-Statistic	Probability
Constant	1.373	0.730	1.881	0.0603
B_{t-1}	0.488	0.035	13.583	0.0000
B_{t-2}	0.188	0.038	4.870	0.0000
B_{t-3}	0.121	0.034	3.530	0.0004
Ir_t	-127.030	21.081	-6.025	0.0000
Ir_{t+1}	-7.484	21.482	-0.348	0.7276
S^2	-1267.812	1443.524	-0.878	0.3801
R-squared	0.533			
Adjusted R-squared	0.529			
Durbin-Watson stat	2.037			

Results of the second regression are satisfying. Adjusted R-squared is 52.9% which is fairly larger than Chen et al. results. Durbin-Watson shows no problems with residual autocorrelations. Constant term is not significant which supports the equation. Values of lagged basis seem to have strong influence to the value of measurement day. Third lag seem to affect 12% of today's value. Basis seems to last for few days. Index return have strong negative influence in basis, coefficient is significant but shows also large standard error. This result supports coefficient of index change in the first regression. Nonetheless, next days index return is not significant indicating that lead-lag effect of futures and cash market doesn't exist at least for this time frame. Original test were made in 1995 and results showed significant lead-lag effect. Reasonable explanation could develop trading systems, information efficiency due to technological development. Further lead-lag testing should be made with intra-day data. Realized variance shows negative relation to basis but it's not found significant. This can be considered as a backlash for test results. Chen et al. testing were conducted with implied variance and the same results were found with realized values and Wednesday values only. In the same paper they also tested open interest relation to implied volatility and found that open interest is positively correlated with the index.

Intraday lead-lag testing was committed by Chan et.al. (1992). Futures markets were found to be the source of market-wide information. Lead-lag relation is not explained by nonsynchronous trading. The quality of new market information caused different results. Under bad news, no lead-lag patterns were found and under good news, futures market tend lead cash index.

5 CONCLUSION

This paper has provided a theoretical background of futures pricing and empirical testing of basis risk. This price difference is determined by “fair” futures price minus current spot price. Basis risk was tested and modeled with Finnish stock index futures using series of OMX25 -index futures and amount of results were found.

Basis risk has a powerful impact on price changes between to markets. Basis seems to move heavily with market downswings. Testing period was interesting because of current market conditions. Market volatility increased in this sample period due to burst of techno - bubble in the beginning of year 2000. Changes in cash market volatility have negative influence in basis, even though test results using realized variance were not significant. Obviously, using implied variance would be possible to obtain more accurate results.

Yet, basis risk seemed to persist few days in the market. Values of basis were highly autocorrelated and it seemed that third lag still had over 10% effect to today’s values. Price difference between to markets showed negative relationship with index change and index returns. Index returns seemed to have largest influence in basis risk. Basis tend to decrease when market rise and increase when market dropped. However, no lead-lag effect connection between basis and timing differences between two markets were found. Future index returns had no significant effect in basis.

To conclude, investor who considers entering futures markets should adjust his portfolio accordingly to basis risk. Theoretical frame of futures pricing gives pricing models and explanations of behavior of futures prices. Still, theoretical models include several simplifications and as results of this study show that theoretical prices can be hardly compared to actual prices. Because of these deviations and hedging issues, basis risk causes problems for hedger. The price difference between futures and cash markets can be partially explained by few factors as shown in this paper. Despite of given explanations, after presence of lagged values and index change is taken into account, some causes of basis are still left with uncertainty. In overall, basis risks seem to contain far more noise than factors which explain it.

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