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Master's Thesis

Valuation Adjustments of Illiquid Instruments

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Abstract

New regulation changes in the capital requirements directive have led to more stringent demands when calculating the capital base of a financial institute. Two important changes that have been made are concerning prudent valuations and valuation adjustments of financial instruments. The regulations are now formulated such that when estimating the valuation adjustments should several factors be taken into account. The individual factors might be difficult to estimate.

The purpose of this thesis is to suggest a method that can estimate the total valuation adjustment of a portfolio consisting of financial instruments without estimating each of the individual factors. This will be done be using the uncertainty in estimates of underlying market parameters, like volatilities, dividends and correlations. By taking an extreme conservative estimate of the market parameters is it believed that the total valuation adjustment can be estimated.

Keywords: Valuation adjustment, Capital Requirements Directive, Implied dividend, Implied correlation, Uncertainty,

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Contents

1. Introduction

The capital base of a financial institute[1] has the function as a buffer against unexpected losses that can arise from exposed risks. The size of the capital base is regulated by the capital requirements directive (CRD)[2]. The CRD is based on the Basel II framework issued 2004 by the Bank for International Settlements for the purpose to ensure that financial institutes are financial sound and stable. During the financial crisis it became clear that the CRD and Basel II framework was insufficient.

In the beginning of the financial crisis there was a major decrease of market liquidity since investors moved their capital to safer investments. The decrease of liquidity led to that many financial products became less frequently traded which led to an increased use of valuation models. The increased use of valuation models led to more uncertainty in the valuations of the financial instruments due to difficulties in determining whether the inputs for valuation models were reliable and did not represent distressed sales. Since accurate valuations is of great importance for financial institutes in their calculation of the capital base it was realized that some changes and amendments concerning the valuation of financial instruments had to be made to Basel II [1] and the CRD [2]. In Sweden these new changes became effective the last December 2011 in form of issuing a new release of the CRD [3].

1.1 Valuation Models and Uncertainty

Uncertainty in valuations is generally greater for instruments that are more complex, less frequently traded and less standardized. The uncertainty arises from the lack of market prices and that the financial institutes must rely on valuation models. A large part of the uncertainty comes from the difficulties in estimating market parameters (input data) necessary for the valuation models. Since the estimated value from a valuation model should reasonable reflect how the market could price an instrument it is important that the

[1]investment firms and credit institutes

[2]Here the CRD refers to the capital requirements directive used in Sweden, FFFS2007:1, and should not be taken for the capital requirements directive issued by EU, even though they are similar.

parameters accurately reflects the market expectations. For complex instrument are some of the market parameters not directly observable and need to be estimated from other market data. An example is the volatility estimated from the Black-Scholes formula. This market parameter is commonly known as the implied volatility. Due to bid-ask prices the implied volatility can be estimated within two values, one corresponding to the bid price and one to the ask price. This uncertainty in the estimates of the market parameters contributes with uncertainty in the valuation models.

1.2 New Regulations

There are two improvements in the CRD that is of interest for this thesis. The first improvement is a requirement for conservative assumptions when using valuation models [2, 12 kap. 4 §]. The second improvement is the demand for valuation adjustments of financial instrument[3] and less liquid instruments [2, 12 kap. 10-11 §§]. It is believed that these changes will contribute to a more prudent valuation of financial instruments and therefore a better capital base that has the ability to absorb future losses.

The estimated valuation adjustments should include several factors. Examples of the factors that are stated in the paragraphs are unearned credit spreads, investing and funding cost and cost of early termination. For less liquid instrument are market concentrations, time it would take to hedge out the position/risk within the postion, and the availability of market quotes example of factors that should be included in the valuation adjustments. The problem here, which also has been raised by the Swedish Bankers [4], is the lack of clarifications what these factors means. It is also unclear how these factors should be estimated which can cause problems for financial institutes when the valuation adjustments must be calculated.

1.3 Purpose

The purpose of this thesis is to suggest an alternative method to how the valuation adjustments can be estimated without directly estimating the individual factors described in the directives. Important for the method is that it is comprehensive, will work for almost any instrument, effective and easy to implement.

To shortly describe the main idea behind the method let $V = V(p_1, \ldots, p_n)$ be the value from a valuation model using the market parameters $p_1, \ldots, p_n$. Let V^* be the value for a financial instrument after the valuation adjustments are made. The value V^* can also be determined by the valuation model using a set of market parameters, i.e. $V^* = V(p_1^*, \ldots, p_n^*)$. The idea behind

[3] The paragraphs concerns any position in the trading book, but in this report will only financial instruments be considered

the method is to estimate the parameters $p_1^*, \ldots, p_n^*$ directly and therefore get a value where the valuation adjustments are included. The parameters that will need to be estimated are those who are not directly observable in the market. In this report the parameters will be volatilities, dividends and correlations. By using the spreads that the parameters will be estimated within can the boundaries be used to give direction on how $p_1^*, \ldots, p_n^*$ should be determined.

1.4 Clarifications and Limitations

The method is developed to work for so called level 2 and level 3 instruments in the fair value hierarchy [5, paragraph 27A]. Basically the meaning that an instrument is level 2 or level 3 is that the value of the instrument is determined through a valuation model. The limitation is that it is very hard to get real examples of these types of instruments since there exist almost no open markets where the instruments is traded. Therefore will the portfolio used in this report consist of instrument constructed only for the purpose of this thesis.

1.5 Outline

Chapter 2 and 3 are devoted to describe the necessary theory and regulations that are of importance for this thesis. Chapter 4 then follows up with a general description of the method to determine the valuation adjustments. Chapter 5 describes an example portfolio that is used in this report to demonstrate the results.

Chapter 6 describes how volatilities, dividends and correlations can be estimated as spreads from market data. Chapter 7 displays the results of the portfolio and also analyzes sources of bias that could affect the reliability in the results. Chapter 8 ends the thesis with a conclusion and suggestion for further research.

2. Theory

The following chapter will contain the necessary definitions and theory that are relevant for the results in this thesis. A greater part of the this chapter will later on be used for estimating the market parameters in chapter 6.

2.1 Definitions

Volatility

A measure of the uncertainty of the return realized on an asset[6, p.713].

Dividends

A dividend is a cash payment made to the owner of a stock [6, p.704].

Ex-Dividend Date

The last date after which the buyer of a stock is not entitled to receive the next dividend payment [7, p.8].

Correlation

Definition 2.1. *Given two variables X and Y, the correlation between them is defined as*

$$\rho_{X,Y} = \frac{Cov(X,Y)}{\sqrt{Var(X)Var(y)}} = \frac{E[(X-\mu_X)(Y-\mu_Y)]}{\sigma_X \sigma_Y} \tag{2.1}$$

where Cov is the covariance between X and Y, Var is the respective variance, μ_X *and* μ_Y *denote the respective means and* σ_X *and* σ_Y *denote the respective standard deviations of X and Y.*

Correlation describes a linear relationship, in both size and direction, between two variables. In practice is the correlation, often called realized or historical correlation, between two assets determined by using series of each asset corresponding daily log returns. The computed correlation take values between -1 and $+1$. A negative correlation indicates historically that an upward movement for one assets corresponds to a downward movement for the other. A positive correlation indicates historically that both assets have moved in the same direction. Historical correlations for several assets is commonly represented through a correlation matrix $\mathbf{M}_\rho$ given by

$$\mathbf{M}_\rho = \begin{pmatrix} \rho_{11} & \rho_{12} & \cdots \\ \rho_{21} & \rho_{22} & \cdots \\ \vdots & \vdots & \ddots \end{pmatrix}$$

where $\rho_{ii} = 1$ for $i = 1, 2, ..., n$ and $\rho_{ij} = \rho_{ji}$ for all $i, j = 1, ..., n$. A second demand for the matrix $\mathbf{M}_\rho$ to be a correlation matrix is that it is positive definite, i.e. that the eigenvalues of $\mathbf{M}_\rho$ are real and positive [7, pp.106-109].

Fair Value

Fair value is defined in IFRS 9 [8, Appendix A] as

Definition 2.2. *Fair Value: The amount for which an asset or liability could be exchanged between knowledgeable, willing parties in an arm's length transaction.*

In common terms can fair value be seen as a price that independent parties are willing to pay or sell a product for in a transaction that is not forced.

Short and Long Position

A position in a portfolio is often described by using the term short or long. The following definitions are used in the CRD [9, ch. 2]

Definition 2.3. *Long position: a position which increases in value when the value of the instrument or underlying asset increases. A long position also means a position that confers upon or may confer upon an institution the right or obligation to acquire an asset.*

Definition 2.4. *Short position: a position which decreases in value when the value of the instrument or underlying asset increases. A long position also means a position that confers upon or may confer upon an institution the right or obligation to deliver an asset.*

For example: bought put options and sold call options are considered a short position.

2.2 Standard Options

The most common traded options in the market are so called European and American options which often are known as standard options, vanilla options or first generation options. Typical for these options are that they give the buyer the right but not obligation to buy or sell one asset for a predefined price at a certain time [10, p.88].

2.2.1 European Options

The European call and put option is defined as [11, pp.93-94],

Definition 2.5. *A European call option with exercise price K and time of maturity T on the underlying asset S is a contract defined by the following condition: The holder of the option has, at time T, the right, but not the obligation, to buy one share of the underlying asset at the price K from the writer of the option.*

Definition 2.6. *A European put option with exercise price K and time of maturity T on the underlying asset S is a contract defined by the following condition: The holder of the option has, at time T, the right, but not the obligation, to sell one share of the underlying asset at the price K from the writer of the option.*

From the definitions it follows that the value of the European call and put, denoted with C_T^E and P_T^E, at time of maturity, must be given by

$$C_T^E = max(S_T - K, 0) \quad \text{and} \quad P_T^E = max(K - S_T, 0) \tag{2.2}$$

The price of a European call option written on a stock paying dividend is given by the Black-Scholes-Merton (BSM) formula [12, p.161]

Theorem 2.7. (Black-Scholes-Merton Formula) *The value of European call option written on a stock S at time t*

$$C^E(S,t) = N(d_1)S_t e^{-q(T-t)} + N(d_2)Ke^{-r(T-t)} \tag{2.3}$$

where

$$d_1 = \frac{ln(\frac{S_t}{K}) + (r - q + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}} \quad \textit{and} \quad d_2 = d_1 - \sigma\sqrt{T-t}$$

and $N(\cdot)$ is the cumulative distribution function of the standard normal distribution, r is the risk-free interest rate and q is the dividend yield of the stock.

Furthermore there also exist a very common and useful relationship between the price of the European call and put option. The relationship is called the put-call parity and is stated as following

Theorem 2.8. (Put-Call Parity for European Options)

$$C_t^E - P_t^E = S_t - D_t - Ke^{-r(T-t)} \tag{2.4}$$

where D_t denotes the value of the received dividends at time t.

Proof. Consider a portfolio consisting of one long underlying stock, one long put and one short call. The payoff at expiration will be given by

$$max(K - S_T, 0) - max(S_T - K, 0) + S_T + D_T = K + D_T$$

To avoid arbitrage possibilities must the price of the portfolio today be equal to the present value of the future payoff. Hence

$$P_t^E - C_t^E + S_t = Ke^{-r(T-t)} + D_t$$

which can be rearranged as equation (2.4)

□

2.2.2 American Options

The American option is similar to the European option only with the difference that the American option can be exercised at any time prior to the exercise date T. Due to that the exercise time is unknown, there is practically no analytical formulas to price American contracts. Still some useful inequalities and properties can be derived for American options [11, pp.110-111]. The purpose of this section is to end up with a put-call parity for American options that can be used to estimate the implied dividends in chapter 6.

Proposition 2.9. *For an American call option, written on a non-dividend paying stock, the the optimal exercise time τ is given by $\tau = T$. Thus the price of the American option coincides with the price of the corresponding European option.*

Proof. First consider the inequality

$$C_t^A(s) \geq C_t^E(s) \tag{2.5}$$

where s is the price of the underlying asset and C_t^A is the value of an American call option at time t. The opposite can not hold since the American call is indirect an European call if the contract is hold to maturity, hence to avoid arbitrage possibilities must the American call option be more expensive than its corresponding European counterpart. Secondly consider the inequality

$$C_t^E(s) \geq s - Ke^{-r(T-t)} \quad \forall t < T \tag{2.6}$$

To understand this consider the portfolio A, consisting of a long call option, and portfolio B, consisting of a long position in the underlying stock and a loan expiring at T with face value K. At time T will the price of A be $A_T = max(S_T - K, 0)$ and for portfolio B be $B_T = S_T - K$. This gives

$$\left.\begin{array}{ll} A_T = B_T & \text{if } S_T \geq K \\ A_T > B_T & \text{if } S_T < K \end{array}\right\} \Rightarrow A_T \geq B_T$$

Hence to avoid arbitrage possibilities must $A_t \geq B_t$ for all $t < T$ which is the same as (2.6). Using the following trivial inequality

$$s - Ke^{-r(T-t)} > s - K, \ \ \forall t < T,$$

gives

$$C_t^A(s) > s - K, \ \ \forall t < T. \tag{2.7}$$

On the left-hand side is the value of the American call option at time t and on the right-hand side is the value exercising the option at time t. Since the value of the option is strictly greater than the value of exercising the option is it never optimal to exercise the option before maturity. Hence will American call options, written on a non-dividend paying stock, always be exercised at time of maturity. □

Theorem 2.10. (Put-Call Parity for American Options) *The following double inequality holds for American call and put options where the underlying asset is non-dividend paying*

$$S_t - K \leq C_t^A - P_t^A \leq S_t - Ke^{-r(T-t)}, \ \ \forall t < T \tag{2.8}$$

where P_t^A is the value of an American put option at time t.

Proof. Using the same reasoning as for (2.5) a similar inequality can be stated for the American put option

$$P_t^A(s) \geq P_t^E(s) \tag{2.9}$$

The upper bound

$$P_A \geq P_E = C_E - S_t + Ke^{-r(T-t)} = [\text{Proposition 2.9}] = C_A - S_t + Ke^{-r(T-t)}$$

$$\Rightarrow C_A - P_A \leq S_t - Ke^{-r(T-t)}$$

For the lower bound consider portfolio A, consisting of an American put option and one unit of the underlying stock, and portfolio B, consisting of one European call option and the cash amount K. The following inequality is then true

$$C_E + K \geq P_A + S_t \tag{2.10}$$

Assume that the American put is exercised at time τ where $t < \tau \leq T$, this gives the price at time T for portfolio A and B

$$A_T = max(K - S_\tau, 0)e^{r(T-\tau)} + S_T$$

$$B_T = max(K - S_T, 0) + Ke^{r(T-t)}$$

Now assume the most extreme case where $S_T < K$ and $S_\tau > K$. This gives

$$A_T = (K - S_\tau)e^{r(T-\tau)} + S_T = Ke^{r(T-\tau)}$$

$$B_T = max(S_T - K, 0) + Ke^{r(T-t)} = Ke^{r(T-t)}$$

Since $Ke^{r(T-t)} \geq Ke^{r(T-\tau)}$ or $A_T \geq B_T$ must $A_t \geq B_t$ for all $t < T$ to avoid arbitrage possibilities and hence does (2.10) hold. This gives

$$S_t - K < C_t^E - P_t^A \overset{(2.5)}{\Longrightarrow} S_t - K < C_t^A - P_t^A$$

□

2.2.3 American Options and Dividends

When the underlying stock pays dividend the previous results for American call options will be slightly different.

Proposition 2.11. *An American call option will only be exercised at expiration or just before an ex-dividend date*[1].

Proof. Let t_d denote the time of the ex-dividend date and D the dividend. Between $t < t_d$ and $t_d < t \leq T$ will the result be the same as for proposition 2.9 since there is no dividend payment during that time. At t_d it is not necessarily that equation (2.7) holds since the right hand side will be replace by $s - K + D$. If D is large enough it might be profitable to exercise at t_d. □

Proposition 2.12. *An American call option will not be exercised at the ex-dividend date if*

$$D < K(1 - e^{-r(T-t_d)}) \tag{2.11}$$

Proof. The payoff at the ex-dividend date is $S_{t_d} - K + D$ if $S_{t_d} > K$ and the payoff at expiration is given by $S_T - K$ if $S_T > K$. The option will not be exercised at t_d if

$$(S_{t_d} - K + D)e^{r(T-t_d)} < S_T - K \Rightarrow D < K(1 - e^{-r(T-t_d)})$$

□

For the American put option it is much harder to determine when it is optimal to exercise and similar results, as for the call option, cannot be derived. Due to the dividend payment and that the exercise time of the American put option is unknown must the put-call parity for American options be modified to hold.

[1]Note: For the following theorems and propositions will only consider options that has one ex-dividend date before expiration, but similar results can be derived for several ex-dividend dates

Theorem 2.13. (Put-call Parity for American options) *For American call and put options written on a dividend paying stock do the following inequalities hold,*

$$S_t - D_t - K \leq C_t^A - P_t^A \tag{2.12}$$

and if the call option is not early exercised does the following hold

$$C_t^A - P_t^A \leq S_t - D_t - Ke^{-r(T-t)} \tag{2.13}$$

Proof. For the lower bound assume that the opposite holds, i.e.

$$P_t^A + S_t > C_t^A + K + D_t$$

Construct a portfolio consisting of a long American call option, a long risk-free bond with a face value of the expected dividend amount and a long risk-free bond with price K, a short American put option and short one share of the underlying stock. At time t the value is given by

$$(P_t^A + S_t) - (C_t^A + K + D_t) > 0$$

and the position in the portfolio is given by

$$C_t^A + K + D_t - P_t^A - S_t$$

The borrowed dividend amount will neutralize the necessary dividend payment from the stock sold short. If the put option would be exercised at any time τ before expiry the value of the portfolio is given by

$$C_\tau^A + Ke^{r\tau} + S_\tau - K - S_\tau = C_\tau^A + Ke^{r\tau} - K > 0$$

If the put option is not early exercised is the value of the portfolio given at expiry

$$C_T^A + Ke^{rT} - P_T^A - S_T = Ke^{rT} - K > 0$$

Hence does the assumption $P_t^A + S_t > C_t^A + K + D_t$ induce arbitrage and therefore must the opposite hold, i.e.

$$S_t - D_t - K \leq C_t^A - P_t^A$$

For the upper bound consider the put-call parity for European options

$$P_t^E = C_t^E - S_t + D_t + Ke^{-r(T-t)}$$

if the call option is not early exercised is $C_t^A = C_t^E$. Also is $P_t^A \geq P_t^E$ which gives

$$P_t^A \geq C_t^A - S_t + D_t + Ke^{-r(T-t)}$$

which can be rewritten as equation (2.13). □

2.3 Exotic Options

Exotic options, or so called second generation options, are more complex and flexible contracts than the standard options. There is no exact definition of what an exotic option is but loosely speaking an exotic option can be classed as any option that is not a standard option. Basically is any exotic option a standard option that differs from the standard option in at least one aspect. Two common aspects that differs exotic options from standard options are either path-dependency, capturing the movements of the underlying assets, or correlation, capturing the relationship between the underlying assets. Due to the complex nature of the exotic options are many traded in an inactive market, meaning that there exist no quoted market prices due to the lack of trading volumes. To be able to price these options accurately is it important for market participants to rely on valuation models or brokers. In the case of valuation models it is important to have solid models and also have relevant input data that reflect the current market expectations [10, p.88].

2.3.1 Market Parameters

The input data for valuation models are often in the form of instrument and market parameters. The parameters are any information that is necessary to determine the price of an option. For exotic options are the most common instrumemt parameters strike price, interest rate and time to maturity. The most common market parameters are prices of the underlying assets, volatilities, dividends and correlations. The market parameters can be divided in to three groups. That is directly and indirectly observable parameters and unobservable parameters. The indirectly and unobservable parameters are those who are hardest to determine and might contribute with uncertainty to the valuation of the option. Some parameters that often are not directly observable are volatilities, dividends and correlations. These parameters are instead estimated from historical data or from the market expectations. Historical data are most of the times a bad estimate since it represent the past and not the current situation or the future. Instead is it better to use information about what the market is implying about the future situation. These implied parameters can be estimated by using prices and information about liquid traded standard options that are written on relevant assets. Due to that market participants have bullish (optimistic) and bearish (pessimistic) expectations about the future market scenario there exist several possible estimations of the market parameters, that each can be realistic. This means that each parameter can be estimated as a spread.

2.3.2 Multi-Asset Options

Instead of using a single asset as underlying many derivatives are written on multiple assets, known as a basket or an index. Using multiple assets it is possible, due to diversification, lower the exposure for each of the single assets and also lower their impact on the portfolio. Using multiple assets makes it important to understand their mutual relationships, i.e. it is important to determine the correlation between each asset. The correlation has mainly only one effect on a portfolio and that is for computing the volatility of the portfolio. Using the basics in portfolio theory the link between correlation and volatility becomes clear. Consider a portfolio of n assets $S_1, S_2, ..., S_n$ and let R_i denote the return of the ith asset. Then the expected return for the whole portfolio, R_P, is given by

$$E[R_P] = \sum_{i=1}^{n} w_i E[R_i]$$

where w_i is weight of the ith asset, and the variance is given by

$$\sigma_P^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} w_i w_j \rho_{ij} \sigma_i \sigma_j \tag{2.14}$$

where σ_i is the volatility for the ith asset and ρ_{ij} is the correlation between assets i and j [7, pp.105-106,100-111].

2.3.3 Asian Options and Cappuccinos

The portfolio used in the report will be based on two different types of exotic options; Asian options and Cappuccinos.

Asian Option

The Asian options have the same payoff as plain vanilla options except that the underlying asset price at maturity is exchanged for the mean value of the underlying asset at some predetermined points in time. The payoff function is given by

$$\begin{array}{ll} max(\overline{S} - K, 0) & \text{for a call} \\ max(K - \overline{S}, 0) & \text{for a put} \end{array}$$

where $\overline{S}$ is the mean of the value of the underlying asset over some predetermined points in time during the life of the option. The mean is calculated as the arithmetic mean

$$\overline{S} = \frac{1}{N} \sum_{i=1}^{N} S_i$$

where S_{ij} is the value of the underlying asset at one of the predetermined points in time. If the underlying asset is a basket with M components, then each observation S_i is defined as

$$S_i = \sum_{j=1}^{M} w_j S_{ij}$$

where S_{ij} is the value of the underlying asset j at one of the predetermined points in time $i = 1, \ldots, N$.

Cappuccino

The payoff for a Cappuccino is determined by the performance of its underlying assets. At expiry are all underlying assets compared with a predefined individual strike. If the asset at maturity is traded above the individual strike it will contribute to the overall basket return with a predefined cap level. If the asset has is below the individual strike it contributes with its actual performance to the overall return. The payoff function is given by

$$\begin{array}{ll} max(\overline{S} - K, 0) & \text{for a call} \\ max(K - \overline{S}, 0) & \text{for a put} \end{array}$$

where $\overline{S}$ is the average mean calculated of the capped values of the underlying assets over some predetermined points in time. The mean is given by

$$\overline{S} = \frac{1}{M} \sum_{i=1}^{M} w_i S_i$$

where S_i is the capped mean value of the underlying asset i, w_i is the weight of asset i and M is the number of underlying assets. The capped mean S_i is defined as

$$S_i = C \cdot D_t + (1 - D_t) \frac{1}{N} \frac{1}{S_{i0}} \sum_{j=1}^{M} S_{ij}$$

where

$$D_t = \begin{cases} 1 & \text{if } \frac{1}{N} \frac{1}{S_{i0}} \sum_{j=1}^{M} S_{ij} > K_i \\ 0 & \text{else.} \end{cases}$$

where S_{ij} is the value of the underlying asset S_i at one of the predetermined points in time $j \in [1, \ldots, N]$, S_{i0} is the initial level[2] of the underlying asset i , and K_i is the individual strike for asset i and C is the predefined cappuccino coupon level.

[2] In this report is the initial level the spot price at creation date of the contract.

2.4 The Greeks

Hedging is a common way to reduce the risk of a portfolio. The risks that arise from different derivatives are counterbalanced by engaging in other financial transactions. By studying how the sensitivity of a derivatives price is affected by various parameters, that have an impact on the price, it is possible to determine which risks those are of importance. The sensitivities of an option's price, known as the hedge ratios, are commonly referred to as the Greeks since many of them are label by Greek letters. Here will only one hedge ratio be mentioned, Delta, since it is the only one that will be studied later on in the report [7, pp.65-68].

2.4.1 Delta

The most fundamental of all Greeks is Delta. Delta is the sensitivity of an option with respect to the price of the underlying asset and is simply defined as

$$\Delta = \frac{\partial P}{\partial S}$$

where P denote the price of the option and S the price of the underlying asset. To hedge the option against changes in the price of the underlying asset should Δ shares be bought of the underlying asset.

3. New and Existing Regulations

Since the regulation changes of the CRD are very present there exist no previous studies concerning how the changes should be implemented. Therefore are the basic ideas in this report based on own interpretations of certain paragraphs from the CRD, statements from Finansinspektionen (FI) and paragraphs from the International Financial Reporting Standards (IFRS) 9: Financial Instruments.

3.1 IFRS 9

IFRS 9 are regulations issued by the International Accounting Standard Board (IASB) concerning financial instruments. The most relevant regulations are those concerning fair value measurement.

3.1.1 Fair Value

IFRS 9 describes how fair value should be measured for active and inactive markets. An active market can be described as one which transactions are taking place regularly on an arm's length basis [13, p.10]. There is no bright line between active and inactive markets but the instruments that this report concerns are all traded in an inactive market. The most necessary sentences in the section concerning fair value measurement is described below

- "If the market for a financial instrument is not active, an entity establishes fair value by using a valuation technique." [8, paragraph B5.4.6]
- "Fair value is estimated on the basis of the results of a valuation technique that makes maximum use of market inputs, and relies as little as possible on entity-specific inputs. A valuation technique would be expected to arrive at a realistic estimate of the fair value if (a) it reasonably reflects how the market could be expected to price the instrument and (b) the inputs to the valuation technique reasonably represent market expectations and measures of the risk-return factors inherent in the financial instrument." [8, paragraph B5.4.7]

- "Therefore, a valuation technique (a) incorporates all factors that market participants would consider in setting a price and (b) is consistent with accepted economic methodologies for pricing financial instruments." [8, paragraph B5.4.8]

Summarized should a fair value measurement of financial instruments in inactive markets be established by using valuation models. The models should maximize the use of relevant market input that reflects the market expectations. Meaning that the fair value should be a price that the market would expect in a legitimately transaction.

The input for the valuation method should reasonably reflect the market's expectations. As mention in section 2.3.1 will different expectations on a future market scenario give different estimates on the market input for the valuation models. Since all the different expectations are realistic there will exist different inputs for each parameter that must be estimated, generating several measurements of the fair value of an instrument. In the end will there only be one fair value of a financial instrument, the one used in the transaction, but the expected fair value can be restricted to a certain interval. This interval will be referred to as *the fair value interval.*

For example is the implied volatility for an asset often estimated by using corresponding standard options and inverting the BSM formula [1]. The price of an option is needed to estimate the implied volatility. Since there exist both bid and ask prices for the option will there be two estimates of the volatility, one corresponding to the bid price and one corresponding to the ask price. The different estimates of volatility are both realistic since they are based on market data. The implied volatility can then be used to price another instrument with the same underlying asset and since there are two realistic estimates of the volatility will there be two realistic fair values.

3.2 Capital Requirements Directive

FI has released two documents that are relevant for this thesis. First is the regulation FFFS2011:45 [2] concerning the changes and amendments of FFFS2007:1. The second document is a memorandum [14] concerning some of the changes made. The memo contains the reasons behind the changes and also responds of remittances opinions concerning the changes. The two main changes that concern this thesis are about prudent valuations and valuation adjustments.

3.2.1 Prudent Valuations

One of the new amendments is a requirement when using marking-to-model (valuation models/techniques). The new requirement states that marking-

[1] This is in detail described in section 6.2.

to-model should be based on conservative assumptions [2, 12 kap. 4§]. Basel II formulates it as an extra degree of conservatism is appropriate when marking-to-model [1, paragraph 718(cv)]. How conservative the assumptions should be is not mentioned and it is therefore up to each institute to consider what they believe a reasonable prudent valuation is. Using the fair value interval is it reasonable to believe that a prudent valuation should correspond to a valuation closer to the boundaries, since these valuations are based on more conservative estimations of the market parameters.

FI also believes that the requirement of conservative assumptions when marking-to-model allows the regulations for valuations and valuation adjustments in FFFS2007:1 chapter 12 to go further than the accounting regulations according to IFRS since IFRS has no demand for conservative assumptions when marking-to-model. This means that the valuation for the purpose of capital adequacy can differ from the valuation used in the external reporting [14, p.19].

A prudent valuation might not just mean that the market parameters are chosen conservative. But also different model assumptions, for example using a skewed volatility instead of a flat volatilitym, often contribute to a more conservative approach. Also taking risk factors, like correlation risk[2], into account will give a more prudent valuation.

3.2.2 Valuation Adjustments

There are two paragraphs that concerns valuation adjustments [2, 12 kap. 10-11§§]. The first one is in general concerning positions in the trading book. The second is concerning positions that are classified as less liquid[3]. These two paragraphs describes several factors[4] that should be taken into account when estimating the valuation adjustments. Since there exist no guidelines concerning these paragraphs there are two questions that becomes relevant when discussing valuation adjustments;

1. When should valuation adjustments be made?

2. How large should the valuation adjustments be?

For the first question there are several phrases in the memorandum from FI concerning when valuation adjustment should be made. FI states that some of the adjustment factors can to some part be included in a fair value measurement according to IFRS. If a institute finds that the fair value measurement according to IFRS fulfills the requirements in 12 kap. 4-6§§ and

[2]Correlation risk: the risk of loss due to the difference between assumed correlation and realized correlation between to assets, between to financial instruments or between to markets [2].

[3]A position is consider less liquid if it become less liquid from market events or institute related-situation.

[4]Theses factors will be denoted as adjustment factors through the report.

8-12§§ there is no need for valuation adjustments, otherwise should valuation adjustments be made. FI also state that valuation adjustments can be necessary when calculating the capital base regardless how the assets is valuated according to IFRS. This means that it is very hard to determine whether valuation adjustments are necessary or not. Therefore is there no exact answer to the first question and it will be up to each institute to determine when they think valuation adjustments are necessary[14, p.19].

The second question is sort of the main question for this thesis. Since the lack of guidelines on how the adjustment factors should be estimated it is very hard to tell what a reasonable size of the adjustments are. Hopefully will the results in this report give some estimation about the size of the valuation adjustments.

4. The Method

This chapter will describe the method that will be used to estimate the valuation adjustment but first will the idea that the method is based on be explained.

4.1 Background

Let $V = V(p_1, \ldots, p_n)$ be the value of a valuation model using the market parameters $p_1, \ldots, p_n$. Let V^* be the value of a financial instrument after the valuation adjustments are made. The value V^* can also be determined by the valuation model using a set of market parameters $p_1^*, \ldots, p_n^*$, i.e. $V^* = V(p_1^*, \ldots, p_n^*)$. The idea behind the method is to estimate the parameters $p_1^*, \ldots, p_n^*$ directly and therefore get a value where the valuation adjustments are included. Since there exist several possible solutions to determine this parameters it is likely that at least one can be found. However is the adjusted value of a financial instrument not known and therefore there is a need of directions on how a set of parameters can be estimated.

4.1.1 Assumptions

The method will be based on two assumptions

Assumption 4.1. *The expected fair value of a financial instrument can be found within a certain interval, called the fair value interval.*

Assumption 4.2. *There exist at least one set of market parameters such that the value of an instrument will include all adjustment factors.*

The first assumption is based on the fact that different expectations on the market parameters give different values of a financial instrument, as described in section 3.1.1. In the end will there only be one fair value but before any transaction is made there exist several possible values that the fair value may take. The IASB Expert Advisory Panel in their guidelines concerning fair value measurement describes the possibility that an instrument can have two fair values [13, paragraph 26-27]. This indicates that the assumption concerning the existence of a fair value interval is realistic since all values between these two fair values also reflects reasonable estimates of a fair value.

There are several statements in the memorandum issued by FI that are helpful to get directions on how the set of market parameters can estimated. FI state that the requirement on conservative assumptions, in case of valuation models, takes the valuation, for the purpose of capital adequacy, further than a valuation according IFRS, since IFRS has no requirement on conservative assumptions [2, p.19]. FI also has two other statements that is concerning whether a valuation according to IFRS might include the adjustment factors or not. FI state it as that a valuation according to IFRS might include some or all of the adjustment factors meaning that the valuation adjustment might not be necessary. However FI also states that valuation adjustments might be necessary no matter how the instrument is valued according to IFRS [2, p.18].

Using the fair value interval gives directions on a set of market parameters that unlikely will include the adjustment factors in the valuation. If the valuation, for the purpose of capital adequacy, should go further than a valuation according to IFRS, should the set of the market parameters go further than the ones used in a fair value measurement. Meaning that the market parameters should represent a value outside the fair value interval. The hard part is to estimate how far outside the interval the value should be. Since that the valuations closer to the boundaries of the fair value interval will correspond to a more prudent valuation, shouldn't the set of parameters give a value that is too far outside the boundaries.

The method is divided into three different steps. First will the fair value interval be estimated, secondly will a prudent valuation be determined and third will the valuation adjustments be determined.

4.2 Step 1: Fair Value Interval

The value V of a financial instrument will dependent on several different parameters, some of them known with certainty and some other with less certainty, i.e. they need to be estimated. The necessary parameters should only be those who are relevant to end up with a fair value measurement of the instrument according to IFRS 9. Let $p_1, p_2, \ldots, p_n$ denote the parameters that need to be estimated. Due to bias and uncertainty of the estimation will each parameter be estimated within a spread,

$$p_i \in [p_i^{min}, p_i^{max}] \text{ for } i = 1, 2, \ldots, n$$

The value of the instrument will then belong to an interval where the boundaries are estimated using the boundaries of the spreads for each parameter

$$V \in [V^{min}, V^{max}] \tag{4.1}$$

where V^{min} and V^{max} is given by

$$V^{min} = V(p_1^{min}, \dots, p_n^{min})$$

$$V^{max} = V(p_1^{max}, \dots, p_n^{max})$$

Since the value V will be estimated according to the fair value measurement in IFRS 9 can equation (4.1) be seen as a fair value interval for the instrument.

4.3 Step 2: Prudent Valuations

The next step is to determine how the conservative assumptions will affect the value of the instrument. There are several conservative assumptions that should be included in a prudent valuation, some are described in section 3.2.1. The problem is that it is not always easy to demonstrate how conservative assumptions affect the valuation of an instrument. Therefore will the conservative approach in this report be to choose the market parameters conservatively to get a prudent valuation.

The prudent valuation is also dependent on what type the option is. For a short position will the prudent valuation be to the right in the fair value interval and for a long position will the prudent valuation be to the left. In this report will all options have short positions and all results will be based on that.

Let V^{mid} correspond to the valuation using the mid-parameters

$$V^{mid} = V(p_1^{mid}, \dots, p_n^{mid})$$

where p^{mid} is defined as

$$p^{mid} = \frac{p^{max} + p^{min}}{2} \tag{4.2}$$

A smaller interval around V^{mid} can be interpreted as a completely theoretical valuation, meaning that no conservative assumptions are made. The conservative assumptions, which are choosing the market parameters more conservatively, will lead to that the value V is located to the right in the fair value interval, i.e.

$$V^{cons} \in (V^{mid}, V^{max}],$$

the closer to the boundary V_{cons} is the more prudent is the valuation.

4.4 Step 3: Valuation Adjustments

If there is any belief that there is a need for valuation adjustments should the prudent value V^{cons} be adjusted such that $V^* \geq V^{cons}$. Meaning that the market parameters should be shifted such that $p_i^* > p_i^{cons}$ for $i = 1, \ldots, n$, where p_i^* corresponds to the valuation V^* and p_i^{cons} to V^{cons}. The parameters p_i^* should be shifted large enough to represent an extreme prudent valuation such that assumption 4.2 is fulfilled, meaning that all the adjustment factors are included. The total valuation adjustment is than given by $V^* - V_{cons}$.

4.5 Graphical Interpretation

Figure 4.1 shows the price of a financial instrument. Around V_{mid} are the theoretical valuations of the instrument. When the conservative assumptions are made will the value move to the right into a more prudent valuation. The further to the right the more prudent the valuation is. The total valuation adjustment is then made to include the adjustment factors and the value of a financial instrument is then given by V^*.

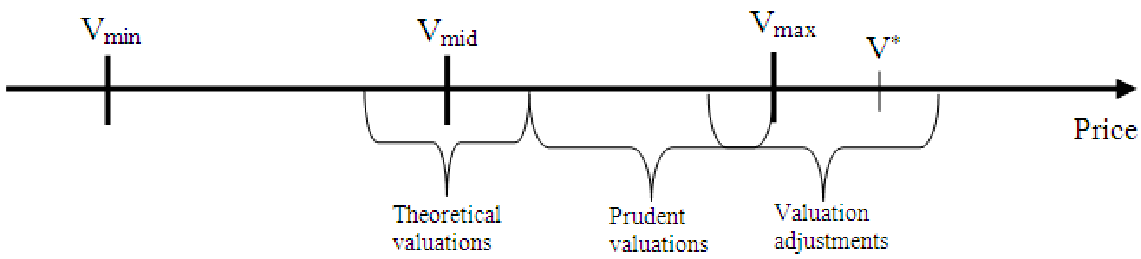

Figure 4.1: *Graphical interpretation of the method*

5. Data and the portfolio

5.1 Data

The data used in this report are daily closing prices for the stocks in the OMXS30 index and daily closing prices for the corresponding standard options. Almost all calculations are done on daily data between the 12 December 2011 to the 3 January 2012, 16 banking days. For some results concerning the correlations will daily historical closing prices, between 8 August 2011 and 3 January 2012, be used for the stocks. All the data are taken from Reuters.

5.2 Portfolio

The results in the report are based on a portfolio containing nine exotic options. These options are not traded in any market and are only constructed for this thesis. The options are of two kinds; Asian options and Cappuccinos. Each option will use one of three different baskets as underlying. Each basket contain about 8-10 stocks equally weighted from OMXS30. The baskets are chosen to resemble a random collection of assets[1].

5.2.1 The Baskets

The three different baskets are described in table 5.1. Explanation of the abbreviations is given in appendix A.

5.2.2 The options

Each basket will have three options using it as underlying. The options on each underlying will be of the same type, using the same strike but with different time to maturities. The reason for this is to capture time effects. The strike will be chosen as the spot price of the underlying basket. Common for all options is that the predetermined price dates, when the underlying assets are evaluated i.e. the points j in subsection 2.3.3 , is that they are evaluated monthly starting 6 months before expiry.

[1] The assets were arbitrary chosen by hand, not randomly sampled by a computer.

Basket 1	Basket 2	Basket 3
ABB	ATCO A	ALFA
AZN	ERIC B	LUPE
ERIC B	MTG B	SKA B
HM B	SAND	SSAB A
SCA B	SCA B	SWED A
SHB A	SCV B	SWMA
SKF B	SEB A	TLSN
SWMA	SECU B	VOLV B
TEL2 B	SHB A	-
-	TEL2 B	-

Table 5.1: *Baskets*

Asian options

Common for the Asian options is that the strike price is chosen to the spot price of the underlying basket.

Group 1 The first three options are Asian options written on basket 1. The time to maturities are one, three and five years. These options are denoted $Asian_{1,1}$, $Asian_{1,3}$ and $Asian_{1,5}$.

Group 2 The next three options are Asian options written on basket 2. The time to maturities are two, four and six years and they are denoted by $Asian_{2,2}$, $Asian_{2,4}$ and $Asian_{2,6}$.

Cappuccinos

The last three options are Cappuccinos with a cappuccino coupon at 1.8 and each individual strike at 1.8 of the initial price for each asset. The time to maturities are two, four and six years and the options are denoted by Cap_2, Cap_4 and Cap_6.

5.2.3 Portfolio Set Up

The portfolio will consist of short call options, where the options are those described above. Each option will have a position of 100000[2]. The results will be displayed for the total position of each option.

[2] This choice of position is only to facilitate the presentation of the results.

6. Parameter Estimation

The parameters that are relevant and need to be estimated are dividends, volatilities and correlations. As mentioned earlier will each parameter be estimated within an interval, defined as following

$$D_i \in [D_i^{min}, D_i^{max}]$$

$$\sigma_i \in [\sigma_i^{min}, \sigma_i^{max}]$$

$$\rho_{ij} \in [\rho_{ij}^{min}, \rho_{ij}^{max}]$$

where $i, j = 1, 2, \ldots, n$ and $D_i = D_i(t)$, $\sigma_i = \sigma_i(t)$ and $\rho_{ij} = \rho_{ij}(t)$.

As mentioned earlier are implied estimations of market parameters often much better than estimations based on historical data. Therfore are most of the bounds determined by using bid and ask prices for standard options and it is therefore important to have access to those. For options with longer time to maturity the market is almost non-existing and estimating the intervals becomes very hard unless certain assumptions are made to simplify the situation. The idea is to assume that the range of each interval is the same for all assets over time. This assumption makes it possible to determine the boundaries even when there is lack of market data. The assumption can be stated as following

Assumption 6.1. *The uncertainty for each market parameter will be the same for all assets, $i = 1, \ldots, n$, and over time, i.e.*

$$D_i^{min} = (1-\alpha) \cdot D_i^{mid}, D_i^{max} = (1+\alpha) \cdot D_i^{mid}$$

$$\sigma_i^{min} = \sigma_i^{mid} - \beta, \sigma_i^{max} = \sigma_i^{mid} + \beta$$

$$\rho_{ij}^{min} = \rho_{ij}^{mid} - \gamma, \rho_{ij}^{max} = \rho_{ij}^{mid} + \gamma$$

where α, β and γ are constants that measures the uncertainty in each parameter.

The mid-values D^{mid}, σ^{mid} and ρ^{mid} is defined as equation 4.2. Since it is possible to get information about estimates of, for example, future dividends from financial news firms, like Reuters and Bloomberg, it is possible to estimate the boundaries for parameters corresponding to maturities greater than one year. Since the range of the intervals is constant over time must the constants α, β and γ be determined as such. Therefore will the constants be estimated from standard options with approximately one year to maturity and then is an extra factor added to the constant to capture the higher uncertainty of parameters corresponding to longer maturities. To avoid daily abnormalities are the constants estimated as an average for a period of 16 days. The constants is determined as the average uncertainty of all assets

$$\alpha = \frac{1}{N}\sum_{i=1}^{N}\alpha_i$$

$$\beta = \frac{1}{N}\sum_{i=1}^{N}\beta_i$$

$$\gamma = \frac{1}{N}\sum_{i=1}^{N}\gamma_i$$

where α_i, β_i and γ_i is the estimated uncertainty from asset i, for example α_i corresponds to solving

$$D_i^{min} = (1-\alpha_i)\cdot D_i^{mid}, D_i^{max} = (1+\alpha_i)\cdot D_i^{mid}$$

The constants describes the average uncertainty in the estimation of each parameter

6.1 Implied Dividends

Implied dividends are the markets expectations for future dividends. By using prices of standard options it is possible to determine the implied dividends for the corresponding underlying stock. Since most of the standard option written on single stock are American options is it not possible to determine a single estimation of the implied dividend but instead can an upper and lower bound be determined. By using the put-call parity for American options, theorem 2.13, is it possible to extract an interval for the implied dividend. By rewriting equation (2.12) and (2.13) the lower and upper bounds can be determined for the implied dividend and the bounds is given by

$$D_t^{min} = P_t^A - C_t^A + S_t - K$$

$$D_t^{max} = P_t^A - C_t^A + S_t - Ke^{-r(T-t)}$$

This way of estimating the dividends is not a new approach. The lower and upper bound is also derived by Guo and Su [15] and also by Brooks [16]. A problem, which is less discussed in the articles, is that the upper bound will only be known with certainty if the American call option is not early exercised. By using proposition 2.11 it is possible to determine whether the call option will be early exercised or not. Unfortunately will it be shown that for most of the stocks in OMXS30 will their corresponding American call options be early exercised and hence does not the upper bound hold. This is not such a big problem since it can either be solved by assuming that upper bound still will be an approximately good estimate or the upper bound can be estimated by using prices of out-of-the money call options, since it is unlikely that they will be exercised. Here will the first approach be used.

The prices used for calculating the bounds are bid prices for At-The-Money (ATM) American call options and ask prices for ATM American put options. The reason for this is that this choice of prices will slightly overestimate the bounds which is positive for the upper bound. In the case of the lower bound will this choice of prices avoid that the estimated dividend is negative which could happen if only bid prices were used.

6.1.1 Results

Table 6.1 shows the estimated bounds for a few chosen stocks. Table 6.2 shows the average estimated bounds for the same stocks. The estimated dividends are shown as the expected value at their ex-dividend days. Appendix B contains the average of the estimated boundaries of the implied dividends for stocks in the OMXS30 index.

Stock	D^{min}	D^{max}
ERIC B	1.5122	2.2777
ABB	2.1674	3.6436
HM B	5.2914	7.6965
VOLV B	2.0627	2.9359
SHB A	5.8804	7.8431
TEL2B	4.0342	5.5111

Table 6.1: *Implied dividends 2012-01-03*

Table 6.3 shows the uncertainty, α_i, for the stocks and D_i^{mid}. Using all stocks gives $\alpha = 0.1766$. This value is adjusted to $\alpha = 0.2$ to compensate for greater uncertainty for dividends paid after two years.

Stock	D^{min}	D^{max}
ERIC B	2.5134	4.1501
ABB	3.4459	4.9647
HM B	4.2159	5.9924
VOLV B	3.0412	4.3841
SHB A	6.2943	8.4245
TEL2B	5.1769	6.7799

Table 6.2: *Average implied dividends during the 16 days period*

Stock	D_i^{mid}	α_i
ERIC B	1.89506	0.2020
ABB	2.9055	0.2540
HM B	6.4939	0.1852
VOLV B	2.4993	0.1747
SHB A	6.8617	0.14301
TEL2B	4.7726	0.1547

Table 6.3: *Uncertainty in the estimation of the implied dividends*

6.2 Implied Volatility

The implied volatility is the markets expectation of the future volatility. The implied volatility is calculated by inverting the BSM formula, i.e. solving the corresponding equality for the implied volatility σ^*

$$C_t^E = C^E(t, T, r, q, K, S, \sigma^*)$$

Even though the BSM formula is used to price European options it also works as a fast and accurate solution to estimate the implied volatility for American options. The lower and upper bound for the implied volatility is estimated by using bid and ask prices. The lower bound corresponds to the bid price and the upper bound correspond to the ask prices. Since the BSM formula is dependent of the dividend yield is it important that the lower and upper boundaries of the dividend are used when calculating the boundaries of the implied volatility. The bounds is given by solving σ^{min} and σ^{max} for

$$C_{Bid}^E = C^E(t, T, r, q^-, K, S, \sigma^{min})$$

$$C_{Ask}^E = C^E(t, T, r, q^+, K, S, \sigma^{max})$$

Stock	σ^{min}	σ^{mid}	σ^{max}	Spread
ABB	0.2346	0.2634	0.2921	0.0575
ERIC B6	0.2907	0.3161	0.341	0.0509
HM B	0.2279	0.2562	0.2845	0.0566
SHB A	0.2072	0.2486	0.2900	0.0827
TEL2B	0.2187	0.2240	0.2875	0.0775
VOLV B	0.3416	0.3506	0.3595	0.0179

Table 6.4: *Implied volatility 2012-01-03*

	σ^{min}	σ^{max}	Spread
OMXS30	0.2137	0.2418	0.0281

Table 6.5: *Implied volatility of OMXS30 2012-01-03*

where q^+ and q^- are the upper and lower bound of the dividend yield which corresponds to the upper and lower bound of the dividend, D^{max} and D^{min}.

6.2.1 Results

Table 6.4 shows the upper and lower bound for the implied volatility of the chosen stocks and also shows the mid volatility and the spread ($\sigma^{max} - \sigma^{min} = 2\beta$), appendix C contains the average boundaries of implied volatility for all stocks in the OMXS30 index. This gives the average value of the constant $\beta = 0.0352$. Adjusting it for the increased uncertainty of volatilities corresponding to longer maturities gives $\beta = 0.04$.

In the next section concerning correlations is also important to estimate the implied volatility for the index OMXS30 and its corresponding β_O. The implied volatility for the index is estimated from European options with a shorter time to maturity then the used American options for the underlying assets. The min and max volatility is shown in table 6.5. Using the same procedure as for the underlying asset gives $\beta_O = 0.0122$. Adding an extra factor to compensate for the uncertainty of longer maturities gives $\beta_O = 0.02$.

6.3 Correlation

Correlation is truly the hardest parameter to estimate. In the same way for dividends and volatility it would be nice to have some way to determine the corresponding implied correlation between two assets. Sadly does the market not allow it. By using the relationship between volatility and correlation given by equation (2.14) it would be possible to determine implied correlation between two assets. The problem is that market for standard options written on pairs of assets is not liquid and the lack of prices makes it impossible to determine the implied correlation this way. But by widen the view and instead using standard options written on indices, such as OMXS30, it is possible to determine something called the implied correlation index, or an average implied correlation of the stocks in the index. Since there exist standard options for the index and its underlying assets it is possible to determine implied volatility for both the index and the assets, making it possible to use equation (2.14) with a slightly modification.

6.3.1 Implied Correlation

The relationship between volatility and correlation for an index of n assets is given by

$$\sigma_{index}^2 = \sum_{i=0}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} w_i w_j \rho_{ij} \sigma_i \sigma_j$$

where the weight is defined as following $w_i = \frac{S_i P_i}{\sum_{j=1}^{n} S_j P_j}$ where S_i are the number of outstanding shares and P_i is the price of one share for asset i. The $n(n-1)$ correlations ρ_{ij} is replaced with the implied correlation of the index, seen as an average implied correlation, $\rho_{implied}$ which gives

$$\sigma_{index}^2 = \sum_{i=0}^{n} w_i^2 \sigma_i^2 + \rho_{implied} \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} w_i w_j \sigma_i \sigma_j$$

and the expression for the implied correlation is given by

$$\rho_{implied} = \frac{\sigma_{index}^2 - \sum_{i=0}^{n} w_i^2 \sigma_i^2}{\sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} w_i w_j \sigma_i \sigma_j}$$

This implied correlation index is described in a white paper by CBOE (Chicago Board Options Exchange) [17], in an article by Walter and Lopez [18], a technical report by Bossu and Gu [19] and also by Bouzoubaa and Osseiran [7, pp.111-113].

The implied correlation index is clearly no good estimate for the underlying assets implied correlation, but together with the historical correlation it still has some impact when determining the implied correlation between the underlying assets. In analogy with the implied correlation index is it possible to define a realized correlation index. The realized correlation index is defined as the weighted average of the realized correlation matrix between the components, excluding the diagonal of 1's:

$$\rho_{realized} = \frac{\sum\limits_{1 \leq i < j \leq n} w_i w_j \rho_{ij}}{\sum\limits_{1 \leq i < j \leq n} w_i w_j} \tag{6.1}$$

The idea that is described by Bouzoubaa and Osseiran [7, p.112] is then to introduce a simple parameterization involving a coefficient λ which relates the realized and implied correlation of the index, and then use this coefficient between the components in the index to get an implied correlation from their realized correlation. The coefficient λ is determined through

$$\rho_{implied} = \rho_{realized} + \lambda(1 - \rho_{realized}) \tag{6.2}$$

When the coefficient λ is known is it possible to calculated the correlation between two assets in a index by reapplying formula (6.2) and instead using the realized correlation between the assets which simply is the historical correlation. When each of the implied correlation is calculated one can check of well they estimate the volatility of the index by using (2.14). Whether this is a good way to determine an accurate correlation is hard to tell but the benefit from this method is that it makes it possible estimate determine boundaries for the implied correlation and when the boundaries is known is it possible to determine the constant γ. One thing that argues against this method is that volatility of the underlying assets affect the correlation negatively and the problem that occurs is that ρ^{max} will be connected to σ^{min} for the assets and σ^{max} for the index. Normally are high correlation and high volatility both represented during a downturn in the market and during an upturn are often the correlation and volatility lower. Therefore that ρ^{max} corresponds to σ^{min} for the assets is not a good representation, but the method will still give an estimation of how the uncertainty in the correlations can be estimated from the uncertainty in volatility.

6.3.2 Results

Table 6.6 shows the estimated bounds and mid values for implied correlation index for the 90 days and 1 year correlation which gives $\gamma = 0.05792$. This value is believed to be too small to capture the uncertainty in the correlations. Since it is very hard to estimate the actual correlations should the spread between ρ^{min} and ρ^{max} be relatively large. Comparing γ with the corresponding constant for dividends and volatility would this value lead to that correlation had smallest uncertainty. For dividends are the bounds 20 percent from the middle value, for the volatility is the bounds in average about 11 percent from the middle value. The same value for correlations is about 9 percent, meaning that γ might be to small. To get a more reasonable

	90 days	1 year
ρ^{min}	0.5058	0.5176
ρ^{mid}	0.5487	0.5629
ρ^{max}	0.60544	0.6231

Table 6.6: *Implied correlations*

uncertainty in the correlation is γ chosen to 0.1 which would give that the bounds are approximately 17 percent from the middle value, still lower then for the dividends but might still be good enough.

Figure 6.1 and figure 6.2 shows the implied correlation index and the realized correlation index for the 1 year and 90 days correlation. The implied correlation seems to fluctuate much more then the realized correlation meaning that the implied correlation is not necessary a good measure. Even though that the realized correlation is no good estimate of the future correlation it still tells something about the behavior of the correlation. The implied correlation is clearly not following that behavior. Another interesting observation is to study how correlated the implied correlation index is with the implied volatility for the index. This is done by calculating the correlation between the daily relative changes for both parameters. The relative change for the implied volatility and correlation is displayed in figure 6.3 for 1 year and in figure 6.4 and for 90 days. The correlation is 0.86 for the 90 days implied correlation and implied volatility. The same value for 1 year is 0.84. This means that the implied correlation index and the implied volatility of the index is highly correlated. This explains why the implied correlation fluctuates so much and comparing with the historical correlation this is not a reasonable behavior, meaning that the implied correlation (calculated as in this thesis) should not be used when valuating financial instruments.

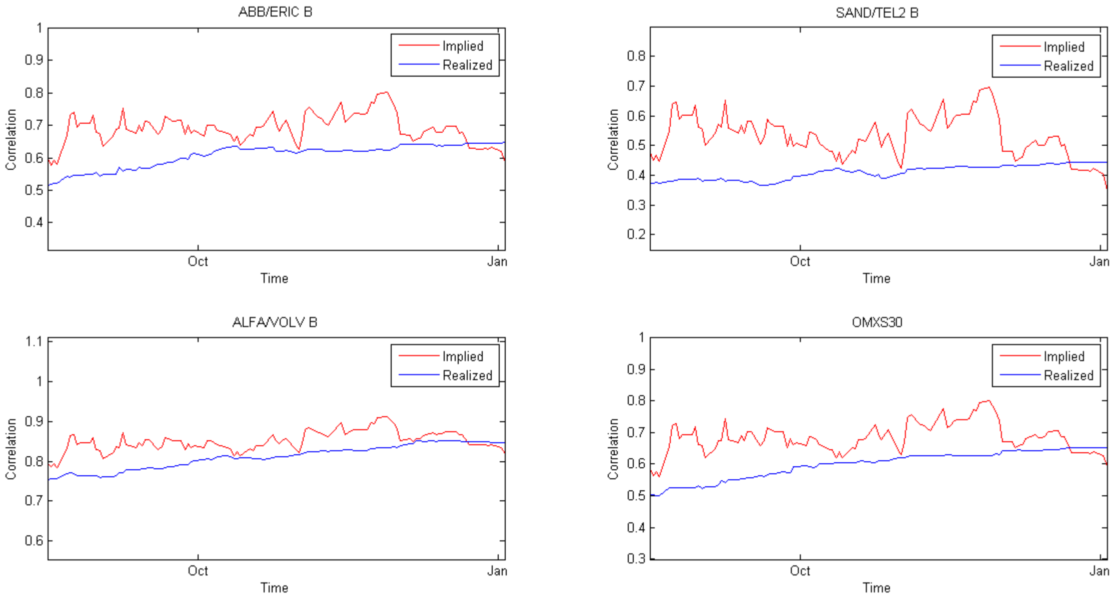

Figure 6.1: *Implied and realized correlation 1 year*

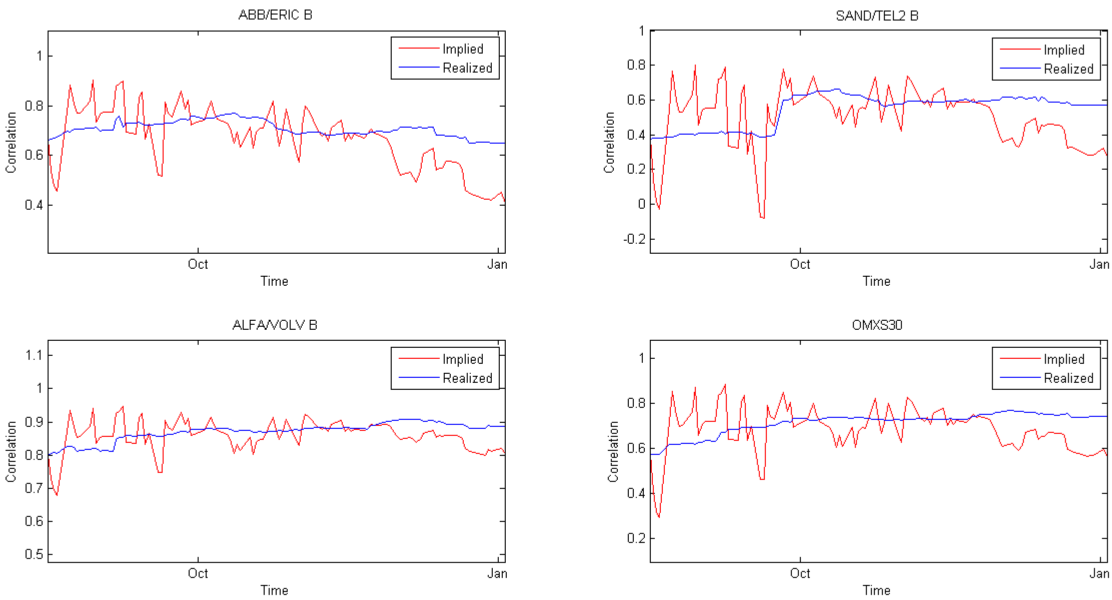

Figure 6.2: *Implied and realized correlation 90 days*

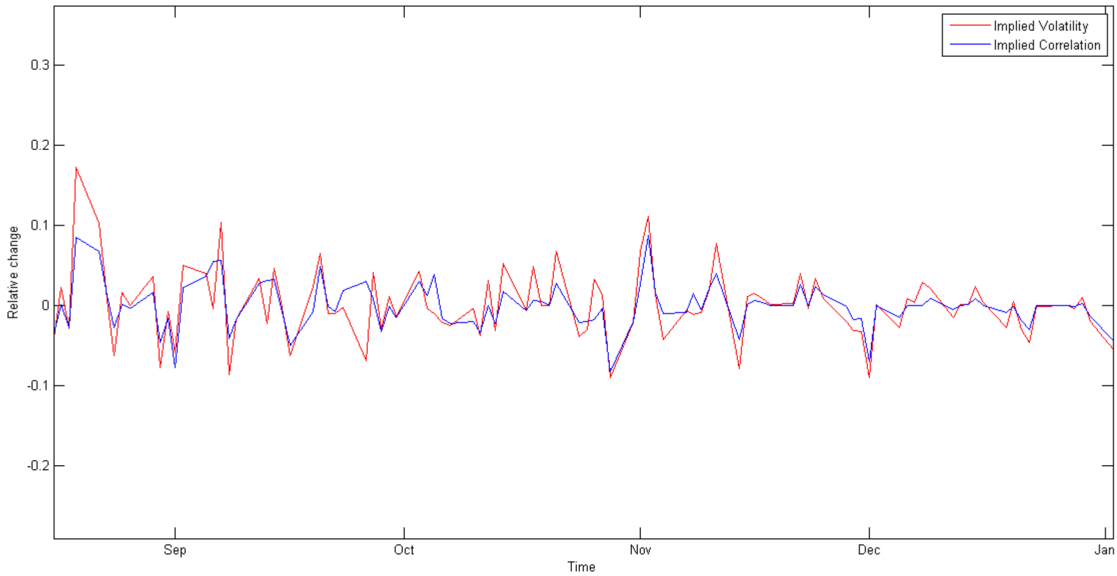

Figure 6.3: *Relative changes of implied volatility and implied correlation for 1 year of index OMXS30*

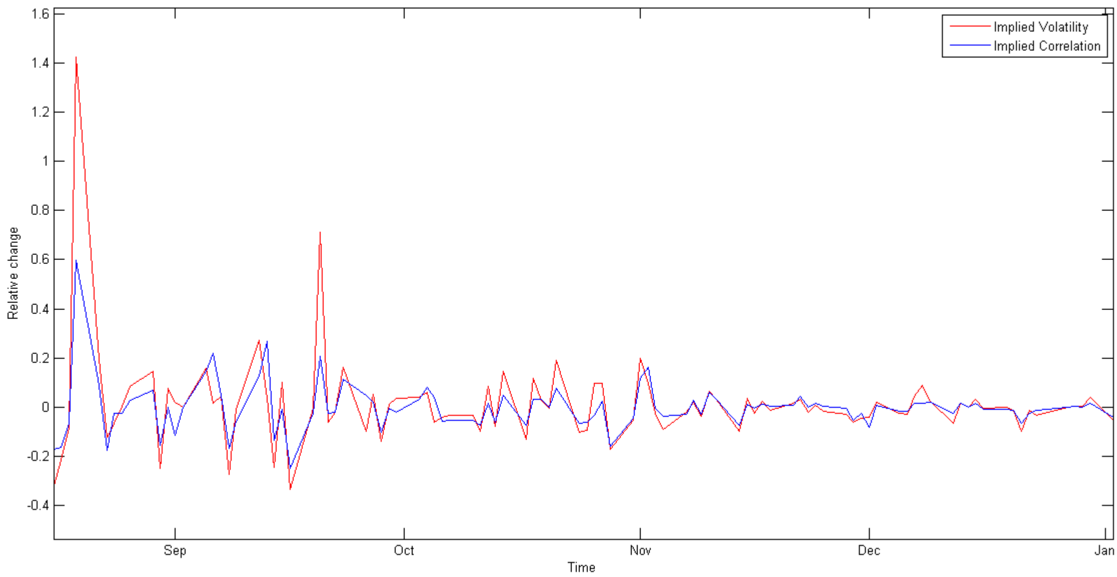

Figure 6.4: *Relative changes of implied volatility and implied correlation for 90 days of index OMXS30*

7. Portfolio Analysis

The portfolio described in section 5.2 will be used to see how much uncertainty in the parameters will affect the value. This will be done by shifting[1] each parameter alone to its maximum and minimum as well shifting them together to see the combined effects. After the parameters effects it demonstrated will the valuation adjustments for the portfolio be determined.

7.0.3 Single Parameter Shifts

The value V is calculated when each parameter, one at the time, is shifted. For example when the upper boundary of the volatility is used, and the other parameters are kept constants, does the value of the portfolio correspond to $V_{\sigma_{max}} = V(\sigma_{max}, D_{mid}, \rho_{mid})$.

Table 7.1 show the values of the instruments and the portfolio for single shifts. Table 7.2 and table 7.3 shows how much each options changes in value measured in absolute value and in percentage change. Interesting to see is that the ρ_{min} and ρ_{max} contributes with the smallest amount of uncertainty to the portfolio value. Which can either depend on that the uncertainty in correlation is underestimated or that the portfolio is less sensitive to changes in correlations than the other parameters.

7.0.4 Pairwise Shifts

The value of the portfolio using the pairwise combined effect corresponds to shifting two parameters such that the value of the portfolio is maximized or minimized, for example shifting dividend and volatility to their minimum and maximum to get a maximum value of the portfolio, when the correlation is kept constants, $V_{\sigma_{max},D_{min}} = V(\sigma_{max}, D_{min}, \rho_{mid})$.

Table 7.4 and table 7.5 shows the combined effect on the options and the portfolio value when both dividends and volatilities are shifted, table 7.6 and table 7.7 for correlations and volatility and table 7.8 and table 7.9 for dividends and correlations.

[1] In general in this report when a parameter is shifted will it mean that that the portfolio is valuated once with the maximum and once with the minimum of that parameter as input. The parameter is shifted from its mid value to it boundaries.

The interesting result here is that the combined effect of the parameters for the Asian options gives a more positive value of the boundaries then when adding the the single boundaries together. This means that the parameters have a positive effect on each other when evaluating the options.

7.0.5 Shifting All

Table 7.10 and table 7.11 shows the result from shifting all parameters. The minimum and maximum value of the portfolio corresponds to

$$V_{min} = V(\sigma_{min}, D_{max}, \rho_{min})$$

$$V_{max} = V(\sigma_{max}, D_{min}, \rho_{max})$$

The time effects are very clear, options with longer time to maturities becomes more affected by the uncertainty in the parameters. The exception is the Asian option with one year to maturity, a possible reason for this is that the option is more affected by short terms effects then the others. Using a more accurate approach, having greater spreads for parameters that corresponds to longer maturities would the time effects be even more obvious. Another factor that is interesting to notice is that the percentage changes varies very much from the three different groups of instruments. The Asian options group 1 is clearly very sensitive to changes in the underlying parameters while the Cappuccinos is not affected in the same way.

7.1 Valuation Adjustments

The total valuation adjustment will depend on how the set of market parameters, described in assumption 4.2, is estimated. Since there are no guidelines of what a reasonable adjusted value is will the estimated parameters be based on what seems reasonable to ensure that the adjustment factors are included in the valuation. Here is it assumed that shifting the parameters another 25% from the boundaries will be sufficient to ensure that the adjustment factors are included. The prudent valuation is assumed to correspond to V_{max} meaning that the total valuation adjustment is given by shifting the parameters in the following way

$$\sigma_{max} \to \sigma^*$$

$$D_{max} \to D^*$$

$$\rho_{max} \to \rho^*$$

where

$$\sigma^* = \sigma_{mid} + 1.25\beta$$

$$D^* = (1 - 1.25\alpha)$$

$$\rho^* = \rho_{mid} + 1.25\gamma$$

The minimum valuation adjustment, δ, is then given by

$$\delta_{min} = V^* - V_{max}$$

where $V^* = V(\sigma^*, D^*, \rho^*)$. The valuation adjustments are done both for the single instruments and the whole portfolio. The values of the adjustments, given in percentage of the prudent valuation, is displayed in table 7.12. For the portfolio is $\delta_{min} \approx 8200$ SEK or 6.98% of V_{max}. A total valuation adjustment about 7% is believed to be a reasonable estimation.

Interesting here is that the size of the valuation adjustment varies very much for the different instruments and this is quite expected. Clearly are the Asian 1 group of instruments much more sensitive to changes of the markets parameters and the Cappuccinos are not, which also is seen in table 7.11 where the boundaries of the Asian 1 group is in percentage much higher compared to the mid-value. The reason why a sensitive instrument should have a larger valuation adjustment is that the loss of that instrument will be much higher in a crisis. A sensitive instrument benefits from higher returns in good times and larger losses in bad times. The possibility of larger losses must be captured in the capital base and therefore is the valuation adjustment larger.

7.1.1 Real Example

To test the method for larger portfolios is the total valuation adjustment also estimated for one of Handelsbankens portfolios. It can be said that the results where similar to the results of the simulated examples[2]. This does not necessary mean that the method will work for larger portfolios in general but at least it doesn't contradict the method.

7.2 Possible Issues

This section will deal with two possible issues that can arise when applying this method. The two issues that are discussed is first how well the hedge portfolio will work for the adjusted set of market parameters before it is re-hedged. The second issue is whether the correlation matrices still are positive definite after shifting the correlation pairs.

7.2.1 Market Risks

The Delta of the portfolio can be found in appendix D. Interesting here is to see how well the Delta-hedge works after the parameters are shifted and before the portfolio is re-hedged. This is done by shifting the price of the

[2]Due to confidential reasons can't any data concerning this result be published.

underlying assets with ±1%. Table 7.13 shows how much the Delta and the portfolio changes in value. The value within the brackets shows how much the value change of the portfolios differs from the Delta value change. For the left boundary of the portfolio does the hedge fit the poorest, still is difference between the change of Delta and the change of the portfolio less than 0.7% of the total portfolio value. This means that the Delta hedge still is a good hedge after the parameters are shifted. Meaning if a scenario would occur which corresponds or is similar to the choice of the adjusted parameters it would not cost too much to hedge the portfolio out.

7.2.2 Correlation Matrix

It is easy to check if the correlation matrix is positive definite after the shift in correlations by calculating the eigenvalues. For the 1 year correlation matrix is the smallest eigenvalue, denoted by λ, displayed for the baskets given in table 7.14 when the correlations takes the values ρ^{min}, ρ^{max} or ρ^{mid}. For the 90 days correlation matrix are the eigenvalues given in table 7.15. For both the 1 year and 90 days correlation is the eigenvalues positive meaning that the matrix is still positive definite.

This result might not always be the outcome. To demonstrate when this might not occur the eigenvalues for the OMXS30 index correlation matrix is also calculated after when the correlation has been shifted to ρ^{max}. The lowest eigenvalue is given by -0.08 and also several more eigenvalues are negative meaning that the correlation matrix is not positive definite after a positive shift. If this would occur the correlation matrix must be adjusted so that it is positive definite before any values are calculated.

7.3 Sources of Bias

Since this is an new developed and untested method it is important to discuss sources of bias that can affect the results and is reliability. The source that is believed to has most potential to contribute with bias in the method is the estimations of the market parameters. A second source of bias is the estimation on how much the market parameters should be adjusted to guarantee that the adjustment factors are included.

7.3.1 Source 1

Using the BSM-formula to estimate the implied volatility is a standard approach and also a reliable method meaning that there are no beliefs that the estimation of the implied volatility would contribute with bias. The estimation of the implied dividend is based on a method derived from a reliable relationship, the put-call parity. The derivation is straight forward and the method is also believed to be reliable. However is the estimation of the correlation not as reliable as for the other parameters. Estimating correlations is hard and there exist no good methods for doing this. The approach in this report is to use the implied correlation index to estimate the spreads of the correlations. To compensate for the uncertainty in the estimations of the correlations spreads are the spreads assumed to be wider than the estimated ones. Therefore is the bias from the correlation minimized but still a source that should be concerned when evaluating the results.

To see how much wrong estimations of the spreads of the market parameters can affect the results are the spreads assumed to be narrower than the estimated ones, meaning that the valuation adjustments might be underestimated and therefore are not all the adjustments factors included. This is done by assuming that the range of the spreads are two percent less, meaning that the estimated constants α, β and γ is instead given by

$$\hat{\alpha} = 0.99\alpha, \hat{\beta} = 0.99\beta \text{ and } \hat{\gamma} = 0.99\gamma$$

This gives

$$\hat{\sigma}^{max} < \sigma^{max}, \hat{D}^{max} < D^{max} \text{ and } \hat{\rho}^{max} < \rho^{max}$$

which eventually gives that the adjusted portfolio value with the narrower spreads, $\hat{V}^* = V(\hat{\sigma}^{max}, \hat{D}^{max}, \hat{\rho}^{max})$, is less than the original adjusted portfolio value V^*. This means that it is not necessary that all adjustment factors are included when the spreads are narrower. However when inserting the values of the adjusted parameters is V^* only 0.4% larger than $\hat{V}^*$ meaning that the affect of a narrower spread is very small and it is still likely that the adjustment factors are included.

7.3.2 Source 2

An important part in determining the total valuation adjustment is adjusting the market parameters sufficient such that all the adjustment factors are included. If the set of market parameters that correspond to an adjusted value is not conservative enough some of the adjustment factors might not be included. This means that this is a question of judgement and if there is any belief that the estimated total valuation adjustment is to small should to market parameters be chosen more conservatively.

In this thesis is it believed that the choice of market parameters is sufficient to ensure that the total valuation adjustment include all adjustment factors.

Option	V_{mid}	$V_{D_{max}}$	$V_{D_{min}}$	$V_{\sigma_{min}}$	$V_{\sigma_{max}}$	$V_{\rho_{min}}$	$V_{\rho_{max}}$
$Asian_{1,1}$	1670	1443	1920	1091	2303	1365	1964
$Asian_{1,3}$	5005	4195	5901	3638	6423	4235	5726
$Asian_{1,5}$	6657	5303	8183	4915	8451	5676	7572
$Asian_{2,2}$	9267	8384	10197	7836	10699	8453	10026
$Asian_{2,4}$	12418	10801	14142	10408	14424	11288	13469
$Asian_{2,6}$	13947	11584	16503	11637	16247	12660	15143
Cap_2	12192	11429	12976	11288	12909	11303	13025
Cap_4	12174	11042	13339	11671	12387	11011	13302
Cap_6	10715	9341	12114	10573	10583	9491	11920
Total Value	84044	73522	95275	73056	94425	75481	92146

Table 7.1: *Values (SEK): single shifts*

Option	$\Delta V_{D_{max}}$	$\Delta V_{D_{min}}$	$\Delta V_{\sigma_{min}}$	$\Delta V_{\sigma_{max}}$	$\Delta V_{\rho_{min}}$	$\Delta V_{\rho_{max}}$
$Asian_{1,1}$	-227	250	-579	633	-305	294
$Asian_{1,3}$	-809	897	-1366	1419	-770	722
$Asian_{1,5}$	-1354	1526	-1742	1794	-980	915
$Asian_{2,2}$	-884	930	-1431	1432	-814	758
$Asian_{2,4}$	-1617	1725	-2009	2006	-1130	1051
$Asian_{2,6}$	-2363	2556	-2310	2300	-1287	1196
Cap_2	-763	784	-905	717	-889	833
Cap_4	-1132	1165	-503	213	-1163	1128
Cap_6	-1373	1399	-142	-131	-1224	1205
Total Value	-10522	11231	-10987	10382	-8562	8102

Table 7.2: *Value changes (SEK): single shifts*

Option	$\Delta V_{D_{max}}$	$\Delta V_{D_{min}}$	$\Delta V_{\sigma_{min}}$	$\Delta V_{\sigma_{max}}$	$\Delta V_{\rho_{min}}$	$\Delta V_{\rho_{max}}$
$Asian_{1,1}$	-13.57	14.97	-34.68	37.93	-18.27	17.62
$Asian_{1,3}$	-16.17	17.92	-27.30	28.35	-15.39	14.42
$Asian_{1,5}$	-20.34	22.93	-26.17	26.95	-14.73	13.74
$Asian_{2,2}$	-9.54	10.03	-15.44	15.45	-8.78	8.18
$Asian_{2,4}$	-13.02	13.89	-16.18	16.15	-9.10	8.47
$Asian_{2,6}$	-16.94	18.33	-16.56	16.49	-9.23	8.58
Cap_2	-6.26	6.43	-7.42	5.88	-7.29	6.83
Cap_4	-9.29	9.57	-4.13	1.75	-9.55	9.27
Cap_6	-12.82	13.06	-1.33	-1.22	-11.42	11.25
Total Value	-12.52	13.36	-13.07	12.35	-10.02	9.64

Table 7.3: *Value changes (%): single shifts*

Option	$V_{D_{max},\sigma_{min}}$	$V_{D_{min},\sigma_{max}}$
$Asian_{1,1}$	907	2586
$Asian_{1,3}$	2930	7392
$Asian_{1,5}$	3727	10093
$Asian_{2,2}$	6983	11650
$Asian_{2,4}$	8868	16202
$Asian_{2,6}$	9406	18896
Cap_2	10503	13659
Cap_4	10459	13447
Cap_6	9067	11824
Total Value	62850	105748

Table 7.4: *Values (SEK): shift of dividends and volatility*

Option	$\Delta V_{D_{max},\sigma_{min}}$	$\Delta V_{D_{min},\sigma_{max}}$
$Asian_{1,1}$	-763 (-45.71%)	916 (54.85%)
$Asian_{1,3}$	-2074 (-41.44%)	2388 (47.71%)
$Asian_{1,5}$	-2930 (-44.01%)	3436 (51.62%)
$Asian_{2,2}$	-2284 (-24.65%)	2382 (25.71%)
$Asian_{2,4}$	-3550 (-28.59%)	3784 (30.48%)
$Asian_{2,6}$	-4541 (-32.56%)	4949 (35.48%)
Cap_2	-1689 (-13.85%)	1467 (12.03%)
Cap_4	-1715 (-14.09%)	1273 (10.46%)
Cap_6	-1647 (-15.38%)	1110 (10.36%)
Total Value	-21190 (-25.22%)	21705 (25.83%)

Table 7.5: *Value changes (SEK): shift of dividends and volatility*

Option	$V_{\rho_{min},\sigma_{min}}$	$V_{\rho_{max},\sigma_{max}}$
$Asian_{1,1}$	867	2670
$Asian_{1,3}$	3029	7286
$Asian_{1,5}$	4131	9536
$Asian_{2,2}$	7133	11559
$Asian_{2,4}$	9433	15613
$Asian_{2,6}$	10525	17596
Cap_2	10502	13840
Cap_4	10624	13624
Cap_6	9448	11885
Total Value	65692	103609

Table 7.6: *Value (SEK): shift of correlation and volatility*

Option	$\Delta V_{\rho_{min},\sigma_{min}}$	$\Delta V_{\rho_{max},\sigma_{max}}$
$Asian_{1,1}$	-8031(-48.10%)	1000 (59.89%)
$Asian_{1,3}$	-1976 (-39.48%)	2281 (45.58%)
$Asian_{1,5}$	-2526 (-37.95%)	2879 (43.25%)
$Asian_{2,2}$	-2134 (-23.03%)	2291 (24.72%)
$Asian_{2,4}$	-2985 (-24.04%)	3195 (25.73%)
$Asian_{2,6}$	-3422 (-24.54%)	3650 (26.17%)
Cap_2	-1690 (-13.86%)	1647 (13.51%)
Cap_4	-1550 (-12.73%)	1451 (11.92%)
Cap_6	-1266 (-11.82%)	1171 (10.93%)
Total Value	-18352 (-21.84%)	19565 (23.27%)

Table 7.7: *Value changes (SEK): shift of correlation and volatility*

Option	$V_{\rho_{min},D_{max}}$	$V_{\rho_{max},D_{min}}$
$Asian_{1,1}$	1160	2232
$Asian_{1,3}$	3484	6668
$Asian_{1,5}$	4420	9170
$Asian_{2,2}$	7593	10973
$Asian_{2,4}$	9723	15233
$Asian_{2,6}$	10384	17764
Cap_2	10546	13814
Cap_4	9917	14494
Cap_6	8185	13376
Total Value	65412	103723

Table 7.8: *Value (SEK): shift of correlation and dividend*

Option	$\Delta V_{\rho_{min},D_{max}}$	$\Delta V_{\rho_{max},D_{min}}$
$Asian_{1,1}$	-509 (-30.50%)	563 (33.70%)
$Asian_{1,3}$	-1520 (-30.38%)	1663 (33.23%)
$Asian_{1,5}$	-2237 (-33.61%)	2513 (37.75%)
$Asian_{2,2}$	-1675 (-18.07%)	1706 (18.40%)
$Asian_{2,4}$	-2695 (-21.70%)	2815 (22.67%)
$Asian_{2,6}$	-3563 (-25.54%)	3817 (27.37%)
Cap_2	-1646 (-13.50%)	1621 (13.30%)
Cap_4	-2257 (-18.54%)	2320 (19.06%)
Cap_6	-2529 (-23.61%)	2661 (24.84%)
Total Value	-18632(-22.17%)	19679 (23.42%)

Table 7.9: *Value changes (SEK): shift of correlation and dividend*

Option	V_{min}	V_{mid}	V_{max}
$Asian_{1,1}$	705	1670	2970
$Asian_{1,3}$	2382	5005	8298
$Asian_{1,5}$	3043	6657	11248
$Asian_{2,2}$	6304	9267	12528
$Asian_{2,4}$	7944	12418	17432
$Asian_{2,6}$	8381	13947	20312
Cap_2	9722	12192	14597
Cap_4	9444	12174	14717
Cap_6	8006	10715	13179
Total Value	55931	84044	115281

Table 7.10: *Values (SEK): shift of all parameters*

Option	ΔV_{min}	ΔV_{max}
$Asian_{1,1}$	-965 (-57.77%)	1300 (77.86%)
$Asian_{1,3}$	-2622 (-52.39%)	3293 (65.8%)
$Asian_{1,5}$	-3614 (-54.29%)	4592 (68.98%)
$Asian_{2,2}$	-2964 (-31.98%)	3260 (35.18%)
$Asian_{2,4}$	-4473 (-36.02%)	5014 (40.38%)
$Asian_{2,6}$	-5566 (-39.91%)	6365 (45.64%)
Cap_2	-2470 (-20.26%)	2405 (19.73%)
Cap_4	-2730 (-22.42%)	2543 (20.89%)
Cap_6	-2709 (-25.28%)	2465 (23.00%)
Total Value	-28112 (-33.45%)	31238 (37.17%)

Table 7.11: *Value changes (SEK): shift of all parameters*

Option	Total Valuation Adjustment
$Asian_{1,1}$	11.48%
$Asian_{1,3}$	10.55%
$Asian_{1,5}$	10.87%
$Asian_{2,2}$	6.70%
$Asian_{2,4}$	7.44%
$Asian_{2,6}$	8.14%
Cap_2	4.07%
Cap_4	4.21%
Cap_6	4.53%
Portfolio	6.98%

Table 7.12: *Total valuation adjustment*

Stock prices	+1%	-1%
Delta	3850.65	-3850.65
Portfolio	3957.96 (107.30)	-3856.26 (-5.61)
Portfolio(max)	4326.55 (475.90)	-4247.44 (-396.79)
Portfolio(min)	3414.08 (-436.57)	-3283.13 (567.52)

Table 7.13: *Value change (SEK): hedge*

	$\lambda_{\rho_{min}}$	$\lambda_{\rho_{mid}}$	$\lambda_{\rho_{max}}$
Basket 1	0.38	0.28	0.18
Basket 2	0.21	0.114	0.005
Basket 3	0.26	0.16	0.06

Table 7.14: *Smallest eigenvalues 1 year correlation matrix*

	$\lambda_{\rho_{min}}$	$\lambda_{\rho_{mid}}$	$\lambda_{\rho_{max}}$
Basket 1	0.40	0.30	0.20
Basket 2	0.21	0.11	0.01
Basket 3	0.27	0.17	0.07

Table 7.15: *Smallest eigenvalues 90 days correlation matrix*

8. Conclusions

The new release of the capital requirements directive has led to more stringent requirements concerning valuation adjustments of financial instruments. The directive requires that several factors should be taken into account when estimating the valuation adjustments. However these factors are considered to be difficult and time consuming to estimate since there exist no guidelines concerning the topic. The purpose of this thesis has therefore been to develop a method that easy and fast can estimate the valuation adjustments. The method is developed such that it is easy to implement and also comprehensive, will most likely work for any financial instrument whose valuation is based on a valuation model.

8.1 The Method: Evaluation

The total valuation adjustment of the portfolio is estimated to 7% of the prudent value of the portfolio and it is believed to be reasonable. A second important result is that the method captures the sensitivity of financial instruments and therefore get estimations of the valuation adjustments which is reasonable for the instruments. This is a great quality of the method and demonstrates that this approach of estimating valuation adjustments is reasonable.

The reliability of the method has also been concerned in form of discussing sources of bias and possible issues that can arise from using the method. Moreover is it shown that the issues are not a problem that needs to be concerned. The greatest source of bias is believed to be the estimations of market parameters. If the boundaries of these parameters are underestimated it can lead to that the total valuation adjustment is underestimated and therefore are not all the adjustment factors included. The boundaries of both implied dividends and implied volatilities are believed to be estimated accurately but the boundaries of the correlations are more uncertain since there exist no good method to estimate implied correlations. However is this issued treated by widening the range of the estimated correlation spreads. It is also tested how a two percent narrower spread of each parameter would affect the valuation adjustment and the results showed that this effect was negligible.

8.2 Critique

The method has only been demonstrated for a smaller portfolio and it is not necessary that similar results hold for a larger portfolio[1]. Since there exist sources of bias there is always a risk for errors in the outcome. Even if it is believed that the bias is handled it is possible that the situation is otherwise. Therefore is it important to weight the bias from the method with the difficulties of estimating the adjustment factors directly..

8.3 Conclusion

This thesis contributes with an alternative approach to estimate valuation adjustment of financial instruments. However in this stage is a more comprehensive study needed to determine whether this method is possible solution to estimate valuation adjustments, even if it is believed that the method is a reasonable and reliable alternative. It is also important to notice that estimating the adjustment factors directly one-by-one is no guarantee for a more accurate total valuation adjustment since these adjustment factors also will be based on estimation and assumption.

The greatest contribution from this thesis is therefore the methods potential to be improved to work as a standardized procedure or as a guideline on how valuation adjustments can be estimated. If the method would be approved it can also be used by financial institutes in other countries since the CRD is based on changes amended to the Basel II framework which affect other countries as well.

8.4 Further Research

As mentioned earlier is a comprehensive study using larger portfolios needed to truly test the performance of the suggested method. Also would it be interesting to do a comparison between the method and actually estimating the individual adjustment factors described in the CRD. This could either confirm or reject the method.

Two other aspects that would be interesting to research further is to see how the valuation adjustments affects when the estimated spread of the market parameters varies in time, and is not assumed to be constant over time as in this thesis. Secondly it would also be interesting to see how different shifts of the market parameters affect the valuation adjustments. It

[1] A single example as in section 7.1.1 is not considered enough to say that the method holds for larger portfolios in general.

is more realistic that the market parameters are shifted differently and not with the same percentage factor.

Even though that the implied correlation had a minor roll in this thesis the basics in this report could be use for further developments in how the implied correlation can be estimated.

A. Abbreviations of OMXS30 Stocks

Stock	Company
ABB	ABB
ALFA	Alfa Laval
ASSA B	Assa Abloy
ATCO A	Atlas Copco A
AZN	Astra Zeneca
BOL	Boliden
ELUX B	Electrolux
ERIC B	Ericsson
GETI B	Getinge
HM B	Hennes & Mauritz
INVE B	Investor
LUPE	Lundin Petroleum
MTG B	Modern Times Group
NDA	Nordea
SAND	Sandvik
SCA B	SCA
SCV B	Scania
SEB A	SEB
SECU B	Securitas
SHB A	Svenska Handelsbanken
SKA B	Skanska
SKF B	SKF
SSAB A	SSAB
SWED A	Swedbank
SWMA	Swedish Match
TEL2 B	Tele2
TLSN	TeliaSonera
VOLV B	Volvo Group

B. Average Implied Dividends

Stock	D_{avg}^{min}	D_{avg}^{max}
ABB	3.4460	4.9647
ALFA	2.5218	3.9457
ASSA B	3.3987	5.2959
ATCO A	2.8186	4.1720
AZN	10.1525	13.8090
BOL	3.6607	5.1547
ELUX B	4.5614	5.9601
ERIC B	2.5135	4.1501
GETI B	2.6394	3.9948
HM B	4.2159	5.9924
INVE B	4.0366	5.8634
NDA	3.1110	4.04240
SAND	2.0681	3.0057
SCA B	3.3807	4.7435
SCV B	3.3878	4.5150
SEB A	2.1190	2.7210
SECU B	2.9096	4.0242
SHB A	6.2943	8.4245
SKA B	4.3666	5.5877
SKF B	4.4271	5.9563
SSAB A	2.3946	3.1644
SWED A	1.966	3.0316
SWMA	3.1023	5.5235
TEL2 B	5.17692	6.7799
TLSN	1.9564	2.4799
VOLV B	3.0412	4.3841

C. Average Implied Volatility

Stock	σ_{avg}^{min}	σ_{avg}^{max}
ABB	0.2464	0.2967
ALFA	0.2533	0.3501
ASSA B	0.2383	0.3172
ATCO A	0.2970	0.3893
AZN	0.1123	0.1593
BOL	0.3385	0.4120
ELUX B	0.2794	0.3927
ERIC B	0.2913	0.3386
HM B	0.2321	0.2815
INVE B	0.2069	0.2692
LUPE	0.4530	0.5045
NDA	0.2547	0.3073
SAND	0.3541	0.4049
SEB A	0.2698	0.4026
SHB A	0.2266	0.3019
SKA B	0.2146	0.2911
SKF B	0.3088	0.3693
SSAB A	0.4085	0.4683
SWED A	0.3195	0.4050
TEL2 B	0.2263	0.2878
TLSN	0.1887	0.2750
VOLV B	0.3563	0.4027

D. Delta Hedge

Delta of each underlying stock in the portfolio.

Stock	Amount
ABB	-96
ALFA	-102
ATCO A	-131
AZN	-30
ERIC B	-423
HM B	-53
LUPE	-47
MTG B	-48
SAND	-214
SCA B	-249
SCV B	-157
SEB A	-440
SECU B	-244
SHB A	-148
SKA B	-154
SKF B	-181
SSAB A	-185
SWED A	-137
SWMA	-100
TEL2 B	-170
TLSN	-357
VOLV B	-179

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