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The Influence of Macroeconomic Factors on the Probability of Default

A Study of the Relationship between Default Probabilities and Macroeconomic Variables

NEKM03
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Abstract

Title: The Influence of Macroeconomic Factors on the Probability of Default - A Study of the Relationship between Default Probabilities and Macroeconomic Variables

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Purpose: The purpose of this study is to quantitatively verify the relationship between corporate default probability and macroeconomic information. The purpose is further to compare the results of the panel data analysis for the firms from the Large Cap Index with the empirical findings generated by a similar model for the firms from the Mid & Small Cap Indexes. Also, the study aims to examine to which extend the current probability of default can be explained by an autoregressive model.

Method: This thesis presents the panel data analysis used for studying the relationship between default probability and macroeconomic factors in Sweden. Two separate panel models with cross-sectional fixed effects are estimated for two groups of Swedish non-financial firms – the Large Cap firms and the Mid & Small Cap firms, respectively. The regression models are constructed with respect to the delayed effect of macroeconomic information on the default probabilities. Distance to default is used as a dependent variable as closely related to the probability of default, since the variable of the probability of default possesses a variation not sufficient for the reliable regression analysis. The distances to default of the firms are calculated using the structural model similar to the Moody's KMV™ approach. An autoregressive model with one-year lagged distance to default is also estimated.

Empirical Findings: The panel regression results for the two groups of firms appear to be similar. It has been found that the one year lagged Industrial Production Index and the one year lagged SEK/EUR exchange rate exhibit a large negative effect on the probability of default. The interest rate and the one year lagged interest rate have been found to have a positive impact on the probability of default. The autoregressive model with an autoregressive term lagged once shows a decreasing distance to default over time.

Conclusions: Macroeconomic factors such as the one year lagged Industrial Production Index, the one year lagged SEK/EUR exchange rate, the interest rate and the one year lagged interest rate can explain 75% of the changes in the probability of default in the working sample in the model for the Large Cap firms (68% in the model for the Mid & Small Cap firms, respectively). The autoregressive model indicates a weak explanatory power and an increasing probability of default for every year, depending on the previous year probability of default.

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1 Introduction

The studies verifying the relationship between default probability and risk factors of different origin are not any new research area. In this chapter we present the background to the problem of macroeconomic impact on defaulting and the prior researchers' empirical findings in this field. This makes the subject of the current study more clear and leads to a question at issue. The chapter also includes a purpose, delimitations and thesis outline.

1.1 Background

The recent turbulence on financial markets, seen in the economic recession context, influences both a probability of default on debt obligations for borrowers and a loss distribution of credit portfolio for lending institutions. It is hard to decide which factors actually determine the default events. This makes the verification of the risk factors behind default probability important.

The impact of macroeconomic factors and business cycles on firm profitability is considered to be obvious. It is therefore reasonable to account for macroeconomic factors when assessing the risk profile of an individual firm. Default probability analysis is an interesting issue, especially when considering the impact of macroeconomic fluctuations. The economic history has recorded the chains of bankruptcies during recessions as well as more precautionary lending activity of banks in periods of economic downturns.

Macroeconomic factors, however, are left outside the classic modern credit risk models *(Merton (1974),* KMV's PortfolioManager, CSFB's CreditRisk+ and others). Indeed, current risk measurement models asses default probabilities from structural relationship between equity, debt and asset value. These models emphasize the importance of assets volatility, but at the same time ignore the fact that asset volatility exhibits direct connection to the economic condition – either economic downturns or expansions. The empirical evidence of reciprocal relationship between default history and economic slowdown as well as lending activity of banks shows that changes in default frequency are attributable to systematic risk factors beyond idiosyncratic characteristics and industry conditions.[1]

Therefore, the status of the economy does matter for estimation of default probability, beyond the standard criteria such as borrower's credit history and character of investment project. Nowadays we are facing an increase in bankruptcies, increasing volatility of collateral and widening practicing of off-balance-sheet financing. Not least the overall status of the contemporary macroeconomy raises a number of questions concerning the classical risk measurement models being extended with macroeconomic factors.

The practical implementation of the empirical results of this kind could be considered in corporate valuation, when assessing corporate creditability and overall financial health of the firm, when making investment decisions and decisions on financial recapitalization. Further, from the entire society level, continuing monitoring of corporate default probabilities is important for financial stability.

1.2 Prior Research

The importance of risk measurement for the financial institutions and risk exposed companies cannot be denied. Risk assessment techniques are not considered to be a new research area. Nevertheless, the recent years of risk metrics development are defined in the contemporary literature as revolutionary. *(Saunders et al, 2002)* Furthermore, assessing the default probability with respect to macroeconomic fluctuations has been attracting the researchers' minds in the very recent years. Below we present only some examples of the prior researches regarding the relationship between probability of default and macroeconomic factors.

[1] See e.g. Jonsson *et al* (1996), and Wilson (1997)

Wilson (1997a,b) developed the CreditPortfolioView which is an instrument for measuring the portfolio credit risk with respects to economic cycles. CreditPortfolioView is a discrete time multi-period model which uses domestic macroeconomic variables such as GDP, inflation, short term interest rate, exchange rate and equity prices, and some other factors. These are, in turn, related to corresponding foreign variables constructed so that they match the international trade pattern of the country of interest. Because of the global nature of the model, it can be analyzed how a shock to one specific macroeconomic variable affects other macroeconomic variables across countries.

Pesaran and Schuermann (2003) look at risk measurement problem from a viewpoint of banking institution. The authors separate between systematic and idiosyncratic shocks that influence the borrower's collateral, and examine asset volatility of credit portfolio using the global macro econometric model. They assume that negative macroeconomic/financial shocks somewhere in the world economy affect the loss distribution of the bank's credit portfolio later on. Default probabilities of the geographically spread firms assumed to be correlated in the bank's credit portfolio. Correlation between default probabilities can be explained by existence of common systematic risk factors in different regions and globally.

Li and Zhao (2006) build their study on the documented fact that the default rates are higher during recessions. These authors aim to answer the question whether changes in default probability can be explained by cyclical changes in the economy. The research results in a conclusion that such macroeconomic variables as aggregate market return and inflation affect default probability. Even after controlling for idiosyncratic and industry effects, the aggregate market return is stated to be the most important default predictor. Moreover, the existence of cyclical component in default probability was certified by this study.

Qu (2008) is basically following the approach of Wilson (1997) who has for instance stated that a model with a single systematic factor is not sufficient to capture all the systematic information to estimate default probability. Qu examines the relationship between default probability on one side and industrial production, CPI (consumer price index), interest rate spread, share price, unemployment and exchange rate on the other side. Moreover, firm specific variables are included in the model since those are proxy for default probability. Qu analyzes the problem for different industries and geographical regions in order to ensure the robustness of the findings. As expected, the impact of different macroeconomic variables on default probability varies with countries. Macroeconomic variables themselves exhibit differently strong influence on default probability. Even different industries' reaction to macroeconomic information is not homogenous. Another interesting but expected result of this study is that the healthier the company, the less it is exposed to macroeconomic factors.

Dionne, Laajimi, Mejri and Petrescu (2008) perform the study of default probability using the Merton model (1974) and the default barrier model (Brockman & Turtle, 2003).[2] The authors show empirically that the predicting power of the structural models can be enhanced, when using the macroeconomic variables alongside with firm specific ones. Their article is even of a theoretical interest since it critically discusses the existing types of models for assessing default probabilities, *videlicet*: accounting (based on, for instance, Altamn's (1968) Z-score model), structural (originated from the Merton (1974) model) and reduced form models.

Koopman, Kräussl, Lucas and Monteiro (2009) conclude in their study of default probability that defaults are partly affected by macroeconomic variables. They relate default probability and rating cycles to business cycle, bank lending cycle and financial market factors. The authors demonstrate a strong persistence of macroeconomic variables, such as GDP-growth, the short-term interest rate, default spreads, stock market volatilities. However, they notice that when adding an unobservable dynamic component to the model already containing observable systematic risk factors, the models explanatory power increases.

Bonfim (2009) emphasizes the importance of macroeconomic conditions when assessing default probabilities over time. The author shows that firm's idiosyncratic characteristics play a central role in determining the default event. Macroeconomic variables, in turn, explain the evolution of default risk. Bonfim's model investigates firm specific and macroeconomic information simultaneously, verifying whether these variables affect the default process. The study achieves an interesting result for

[2] The Merton model and the Default Barrier model are discussed in the *Theory* chapter

understanding the implicit role of macroeconomic information for default developing. It is shown that periods of economic expansion are, as a rule, followed by increase in default frequency. The author concludes therefore that the risks connected to defaults are built up during the periods of economic growth, when the credit growth is higher. The risks created during expansion periods materialize firstly in recessions and become a source for an increase in default frequency.

Jiménez and Mencía (2009) conduct a study of default probability applied on the aggregate credit portfolio of a whole banking system in Spain. They point out the persistence of the latent factor, besides observable macroeconomic variables in the model (even under condition of augmented adding of macro variables). Thus, the latent factor enhances a strong relationship between credit losses and economic cyclicality (GDP growth and three-month real interest rate are used as explanatory macro variables), as documented in the study. Furthermore, the exposure at default is found to be higher during recessions than during economic upturns, which the authors explain by an obvious increase in lines of credit during recessions.

1.3 Positioning, Problem Discussion, and Question at Issue

As can be concluded from the section for prior studies, the empirical findings concerning macroeconomic effects on default probability differ from each other. Some studies point out the role of industry conditions in default history. Other authors find that some macroeconomic factors are significantly related to default probability, but do not find the cyclicality in default rate in connection with macroeconomic effects. There are also studies attempting to solve a problem of aggregate credit portfolio loss distribution, both on a particular country level and globally. The models associated with a later issue are built on the assumption about correlation between the borrowers' macroeconomic/financial risk factors and impact of these factors on the loss distribution of the aggregated credit portfolio. Other empirical studies in this area raise a cyclicality issue and contemplate default as a process of deterioration in collateral value; they also suggest some default originating events for the continuing default process in relation to macroeconomic cycles.

The relative variation in research results depends probably on the choice of different econometric models and starting assumptions concerning model's inputs. It also can be a sign of complexity of the problem.

The current thesis' interest is generally in a line with a prior research and is about the default probability complex of problems with respect to macroeconomic information. The fact that small economies figurate seldom in studies of this type make it interesting to look upon the Swedish market from the default probability assessing perspective.

As mentioned above, the prior researchers look upon the default probability from two main perspectives – from a financial institution point of view and from a perspective of a corporate borrower. Since the loss distribution of the credit portfolio of a particular lending institution is tied to macroeconomic fluctuations through the macroeconomic risk exposure of its borrowers *(Pesaran et al, 2003),* this thesis assignment is decided first of all to focus on studying the default probabilities of corporate loan takers.

This study attempts to control for macroeconomic explanatory power when examining the relationship between default probability and macroeconomic variables. A **question at issue** for this thesis assignment is therefore stated as follows:

Do macroeconomic factors exhibit an explanatory power as regards corporate default probability level?

- ***If so, which macroeconomic factors are the most important?***

Also, to which extend the current probability of default can be explained by an appropriate autoregressive model?

1.4 Purpose

The main purpose of this study is to quantitatively verify the relationship between corporate default probability and macroeconomic information, using a panel data analysis. The purpose is further to perform a quantitative comparison of the default probability and macroeconomic information between different Swedish stock indexes as well as to verify the expediency of the autoregressive model for the default probability.

1.5 Delimitations

The current study analyzes the corporate default probability development in Sweden. The object of investigation in this study is delimited to the Swedish non-financial companies listed on the Large Cap index[3]. Also, 20 randomly chosen non-financial firms belonging to Mid & Small Cap indexes[4] are included in the study for verifying the results and comparison. The chosen groups of companies are an appropriate studying object for the default probability models based on the Merton approach. We exclude financial firms following *Åsberg and Shahnazarian (2008)* and *Bharath and Shumway (2004)* due to their complex capital structure.

The explanatory variables used for analyzing the corporate default probability are delimited to macroeconomic variables, leaving the idiosyncratic risks associated with firm specific variables beyond the scope of this study. Incremental changes in inflation, interest rate, GDP-index, and other macroeconomic information, are considerable risk factors for any business unit. The more detailed selection of explanatory variables, not least with respect to the prior research, is presented in the chapter for methodological problems.

The time horizon for this study is set between year 1998 and 2008. The sample period is based on the availability of data. The study object consists of 20 firms from the Large Cap Index and 20 firms from the Mid & Small Cap Indexes. The choice of Sweden was simply due to our pre knowledge of the Swedish market and that Swedish

[3] Firms with a market capitalization of one billion euro are to be found here.
[4] Mid Cap includes firms with a market capitalization over 150 million, but below one billion Euro. Small Cap includes firms up to 150 million.

economy is a relatively unexplored research area. Besides, the question at issue for the study is relatively new for the Swedish data. The study is conducted on a yearly basis.

Some further delimitation can be needed if the selected variables lack the reliability in their time series or are inappropriate for use in the model because of the existence of specific interrelative properties.

1.6 Thesis outline

The thesis begins with an overview of the theoretical background of the default probability problem. The chapter is aiming to clarify for a potential reader the theoretical grounds that are essential for understanding the thesis problem.

In the chapter for methodological problems we describe the data collection, explain the chosen approach, and motivate the selection of explanatory variables alongside with generating of the working hypothesis.

In the chapter for empirical results we present the panel data analysis for Big Cap firms and Mid & Small Cap firms, respectively. The working models are constructed gradually with respect to econometric properties of the data – stationarity, autocorrelation, and redundancy of cross-sectional fixed effects *etc*.

In the final chapter we give the comments on the empirical results of this thesis. Based on this analysis, the further research directions in this field are suggested.

2 Theory

In this chapter the theoretical background to the thesis problem is presented. We discuss structural models and models with macroeconomic explanatory variables and/or default risk correlations, since these models are of interest for the current study. The chapter is aiming to clarify for the potential reader the theoretical grounds that are essential for understanding the thesis.

2.1 Structural models

Structural models rely on market information as a main input. Structural models have namely grown from *Merton's (1974)* approach, which is indeed a classic in this field. Merton's technique is based on the idea of applying the option pricing theory when valuing risky bonds and loans.

Speaking generally, structural models apply the Black-Scholes option pricing model. If the stockholders own the call option on the firm's assets and the option strike price corresponds to the firm's debt level, then the probability of default coincides with the probability that the option will not be exercised. Thus, the structural approach considers the company's debt, equity, and asset value as risk factors. These variables are involved in a structural relationship which generates the estimate of default probability. Structural models are appraised to be market-based, since asset value is estimated on the basis of equity market value. (*Dionne et al, 2008*)

Merton (1974) comes with a new insight concerning pricing corporate bonds. He proposes a corporate security pricing technique under condition of significant default probability. He argues that corporate debt depends on the riskfree rate of return, contract conditions and default probability of a firm. The risk structure of interest rate appears, according to Merton, also to depend on these factors. In this context the term "risk" must be tied to unanticipated changes in default probability, not in economy's interest rate.

The theoretical support for his research Merton finds in the Black-Scholes theoretical formula for pricing of options and corporate liabilities.

Black and Scholes (1973) are the first who theoretically have shown that corporate liabilities may be viewed as options. The authors suggest a reader to consider a simple case of a firm with "pure discount bonds"[5] and shares of common stock outstanding. The firm owns shares in another firm. The firm is not allowed to pay dividends. The proceeds from selling the held stock at the time of debt maturity are used for paying the bondholders, whereas the stockholders' claims are residual.

Black *et al* present this situation as such when the bondholders own the firm's assets and at the same time write an option to stockholders, giving them hereby a right to buy back the assets. The non-negative difference between asset value at bonds maturity and bonds' face value gives consequently the value of common stock. This is the same as the value of the option, which is a function of stock price and time to maturity. The value of bonds corresponds therefore to the difference between the price of common stock and the value of option. (*Ibid*)

Black *et al* modify the initial example and assume that the firm has business assets instead of financial. At debt maturity the firm issues new common stock and from proceeds pays to bondholders, whereas the stockholders' claims are residual. Assuming the absence of taxes, the value of the firm equals to the sum of the debt and total common stock value. So, the firm value is not affected by change in the amount of debt, but the firm value distribution between bonds and stock is affected. The total bond value is again depicted by the difference between the stock price and option value. (*Ibid*)

Applying the Black-Scholes theoretical framework when pricing corporate debt, Merton starts with expressing the value of the firm, V, in a dynamic manner with help of the stochastic differential equation: $dV = (\alpha V - C)dt + \sigma V dz$, where α is an expected rate of return per time unit; a positive C stays for the outflow of money per time unit to

[5] The bonds paying no coupons, only face amount at time of maturity (Black *et al*, 1973)

the stake- or bondholders; a negative *C* stays for the inflow of money per time unit from the stock- or bondholders; σ^2 is a return variance per time unit; *dz* is a standard Gauss-Wiener process. (*Merton, 1974*)

Merton illustrates the isomorphic relationship between dynamic value of a firm and dynamic value of a firm's security with a certain market value. Any firm's security *Y* can be expressed, according to Merton, as a function of the firm value, *V*, such as $Y = F(V, t)$ and $dY = [\alpha_Y Y - C_Y]dt + \sigma_Y Y dz_Y$. As such, there is a functional relationship between *α, σ, dz* and α_Y, σ_Y, dz_Y, respectively. Moreover, he argues that the returns on the firm and on the firm's security are perfectly correlated, by showing that $dz_Y \equiv dz$. (*Ibid*)

What regards the parameters that affect the firm value and hence the value of any security issued by the firm, Merton mentions the interest rate, the volatility of firm value (the business risk, measured by the variance), the current and the future payout policy. In turn, the expected rate of return, investors' risk aversion and assets characteristics are of no meaning for the dynamic value of the firm and the firm's security. (*Ibid*)

Next, the author applies the Black-Scholes theoretical reasoning on pricing of corporate risky debt. When the debt matures, applying the Black-Scholes framework, the firm is obligated to pay the debt face value to bondholders. Then, the value of equity appears to be positive and corresponds to the difference between the value of the firm at the time of maturity and the debt face value. The value of equity is zero if the firm value is below the face value of debt. In this case default event occurs. Summarizing, the bond value depends on the value of the firm and time to maturity and takes the lowest value between the value of the firm and the debt face value $(F(V,0) = \min[V, B])$ (*Ibid*)

In such way Merton builds a structural relationship between the parameters which affect the firm value and hence the value of the firm's bond. His corporate debt pricing analysis furnishes an understanding of how the corporation may default on its obligations to financing providers.

However, the fact that structural models use market inputs gives rise to some criticism. That is because of trading “noises” which cause the errors in asset volatility estimates. Moreover, the Merton model does not consider the possibility of default before the firm’s debt matures, which is just an obvious simplification of reality. *(Dionne et al, 2008)*

Brockman and Turtle (2003) propose a barrier structural model that involves down-and-out options for the lenders. In this way they suggest a solution for the problem of option independency from the value development of the underlying asset, which solves the problem of simplification of reality. Instead of a standard call (as it is stated in *Black et al, 1974*), Brockman *et al* argue that the firm’s equity is a down-and-out call on its assets. The authors emphasize that the option’s payoff depend primarily on the asset value development over the option life, and not exclusively on the asset value at the point of debt maturity.

What regards the fact that only stockholders hold the right to exercise the option in the Merton model, the barrier option framework provides the bondholders with a down-and-in call. Brockman *et al* explain that bondholders possess “a portfolio of risk-free debt, a short put option on firm assets, and a long down-and-in call option on firm assets”. (*Brockman et al, 2003*, s.512) Bondholders are able to activate this down-and-in call before the point of total deterioration of asset value, when the pre-specified barrier has been achieved.

Structural models being a subject for critique depend also on their applicative limitations and difficulties regarding default probability interpretation. The former problem involves an inability of structural models to be applied to private companies, because these models rely on equity price information. The later problem involves a difficulty to explain the level of default probability, determined within the model. With other words, explanatory properties are not presupposed in structural models. (*Bunn, 2003*)

However, structural models maintain being of interest for contemporary researchers. Moody’s KMV™ model is, for instance, an example of implementation of the Merton framework on the corporate level.

2.2 The KMV™ model

The *Merton (1974)* framework, developed by *Vasicek (1984)* (and thus known as Vasicek-Kealhofer (VK) model), has successfully been commercialized by KMV™. The credit risk assessment methodology used by KMV™ is also called a contingent claim model that aims to define the probability for a particular firm of defaulting within a certain period. *(Bohn et al, 2003)*

The Black-Scholes option pricing model is extended within the KMV™ model compared to the Merton model. The KMV™'s fundamental principle is similar to the barrier structural model suggested by *Brockman et al (2003)* – the equity of the firm is thus seen as a perpetual down-and-out option. Under these conditions the firm defaults when the asset value reaches the predetermined barrier. Furthermore, the KMV™ model allows modelling for short-term liabilities, long-term liabilities, convertible debt, preferred equity and common equity, whereas the Merton model presumes the default point corresponding to the single debt liability, the one zero coupon bond. (*Ibid*)

The value of the default option on a risky loan depends on the market value of firm's assets, the volatility of the market value of assets, the book value of liabilities, the riskfree interest rate, and time horizon, – that is valid both for the Merton and KMV™ model. There are three main components that are necessary for measuring the default probability and understanding its nature – the market value of assets, the asset risk and the leverage. (*Ibid*)

The market value of assets reflects the enterprise value of the firm, which is determined by the firm's equity value, equity volatility, and liability structure. Because the market value of assets is not directly observable, Moody's KMV™ employs an option-theoretic model to compute this value, contemplating the value of firm's equity as a call option on the firm's underlying assets. The option-theoretic approach enables Moody's KMV™ to determine the market value of a firm's assets from knowing only the market characteristics of its equity value and the book value of its liabilities. In such way even the information about industry and economy is incorporated in the measure corresponding to the market value of assets. The market value of assets must be interpreted as the present value of the future cash flows, generated by the assets. *(Bohn et al, 2003)*

The asset risk is a measure of the uncertainty of asset value and is attributable to business risk and industry risk. Technically, the asset risk can be expressed by the standard deviation of the annual percentage change in the market value of firm's assets. The higher the asset value volatility, the less the investors are certain about the market value of the firm, and the firm's value is more likely to fall below its default point. *(Bohn et al, 2003; Bharath et al, 2004)*

The leverage corresponds to the firm's contractual liabilities. They must be taken at their book value since that is the amount the firm is obligated to pay. (*Ibid*)

Intuitively, when the market value of assets decreases and for this reason reaches the liabilities level, the firm's default risk increases. This leads to the additional important element that determines the default probability – the default point.

The default point is the level of the market value of assets, below which the firm would fail to make scheduled debt payments. A firm becomes bankrupt when the market value of its assets (V_A) is lower than its default point, i.e. the company's debt (D): $V_A < D$. However, firms not always default when the market value of assets decreases so that it reaches the level of liabilities – their survival can be provided by the long-term character of debt. Then, the expression $V_E = V_A - D < 0$ (where V_E is the market value of equity) seems to be more relevant for determining the defaulting. (*Bohn et al, 2003*)

The default point is therefore a firm specific measure and is a function of the firm's liability structure. It is estimated based on extensive empirical research by Moody's KMV™, which has observed thousands of defaulting firms. The default point of each firm is thus related to the market value of the firm's assets at the time of default. These empirical observations resulted in a huge database of expected default frequencies (*EDF*), which are the probabilities that the certain companies default within a certain period.

Moody's KMV™ calculates the *EDF* as a function of distance to default (*DD*). The *DD* in the Moody's KMV™-model measures the number of standard deviations (or distance) between the market value of a firm's assets and its relevant liabilities. Expressed in standard deviation, the *DD* makes it possible to compare default frequencies between different companies, irrespective of their size. (*Bohn et al, 2003)* The results of *DD* can also be interpreted as the amount the company's assets can fall before the company defaults. *(Allen and Saunders, 2002)*

Moody's KMV™ suggests calculating the distance to default that accounts for the sudden changes in the market leverage. As one can expect, the volatility of the market value of the firm's assets is related to the equity volatility in the following way:

$\sigma_E = \frac{V_A}{V_E} \Delta \sigma_A$ (*Bohn et al, 2003*),

where σ_E and V_E are the equity volatility and the market value of equity, respectively. σ_A and V_A are the asset volatility and the market value of assets. (*Ibid*) If there is a sudden decrease in the market leverage, the asset volatility can be overestimated and hence also the default probability. If there is a sudden increase in market leverage, the asset volatility can be underestimated and hence also the default probability. According to Moody's KMV™, the assets returns, retrieved from the initial asset volatility, are used for calculating the next asset values and corresponding asset returns until the process converges and the volatility is derived in this complex manner. The distance to default measure combines the value of the firm's assets, its leverage and its business and industry risk. The distance to default is suggested by Moody's KMV™ suggests to describe the distance to default by the complex expression: $DD = \frac{\ln V_A / V_E + (\mu + \frac{1}{2}\sigma_A^2)T}{\sigma_A \sqrt{T}}$, where μ is the expected asset return per time unit. (*Ibid*)

The market value of assets is to be retrieved from the market value of equity employing the Black-Scholes option pricing formula: $V_E = V_A N(d_1) - e^{-rfT} FN(d_2)$, where V_E is the value of firm's equity, V_A is the value of firm's assets, r_f is the risk free interest rate, *F* stays for the face value of debt, *T* represents the time (maturity), *N(·)* is the cumulative normal distribution, $d_1 = \frac{\ln(V_A / F) + (rf + \frac{1}{2}\sigma_A^2)T)}{\sigma_A \sqrt{T}}$, and $d_2 = d_1 - \sigma_A \sqrt{T}$. (*Bohn et al, 2003*)

Next, the default probability can be predicted exploiting the *EDP*-database. Let's assume that there is a firm whose distance to default (*DD*) is *n* standard deviations away from the default point and it is needed to determine the probability that the default event occurs within one year. Next, let's assume that the KMV™'s *EDF*-database reports that *m* percent of the observed firms that exhibit the *DD* of *n* standard deviations away from default point actually have defaulted within one year. Then, the default probability of the firm of interest intuitively equals *m* percent. Thus, the *EDF* provides a forward-looking measure of default.

As can be noticed, KMV™ is best applied to publicly traded companies for which the value of equity is market determined. The KMV™ model translates the information contained in the firm's stock price and balance sheet into an implied risk of default.

2.3 Models accounting for macroeconomic information and/or default correlations

Another group of models, relevant for this thesis assignment, relies on macroeconomic information and/or accounts for default correlations. These models have an objective to determine on which stage of the macroeconomic cycle the default risks are created. *(Bonfim, 2009).*

An illustrative study on this field is conducted by *Gersbach and Lipponer (2003).* They argue that the default distribution of a particular firm can be derived from the distribution of the returns of firm assets, since loans are sorts of claims on firm value. In such way the correlations between asset returns are connected to the correlations between default distributions. From this point of view, the healthier the firm is, the less its default distribution correlates with other firms' default distributions. When the macroeconomic information is taken into account, the default probability and default correlations increase as macroeconomic risks increases. It is concluded that macroeconomic risks influence the default probabilities and default correlations.

The critics of default probability models, accounting for macroeconomic information, argue that one must be careful about the sample period – it must be long enough for the model to be able to incorporate the macroeconomic effects. *(Bunn, 2003)*

2.4 Autoregressive Model

Autoregressive models are often used in studies of time series data where the behaviour of a dependent variable is determined by its previous estimations. *Åsberg and Shahnazarian (2008)* present an estimation model for predicting the distance to default. The model is based on the hypothesis that the best forecast for future distance to default is provided by the recent outcomes for the variable in question. The model is hereby constructed as follows: $DD_t = \alpha DD_{t-n} + \varepsilon_t$, were DD_t and DD_{t-n} are the distance to default at time t and $t-n$ respectively, ε_t is the error term and α is the estimated coefficient.

3 Methodology and data collection

In this chapter we describe the data collection, explain the chosen approach, and motivate the selection of explanatory variables alongside with generating the working hypothesis regarding the explanatory variables.

3.1 Thesis Methodology and Approach

Our aim with this thesis is to test the macroeconomic factors' explanatory power on the default probability of non-financial firms from the Large Cap Index and of 20 randomly chosen non-financial firms from Mid & Small Cap Indexes. The study is conducted on a yearly basis.

The methodological framework of this thesis assignment contains two substantial parts – the distance to default calculation and the regression modelling.

3.1.1 Calculation of Distance to Default

Since we do not have access to the Moody's KMV™ *EDF*-database, the generating of the default probability is based on the assumption of normally distributed asset returns. *(Bharath et al, 2004)* The time horizon for the default prediction is set to one year. The amount of debt that is reasonable for defining the default probability is assumed to correspond to short term liabilities plus a half of long term liabilities, since it is a commonly used way.[6] The risk free rate is decided to be the one-year Swedish Treasury bill because our studying objects refer to the national macroeconomic data. We assume that the International Fisher Parity holds which makes using other interest rates unnecessary. (*Oxelheim and Wihlborg, 2008)*

[6] See e.g. Bharath and Shumway (2008), Chan-Lau and Amadou (2006), and Korablev and Jiang (2007)

The implementation of the complex sequential technique for determining the volatility of assets, mentioned in the theory-chapter, is beyond the scope of this thesis. Instead, the relationship between volatility of equity and volatility of asset market value is based on the assumption that this relationship holds instantaneously. In this case the equations that describe the relationship between market value of equity and market value of assets (the Black-Scholes option pricing formula), the relationship between volatility of market value of assets and volatility of equity, and the formula for *DD*, are shown by: $V_E = V_A N(d_1) - e^{-rfT} FN(d_2)$, $\sigma_E = \frac{V_A}{V_E} \Delta \sigma_A$, and $DD = \frac{V_A - DefaultPoint}{V_A \times \sigma_A}$, respectively. *(Bohn et al, 2003)*

The estimates of V_A and σ_A are generated by solving the equations for equity value and equity volatility simultaneously. After this, the *DD* can be easily calculated. The assumption of normality allows simply substituting the *DD*-measure into a cumulative density function to determine the probability that the value of the firm will be less than the face value of debt within a forecasting horizon: $DP(T) = N[(-DD(T)]$. *(Bharath et al, 2004)*

We refer to the following example for calculating distance to default in order to sum up the presented information. Let us consider a firm with assets worth 10 million U.S. dollars. The default point is set to 8 million U.S. dollars, and a volatility of the company's assets reaches 10%. We receive a *DD* of 2 as shown below.

$$\frac{\$10.000.000 - \$8.000.000}{\$10.000.000 * 0{,}1} = 2$$

The result means that the company is 2 standard deviations away from a default. Assuming normal distribution, it implies that approximately 95 percent is approximately two standard deviations from the expected value. However, it is only the left tail which is of interest because we are aiming to assess the risk of default. So, it corresponds to a probability of default of 2.5 percent. *(Allen and Saunders 2002)*

3.1.2 Regression Analysis

Regression analysis appears to be a commonly used tool for controlling for relationship between the variables of interest. That's why the regression analysis is decided to be an appropriate instrument for studying and quantitatively verifying the relationship between default probability and macroeconomic factors.

The data material for this study is represented by several timeseries – the generated timeseries of distance to default for the firms belonging to the Large Cap and Mid & Small Cap Indexes, and the timeseries of explanatory macroeconomic variables. In such way the data comprises both time series elements (variation over time, denoted by *t*) and cross-sectional elements (variation over units, denoted by *i* and which are the same for all time periods). The dataset of this kind is known as a panel data or longitudinal data. (*Brooks, 2008; Wooldridge, 2002*) If y_{it} is the dependent variable, α is the intercept, β is the $k \times 1$ vector of explanatory variables' parameters, x_{it} is the $1 \times k$ vector of explanatory variables, then the causal relationship within the panel dataset is expressed by the equation $y_{it} = \alpha + \beta x_{it} + u_{it}$. *(Brooks, 2008)*

The causal relationship within the panel dataset can be estimated using the OLS-technique on a single equation after the data has been pooled. The limitations of the panel data analysis are attributable to the statistical effects of pooling. Pooling the data implies that the relationship between the variables of interest is constant over time and cross-sections. (*Ibid*)

The main benefit of the panel data analysis is that it makes possible to detect some common variation in the series over time in a better way than by running independent regressions. The regressions on the panel data, compared to individually performed regressions, exhibit a better explanatory power due to the increase in degrees of freedom. The omitted variables bias can be eliminated by structuring the model for panel data analysis properly. Thus, using the panel data analysis, one can control for heterogeneity and the effects that are not detectable by individual time series and cross-sectional regressions. *(Baltagi, 2005; Brooks, 2008)*

3.1.3 Panel Data Analysis[7]

The multiple regression model in this thesis assignment must be adapted to the panel properties of the sample. The literature suggests the two main types of panel estimator approaches – fixed effect models and random effect models. (*Wooldridge, 2002; Brooks, 2008*)

Fixed Effect Models with Cross-Sectional Variation

The fixed effect (*FE*) models are able to capture cross-sectional variation in the panel data sample. With other words, the intercept in the regression model differ cross-sectionally and is the same over time. If we consider the effect of the explanatory variables on the dependent variable being the same for each point in time, but varying from unit to unit due to unit specific properties, then the disturbance term in the equation $y_{it} = \alpha + \beta x_{it} + u_{it}$ can be decomposed into an individual specific effect u_i that does not vary over time, and the remaining disturbance v_{it}. Thus, the regression equation can be re-written as $y_{it} = \alpha + \beta x_{it} + u_i + v_{it}$, and u_i refers to unobserved heterogeneity in units. *(Brooks, 2008; Wooldridge, 2002)*

In the context of this thesis assignment this could be interpreted as follows: the default probability level is affected by macroeconomic variables; macroeconomic variables affect the default probability in the same manner at each point in time and differently across the units (depending on the unobservable characteristics of the firm's). Then, u_i is a firm specific fixed effect and v_{it} is an idiosyncratic disturbance term.

Econometric Requirements for the Unit-Effect Models and Estimation Procedures

The described model can be estimated using the least squares dummy variable (*LSDV*) approach, where dummies correspond to cross-sectional units. So, a dummy variable $D1_i$ takes a value of 1 for all observations on the first unit and zero otherwise; $D2_i$ takes a value of 1 for the all observations on the second unit and zero otherwise; a

[7] A summary of properties of the two types of models for the panel data analysis is presented in Appendix 1, Table 1

variable DN_i takes a value of 1 for all observations on the N^{th} unit and zero otherwise. The model turns out to be expressed as follows: $y_{it} = \beta x_{it} + \mu_1 D1_i + \mu_2 D2_i + \cdots + \mu_N DN_i + v_{it}$. It must be noted that under the null hypothesis of equality of all μ the modified Chow test suggests pooling the data and employing the OLS estimation. If the null is rejected, the panel approach must be employed. *(Brooks, 2008; Wooldridge, 2002)*

The pooled OLS is feasible for the estimation of fixed effect models if the condition of strict exogeneity $(Cov(u_{it}, x_{it}) = 0)$ is not violated. However, the correlation between u_i and x_{it} is implied in the model which results in so called heterogeneity bias. To remedy this, the *within transformation* can be applied. This transformation involves the procedure of time-de*meaning*. This technique modifies the original regression by subtracting the time-mean observations on all of the variables and on the disturbance terms as well: $y_{it} - \bar{y}_i = \beta(x_{it} - \bar{x}_i) + \mu_i - \mu_i + v_{it} - \bar{v}_i$ which is the same as $\bar{y}_{it} = \beta \bar{x}_{it} + \bar{v}_{it}$. Now, the term of unobserved heterogeneity in units, correlated with the explanatory variables, is eliminated. This means that the later regression can be estimated with pooled OLS. It must be noted, however, that we lose the degrees of freedom when time-demeaning. *(Wooldridge, 2002)*

Fixed Effect Models with Time-Variation

Construction of dummy-variable regression and technique of demeaning can be also applied on the time-fixed models, which capture the time-variation. The time-fixed effect model can be written as $y_{it} = \alpha + \beta x_{it} + \lambda_t + v_{it}$, where λ_t is a time-varying intercept that allows for time-specific heterogeneity. *(Brooks, 2008)*

In the context of this thesis assignment this could be interpreted as follows: the default probability level is affected by the macroeconomic variables; the default probability is affected by the macroeconomic variables in the same manner across the units and differently for each point in time. Then, λ_t is a time period-specific fixed effect and v_{it} is an idiosyncratic disturbance term.

Econometric Requirements for the Time-Period-Effect Models and Estimation Procedures

Besides the assumption of exogeneity of idiosyncratic errors $E(v_{it}|X_i, \mu_i) = 0$, the additional assumptions on idiosyncratic errors must be held applying the demeaned regression: homoskedasticity $Var(v_{it}|X_i, \mu_i) = Var(v_{it}) = \sigma_v^2$ absence of autocorrelation $Cov(v_{it}, v_{is}|X_i, \mu_i) = 0$ for all $t \neq s$; that the idiosyncratic errors are independent and identically distributed as Normal $(0, \sigma_v^2)$. Plus – the assumption of no perfect linear relationships among the explanatory variables.[8] (*Brooks, 2008*)

Of cause, implementation of the *within transformation* approach leads to estimation of a more parsimonious regression compared to a dummy-variable regression. At the same time a dummy-variable regression exhibits a higher R^2-value. This can be explained by the fact that constructing the dummies for each cross-section explains much of the variation in the data. It must be also noted that the larger T is, the less biased the estimates are. The estimates of unobserved heterogeneity terms can be generated as follows: $\hat{\mu}_i = \bar{y}_i - \hat{\beta}\bar{x}_i$. *(Wooldridge, 2002)*

Basically, implementation of the *FE* models allows for u_i, different for each unit and constant over time (when the regression captures unit-specific heterogeneity), and intercepts λ_t, different for each point in time and constant over cross-sections (when the regression captures time period-specific heterogeneity).

Random Effect Models

The random effects (*RE*) models, also known as error components models, differ from the *FE* models by the fact that the arbitrary correlation between unobserved heterogeneity term and all the explanatory variables is not assumed by the model and is not allowed. This restriction is implied in the regression model by allowing for unit-

[8] The assumptions are valid for the *FE* models containing the λ_t -term as well

specific heterogeneity term ε_i, *id est.* $y_{it} = \alpha + \beta x_{it} + \varepsilon_i + v_{it}$. (*Wooldridge, 2002*) Under the condition of time-period-specific heterogeneity, the model of type $y_{it} = \alpha + \beta x_{it} + \varepsilon_t + v_{it}$ is to be applied. Another principle difference of *RE* models from *FE* models is that the intercept α is common for all cross-sections over time in the model for unit-specific heterogeneity (and for each point in time across units in the models for time-specific heterogeneity, correspondently), whereas the heterogeneity term $\varepsilon_i (/ \varepsilon_t)$ shows how the intercepts of each unit (/time period) *randomly* deviates from the common intercept α. *(Brooks, 2008)*

Econometric Requirements for the Random Effect Models and Estimation Procedures

The following assumptions are applied on the ε_i-term in *RE* models[9]: the expected value of deviation from the common intercept is constant $E(\varepsilon_i)|X_i = \beta_0$ which implies the assumption of strict exogeneity of the ε_i-term and homoskedasticity. Plus – the assumption of no perfect linear relationships among the explanatory variables. *(Wooldridge, 2002)*

The *RE* models are estimated using the *GLS* procedure that allows for autoregressive serial correlation. This procedure works better for the models with large *N* and smaller *T*. (*Ibid*)

The transformation involved is similar to the demeaning technique in the *FE* models. However, it is required to eliminate the serial autocorrelation in errors. This is achieved by multiplying the time-means of each variable and time-means of the disturbance terms within unit-specific-heterogeneity-regressions by θ, which is a function of the variance of idiosyncratic errors σ_v^2 and of the variance of the unit-specific errors σ_ε^2: $\theta = 1 - \frac{\sigma_v}{\sqrt{T\sigma_\varepsilon^2 + \sigma_v^2}}$. The transformed equation then involves a quasi-demeaned data on all the terms and can be written as follows:

[9] The assumptions are valid for the *RE* models containing the ε_t-term as well

$y_{it} - \theta\bar{y}_i = \alpha(1-\theta) + \beta(x_{it} - \theta\bar{x}_i) + (\omega_{it} - \theta\bar{\omega}_i)$, where $\omega_{it} = \varepsilon_i + v_{it}$. (*Brooks, 2008; Wooldridge, 2002*) In the case of time-period-specific heterogeneity the model $y_{it} = \alpha + \beta x_{it} + \varepsilon_t + v_{it}$ is to be transformed for elimination of cross-correlation in the error-terms.[10] *(Brooks, 2008)*

The *RE* models allow for constant over time explanatory variables, which is not possible when implementing the *FE* models. That is because the constant over time variables would be eliminated in the process of demeaning applied on the *FE* models ($\bar{x}_{it} = 0$ for all *i* and *t*, if x_{it} is constant over time). (*Wooldridge, 2002*)

The choice of the regression model that fits the panel dataset depends on the time series statistical characteristics, non-linear relationships between the explanatory variables, errors' properties. In this thesis assignment we start with running the pooled regressions as initial models. In order to control whether the fixed effects are necessary the redundant fixed effects test is to be performed.

3.1.4 Dependent Variable

According to the current thesis assignment the probability of default, *DP*, as a measure of the firms default risk and creditworthiness is to be investigated taking into consideration macroeconomic factors. However, it is statistically problematic to construct the regression for the dependent variable with variability close to zero since any probability assumes numbers between 0 and 1.

In order to avoid this statistic inappropriateness, the distance to default (*DD*) is used as the dependent variable in the regressions. The *DD* is closely linked to the *DP*, which is mirrored in the relationship[11]: $DP(T) = N[(-DD(T)]$. (*Bharath et al, 2004*)

[10] Within time-specific-heterogeneity regressions the unit-means of each variable and the unit-means of disturbance terms are to be multiplied by θ

[11] For more detailed information please see section 3.1.1

3.1.5 Selection of Explanatory Variables and Hypothesis Development

The selection of explanatory variables is naturally based on the prior studies' findings. This allows for comparison of the results of this thesis with authoritative papers. The main macroeconomic factors used by researchers as independent variables when studying their effects on default probability are Gross Domestic Product growth (*GDP*), Consumer Price Index (*CPI*), Equity price index, Equity volatility, Exchange rate, Interest rates, Credit Spread (Baa-rated bonds over Aaa-rated bonds), Term Spread (the 10-year T-bond's yield over the 3-months T-bill's yields), Unemployment rate, Industrial Production Index (*IPI*), Historical probability of default. [12] The explanatory variables are used for both the sample consisting of firms in the Large Cap index as well as the firms included in the Mid & Small Cap indexes.

We have decided to present the macroeconomic conditions by following variables: domestic Industrial Production Index (*IPI*), Consumer Price Index (*CPI*), nominal domestic three-month rate for Treasury bill (*R*3*M*), *GDP*-growth, unemployment rate, exchange rate, equity price index, equity volatility. All the variables describe the macroeconomic conditions in Sweden.

The investigation of the relationship between macroeconomic factors and default probability applied on the Swedish data is not widely presented in the literature. The only found study conducted on the Swedish material is an article "Macro Economic Factors and Probability of Default" by *Qu (2008).*[13] That's why the variables used in this article – *IPI*, *CPI*, Interest rate spread, Equity price index, Unemployment, and Exchange rate, – are of the prior interest for the current thesis.

Below we motivate for selection of each of the macroeconomic variables and develop the hypothesis concerning their influence on the default probability (*DP*).

[12] See the sections for prior research for more detailed information
[13] The essentials of the article are introduced in the section for prior research

Industrial Production Index (IPI) mirrors the level of industrial production and hence is an indicator of the business cycle condition. The *IPI* is based on the three components – labour hours, supply volume, and production volume. (Statistic Central Office homepage) This index is therefore a display of economic activity and is isomorphically related to *GDP*. A relationship between the *IPI* and *DP* is expected to be negative. That is because the *IPI* is related to economic activity and so to aggregate demand; and increasing demand implies increasing economic activity and higher corporate earnings, hence a hypothetic decrease in *DP*.

Consumer Price Index (CPI) is a measure of inflation and shows how the price for average basket of goods fluctuates over time. Thus, the *CPI* shows the purchasing power of domestic currency. Inflation can be regulated by the Bank of Sweden with a help of interest rate. It is associated with hollowing-out of the currency and so with savings and investments. *(Eklund, 2007; Qu, 2008)* We consider the link between inflation and *DP* to be mainly two-folded: the inflation can be contemplated from the factor prices' perspective and the perspective of the prices that companies charge for their goods and services. Higher factor prices lead to increased production costs and tend to weaken credit worthiness which implies an increase in *DP*. Higher goods and services prices can boost earnings and thereby improve creditworthiness which implies a decrease in *DP*.

Within these thesis objectives we have faced the question concerning which *interest rate variable* to use – the short term interest, the long term interest rate, or the interest rate spread (the last interest rate variable is suggested by *Qu (2008)* in the research based on the Swedish data). The Interest rate is associated with a price for borrowed capital for a firm-borrower, and with a forgone consumption, investment opportunities and risk for a creditor. Generally, the interest rate fluctuates depending on the overall macroeconomic condition. The long term interest rate incorporates the inflation risk factor and so lies normally above the short term interest rate. *(Fregert et al, 2005; Qu, 2008)* Positive interest rate spread means upward sloping yield curve and therefore expectations of future market growth and decrease in *DP*. Decreasing or negative interest rate spreads mean vice versa. *(Qu, 2008)*

This reasoning implicitly considers the interest rate structure and expectations about future business cycle condition. Increasing short term interest rate implies a smaller or negative interest rate spread and worse compensation for risk as the time to maturity increases. This induces the *DP* to increase. This can be also explained by investment activity. The investors are willing to sell their short-term interests when they expect the recession. As a result the price on these instruments goes down and the rate of return goes up. The interest rate spread is decreasing, and *DP* is increasing. The investors are also willing to buy the long-term instruments when expecting economic upturn. As a result the price on these instruments goes up and the rate of return goes down. The interest rate spread is increasing and *DP* is decreasing.

Taking into consideration the reasoning above, we suggest using *the short term interest rate* in this thesis. We believe also in a higher *DP* due to increase in short term interest rate. We use the nominal domestic three-month yield for Treasury bill.

Equity Price Index represents the business cycle condition *(Qu, 2008)* and indicates business activity – there are empirical findings pointing up that negative stock returns are associated with negative changes in production. (*Li et al, 2006*) Therefore, equity price index is assumed being negatively related to the default probability.

Unemployment rate is associated with costs for the society in terms of not fully run production and even the use of the capital for social subsidies, which results in the forgone investments in economic growth. (*Eklund, 2007; Qu, 2008*) *Mitchell (1927)* and *Keynes (1936)* found that the unemployment rate is negatively related to business activities. Therefore, we assume the unemployment rate to be positively linked to default probability.

Exchange rate in a small open economy as Swedish one is considered being a complex macroeconomic variable, which depends on the monetary policy, the level of domestic interest rate in relation to foreign interest rate and in such way is affected by foreign investments (when speaking about the economy as a whole) and export-import volume (when speaking about a certain firm performance). (*Fregert et al, 2005; Qu, 2008; Oxelheim and Wihlborg, 2008*) The EURO-area is Sweden's main trading partner.[14] Based on this evidence, we have decided to include the SEK/EURO exchange rate in the study.

The depreciation of the domestic currency leads to better performance of the exporting firm (increasing cash flows) and so might lead to a lower *DP*, if contemplating the exchange rate exclusively from the export-import viewpoint. On the other hand, the higher domestic interest rate (compared to foreign interest rate) leads to increase in investments from abroad and so to appreciation of domestic currency. This is a positive condition for the economy and is normally associated with expectations about economic upturn and therefore might mean a decrease in *DP*. At first glance the conclusions are contradicting, but in reality this points out the complexity of exchange rate factor. Therefore, we do not develop any hypothesis about this macroeconomic variable's influence on the *DP*; at the same time it is of interest to include this variable in the study.

Equity price index volatility is assumed to be positively related to *DP*. This is since the increasing equity price index volatility is associated with anticipated economic instability.

Real GDP is an economic activity indicator based on the production developing. (*Fregert et al, 2005*) The *GDP*'s multiplicative effect implies that increasing investment leads to even stronger increase in *GDP*; whereas every positive change in *GDP* requires an increase in investment. In such way *GDP* is influenced by the production level, and at the same time *GDP* itself affects production through investment behaviour and demand expectations. (*Persson et al, 2005*) Thus, real *GDP* is related to investment behaviour and hence credit taking. The *GDP* is naturally assumed to be negatively related to *DP*; but at the same time it seems to be reasonable to assume that the periods of the strong *GDP*-growth are followed by the increase in *DP* since the intensive credit building coincides with a periods of increasing economic activity. (*Bonfim, 2009*) In this case the relationship between *DP* and *GDP* in prior periods can be even positive, which might be interesting to control for.

[14] Svenskt Näringsliv (http://www.svensktnaringsliv.se/)

The macroeconomic variables, presented above, must be tested for reciprocal dependence and some of them must be probably eliminated from the study on the grounds of the correlation matrix outcome. Some of the timeseries of the variables must be probably further eliminated or modified based on the results of the unit root tests.

The current thesis assignment does not use any foreign macroeconomic variables. This can be motivated by that their effects are assumed to be incorporated in the domestic macroeconomic variables mostly through the exchange rates and the monetary policy of the Bank of Sweden, since Sweden is a small open economy.

In order to improve the statistics for residual autocorrelation, the lagged values of some explanatory variables might be included in the model. Such modification of the model is also consistent with macroeconomic theory: the macroeconomic shocks show the evidence of delayed effects on the economic events of interest. Based on this reasoning, the panel models with different lagged variables have been estimated.

In addition to the explanatory variables discussed above, *the default probability in prior periods* might be taken as a possible independent variable, and is expected to exhibit a positive relation to the independent variable: it is natural to presume that an increase in default probability today leads to even higher default probability tomorrow. The implementation of a model with an autoregressive term is therefore can be possible.

3.2 Qualitative versus Quantitative Study; Deduction versus Induction

This thesis exploits both qualitative and quantitative research methods. The qualitative research method is employed when generating the working hypothesis and modelling, which has been done regarding the prior researchers' assumptions and findings. Moreover, this part of the study is opened for relatively free interpretations. Even the analysis of the results of this thesis assignment is presented in the qualitative research manner.

The quantitative research method is applied when using the constructed econometric model for empirical testing. Within the quantitative research method the relationship between the variables in question has been established with help of quantitative inputs.

The study is built primarily on the deductive reasoning. This is because the starting point of the study is the working hypotheses, which are aimed being verified. We are aware about the main shortcoming of the deduction that implies a certain limit on the theoretical and methodological construction of reality. (*Bryman et al, 2005*) The problem is that the research process from the beginning exists within certain theoretical framework – such as assumptions and prior findings.

3.3 Data Collection and Critique of the Information Sources

The data used in this thesis assignment can be divided into qualitative and quantitative data. The qualitative data consists mostly of academic articles and other printed sources and appears to be a ground for generating working hypothesis and modeling. The quantitative data consists of the time series of inputs for calculating the distance to default and also of the time series of macroeconomic variables. Both firms specific data, such as information regarding debt and book value of assets, and time series of macroeconomic variables has been collected from the *Datastream* which is a financial database. However, the sources for both qualitative and quantitative data are secondary sources of information, which must be kept in mind.

3.4 Reliability and Validity

Methodological problems do occur in thesis writing. In order to measure the reliability of this study two main areas have to be examined – the reliability of the collected data and of the methods used.

What regards the collected data, *Datastream* builds its databases of the firm specific information employing the firms' external reporting. External reporting directly from the firms is deemed to be reliable, or at least the best proxy of information available to external investors. At the same time it must be kept in mind that *Datastream* is a secondary source of information which allows for imperfections in data matherial.

What regards the methodology, it is based on the previous studies. For calculation of distance to default some assumptions must be made, but as much as possible these assumptions are based on the previously used standards. Moreover, the method used for calculation of distance to default is considered being theoretically sound and empirically well tested. The regression analysis is transparent and based on a simple technique.

The internal validity *(Eriksson et al, 2001)* of this study is fulfilled because the variables are selected carefully and belong to the same informative source. The external validity (*Ibid*) is also fulfilled because the econometric tools used in the study are commonly applied in similar studies and therefore fit the reality and question at issue. However, the received results do not allow answering the question at issue with certainty. This can be explained by the data and/or modelling imperfections.

3.5 Weaknesses of the Study

A major weakness of the study is referred to the unavailability of data covering economic downturn periods, which leads to a downwards bias in the default rates. The discussion also leads us to the survivorship bias, since no defaulted firms are included. Another weakness is referred to the randomly picked sample that our study is based on; thus, there is a possibility that the data is skewed towards a particular industry or sector. Exploring the Large Cap and Mid & Small Indexes, we believe that the working samples reflect the Indexes in a desirable way.

Other weaknesses could be derived from the distance to default calculations which are based on a number of assumptions. However, our assumptions are well accepted and academically referred, which enhances the reliability of the working model.

4 Empirical Findings

In this chapter we present the empirical results of the panel data analysis, the autoregressive model and the diagnostic testing. The estimated models and the values of the significant macroeconomic coefficients are presented. Moreover, the autoregressive model containing the one year lagged distance to default is shown. The models are constructed gradually with respect to econometric properties of the data – multicollinearity, presence of unit roots, autocorrelation, and redundancy of cross-section fixed effects etc.

4.1 Regression Models

The models have been developed by preserving the significant variables and leaving insignificant ones outside the final models. The final models of macroeconomic factors' impact on the distance to default are expressed below. Tables *4.1.1* and *4.1.2* contain the estimated coefficients of macroeconomic variables that affect the distance to default for the Large Cap firms and the Mid & Small Cap firms, respectively. For each panel regression model we have used annual observations for 20 firms within 10 years, which sums up to 220 observations. Also, 16 timeseries of macroeconomic variables, expressed in log returns, have been considered in the panel regression models during the model generating process.

Both current and lagged observations of macroeconomic variables have been included in the regressions – this is done with respect to macroeconomic theory and also for improving the statistics for autocorrelation in residuals. The distance to default variable is exposed to the same macroeconomic variables in a similar way, when studying any of the two groups of firms.

The Industrial Production$_{t-1}$ followed by the SEK/EUR$_{t-1}$ are observed to have the highest values of estimated coefficients and are therefore important explanatory variables for the firms' probability of default. Both coefficients exhibit positive values, which imply that an increase in these variables leads to increase in the distance to default, and decrease in the probability of default, correspondently.

The estimated coefficients for the Interest Rate and the Interest Rate$_{t-1}$ appear to be negative, which means that an increase in the interest rate leads to a decrease in the Distance to Default, and increase the Probability of Default, correspondently. These coefficients values are also relatively smaller in comparison with a first pair of significant variables.

The R^2-values are evidence for that 75,8% and 67,8% of the changes in probability of default are explained by the models for the Large Cap firms and the Mid & Small Cap firms, respectively. All of the included macroeconomic factors are significant at the 1% significance level. At the same time it must be noted that the standard errors are small, the *t*-statistics are large, and the *p*-values are small. These statistical properties are evidence for the quality of the models.

Table 4.1. 1 Large Cap

	Coefficient	Standard Error	t-Statistic	p-value
Interest rate***	-0,869	0,152	-5,719	0,000
Interest rate(t-1)***	-1,256	0,105	-11,915	0,000
Industrial production(t-1)***	17,896	2,047	8,741	0,000
SEK/EUR(t-1)***	12,667	1,312	9,655	0,000
R-squared	0,758			
Prob(F-statistic)	0			
DW	1,587			

Table 4.1.2 Mid & Small Cap

	Coefficient	Standard Error	t-Statistic	p-value
Interest rate***	-0,593	0,064	-2,682	0,004
Interest rate(t-1)***	-0,788	0,173	-4,542	0,000
Industrial production(t-1)***	11,346	2,513	4,515	0,000
SEK/EUR(t-1)***	9,642	1,265	7,612	0,000
R-squared	0,678			
Prob(F-statistic)	0			
DW	1,546			

4.1.1 Autoregressive Model

As mentioned earlier, we assume that the distance to default at time point *t-n* can in a satisfactory manner estimate/predict the distance to default at time point *t*. We have constructed an autoregressive model – AR(1)-model, – for testing for this property of the time series of distance to default. The model basically involves the one year lagged distance to default as the only explanatory variable. The result can be interpreted such as the distance to default year *t* is slightly smaller than the distance to default year *t-1*, meaning that the probability of default increases over time. The R^2-value is however pure and equals only 0,272, implying that the model only can explain 27,2% of the changes in the distance to default. The standard error value is very small, and the *t*-statistic is very large, which provides an indication of a high level of statistical significance.

Table 4.1.3 Autoregressive model

	Coefficient	Standard Error	t-Statistic	p-value
Distance to default(t-1)	0,949	0,019	50,153	0,000
R-squared	0.272			

4.2 Result of Diagnostic Testing

Macroeconomic variables are in many aspects correlated to each other and this could cause a problem of multicollinearity. We have constructed a correlation matrix of all independent variables to check for presence of multicollinearity.[15] The rule of thumb is to take actions when the correlation exceeds the boundary of ±0,8. According to the correlation matrix, the GDP is closely connected to the Industrial Production Index and the GDP_{t-1} is closely correlated with the Unemployment-variable. These variables cannot technically be included in the same model. Therefore, the GDP and the GDP_{t-1} are decided to be excluded from the regression models in favour for the unemployment rate and the Industrial Production Index. By doing this one can better rely on the

[15] See Appendix 4, Table 1

interpretation of the regression results, since the problem of undermining of statistical significance of independent variables is mitigated or eliminated.

We have proceeded by testing the panel series for stationarity. The Volatility Index is deemed to contain a unit root and so to be non-stationary. Normally, non-stationary time-series must be re-expressed with respect to their means and variances so that they become stationary. This must be done in order to avoid spurious regression results and can be achieved by the procedure of differencing. At the same time the test for redundancy of fixed effects within the panel data analysis suggests using a model with cross-sectional fixed effects for the panel regressions applied on the data-matherial of the Large Cap firms and the Mid & Small Cap firms.[16]

The fact of using the cross-sectional fixed effect models within the panel data analysis makes the differencing of the non-stationary time-series unneeded, since the non-stationarity problem is mitigated in the cross-sectional fixed effect models due to procedure of demeaning.[17] The estimation outputs of the cross-sectional fixed effect model with differenced Volatility Index and with original time-series of this variable are similar, which confirms a conclusion of unneeded differencing. Moreover, the unit root is rejected in the panel unit root test on the residuals for the equations containing non-differenced time-series and for the same equations with a differenced time-series.

The graph of error terms over time shows that the variance is not constant, which is the first sign for heteroskedasticity.[18] In order to fulfil the assumptions for panel estimation approach, the White correction for heteroskedasticity is to be applied.

Since the Durbin–Watson statistic shows evidence of positive autocorrelation, the panel data analysis is decided to be performed using the Generalized Least Squares (*GLS*) regressions. This allows each observation to have a different error structure which solves the problem of autocorrelation *(Brooks, 2008).*

[16] See Appendix 4, Table 2
[17] See Appendix 4, Table 3
[18] See Appendix 4, Table 4

Further, we have tested if the residuals are normally distributed by examining the residual histogram and the Jarque-Bera statistic. It has been concluded that we have no problem of non-normality in residuals.[19]

In order to define an appropriate lag structure for the autoregressive term in the autoregressive model, the autocorrelation function for the time-series of distance to default has been generated. The autocorrelation function is highly significant at lag 1, giving the grounds for using an AR(1)-model. The test for the lag structure (lag exclusion test with a null hypothesis of redundancy of a particular lag) suggests using lag 1 as well.[20]

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[19] See Appendix 4, Table 5
[20] See Appendix 4, Table 6

5 Analysis

In this chapter we analyse the empirical findings of the current study in the light of the theoretical framework. First, we discuss the empirical findings regarding the significant variables. A coefficient stable test and a comparison between the two models are presented. The autoregressive model is analyzed. Moreover, we discuss the insignificant variables with respect to the working hypothesis for the explanatory variables.

5.1 Regression Models

Interest rate could be defined as a time value of cash. A high interest rate leads to high financial expenditures. At the same time new projects will be discounted with a higher discount rate which lowers the firms' investment willingness and makes it harder to carry through projects solely on financial grounds. Our assumption has been that interest rate is negatively correlated with distance to default and positively with probability of default. The assumption seems to be confirmed empirically and both the current interest rate and the interest $rate_{t-1}$ are significant. This result is in line with *Koopman et al (2009), Jiménez (2009) and Qu (2008)*, who found the short term interest rate having a significant impact on the probability of default. A significance of the one year lagged interest rate can be explained by the fact that many firms take on large loans and a several years fixed rate is therefore of importance for determining firms' financial costs.

Interest rate is positively correlated with exchange rate according to macroeconomic theory. An increase in interest rate leads normally to an increase in the value of domestic currency. Since Sweden is highly dependent on export[21] (making the assumption that the firms included in the current study are not an exception), an increase in interest rate penalizes the domestic firms twice – leading to higher financial costs and weakening the firms' competitiveness on the international market.

[21] www.svensktnaringsliv.se

The Industrial Production Index – not surprisingly – is an important factor that explains the variation in probability of default. The Industrial Production Index is a reliable indicator of the overall national productive capacity and strength. A decrease in the Industrial Production Index is especially sensible for the Large Cap firms, since a 9 of 20 are targeted towards the industrial sector. This result is in line with previous study, e.g. *Qu (2008).*

It can be noted that a 1% increase in the Industrial Production$_{t-1}$ would raise the distance to default by 0,179 standard deviations (for the Large Cap), whereas the mean of the standard deviation for the hole period equals 3,04. This finding can be attributable to the fact that a period of economic upturn and increase in the Industrial Production Index generates financially relatively stable firms with a lower probability of default. A strong demand for industrial goods is assumed to be followed by high profits. Since the Industrial Production Index is closely related to the GDP, an increase in the Industrial Production Index indicates high business activity and economic growth.

As mentioned earlier, an increase in the Industrial Production Index should lead to decrease in the probability of default. A major concern is however whether a firm considers too much about milking the market in good times and less about the future. In connection to this reasoning, an increase in Industrial Production can in the worst case increase the probability of default. Even a problem of overinvestment on the corporate level can be connected to the firms' short-term actions in periods of economic strength and industrial growth. So, having less free cash later on, the firms are more likely to default, as *Li et al (2006)* stated. The same reasoning can be found in the study of *Bonfim (2009)* who argued that the risks connected to defaults are built up during periods of economic growth and are first materialized in recessions. However, we can't observe this phenomenon in our study.[22]

The structure of the working sample has to be taken into consideration, when discussing the significance of the Industrial Production Index variable. The Large Cap sample is overweighed towards Industrials.[23] It is not too brave to believe that our

[22] See Appendix 2, Table 1
[23] See Appendix 2, Table 2

sample is heavily dependent on the Industrial Production because of the overweight towards the industrial sector.

It must be noted that the Industrial Production Index variable is significant when it is lagged. According to macroeconomic theory, changes in macroeconomic factors affect the economy with a lagged effect, which is mirrored in the model and supported empirically.

What regards the SEK/EUR exchange rate, it must be clarified that the observations of the SEK/EUR have only been available from year 2000, which implies that two years of observations are missing. This makes our model less rigid; but since the exchange rate variable appears to be highly significant and is an important variable in a macroeconomic context, it is decided to be included in the models and analysis.

The SEK/EUR_{t-1} exchange rate is observed to have a large positive impact on the distance to default. This means that an increase in the value of Swedish krona in relation to EURO reduces the firm's probability of default. An increase in the value of Swedish krona by 1% in relation to EURO will raise the distance to default by 0,127 standard deviations (for the Large Cap firms). An increase in the exchange rate makes Swedish firms less competitive on the international market. On the other hand, it makes the imported goods cheaper. Our result shows that the firms' probability of default decreases as the Swedish krona increases in value. Generally, a weak krona is beneficial to all exporting Swedish firms. It is true with a modification. A currency that fluctuates increases the uncertainty about the future price. The obtained result actually shows that a strong krona reduces the probability of default for the firms in the working sample. This result can be explained by exploring of hedging of cashflows in different currencies with help of forwards and futures contracts and derivative products.

5.1.1 Autoregressive Model

As explained earlier, the one year lagged distance to default is the only explanatory variable in the autoregressive model. We observe an estimated coefficient value of 0,949. This means that the distance to default will decrease every year, with respect to the previous year information about only this variable. A coefficient value close to 1 would mean that the best estimate of the distance to default this year would be last year's distance to default. The model is however poor – with an R^2-value of 27%, leaving 73% of changes in distance to default to be explained outside the model.

5.1.2 Test of Stable Coefficients

To investigate if the coefficients possess stable values, a Chow test would be desirable. Since our software doesn't support Chow stability test for panel data, we have followed *Åsberg and Shahnazarian (2008)* to check for coefficient stability as new observations have being added.

For this purpose a rolling window between years 1999 and 2008 (year 1998 is excluded since the model counts for the variables lagged once) has been created.[24] Analyzing the significant coefficients from the final model, it can be seen that none of them is stable during the periods of estimation windows. This means that the macroeconomic variables in the final model have different degrees of explanation of changes in probability of default during the sample period.

One reason for the coefficients instability could be the sample period. Thus, after exclusion of year 2008 (because of the financial crisis), we observe stable parameters for Industrial Production_{t-1} and SEK/EUR_{t-1} which also exhibit significant properties within the panel regression analysis.

5.1.3 Comparison with the Mid & Small Cap Indexes

Qu (2008) shows, that different industries react to the same macroeconomic changes with different amplitudes. Since the firms belonging to the Mid & Small Cap Indexes are not as overweighed towards Industrial as the Large Cap firms are[25], we have decided to check if the regression results for this group of firms significantly differ from the regression results for the Large Cap firms. For this purpose 20 firms have been randomly selected from the Mid & Small Cap lists.

[24] See Appendix 2, Table 3
[25] See Appendix 3, Table 3

The procedure for the Mid & Small Cap firms is consistent with the model development for the firms belonging to the Large Cap Index. However, the model possesses a little less explanatory power, which can be assumed being dependent on the structure of the firms included in the Mid & Small Cap sample.

As stated by *Oxelheim and Wihlborg (2008)*, it can be problematic to draw more or less reliable statistical inferences by estimating the regression coefficients on the data matherial containing companies that have just started their businesses. Indeed, the larger part of the firms in the Mid & Small Cap Indexes is relatively new compared to the companies in the Large Cap Index. This fact has been taken into consideration and only the firms with full economic history with start in 1998 and earlier has been included in the working sample.

The model for the Mid & Small Cap firms generates very similar results as the model for the Large Cap firms does. The Industrial Production_{t-1} seems to be an important explanatory variable for the probability of default of the Mid & Small Cap firms, even when the sample is not overweighed towards Industrials.

The exchange rate SEK/EUR_{t-1} variable exhibits a similar explanatory power on the probability of default/distance to default of the Mid & Small Cap firms as it does when studying the Large Cap firms. A strong positive influence of the exchange rate on the distance to default has been observed. The same inference has been made for the Interest Rate and the Interest Rate_{t-1}.

As a matter of fact, the new data had responded in the same way as the previous.[26] The conformable results make us more confident about generalization possibilities from our findings.

[26] See Appendix 3, Table 1

5.2 The Insignificant Variables

Depending on the macroeconomic theory and previous research, we attempt to understand and analyze some variables that have not established the significant properties within the estimated models.

The OMXS30 index and the $OMXS30_{t-1}$ variables have been assumed to capture the business cycle and have been expected to be positively correlated to the distance to default and negatively to the probability of default. As the OMXS30 index increases, the distance to default is expected to increase and the probability of default is expected to decrease. We think the fact that this factor exhibits no explanatory power is out of the ordinary, since we intuitively deem the firms included in the Large Cap sample having a high correlation with the OMXS30 index. Other researchers such as *Qu (2008)* found that the share prices had a significant impact. The potential reasons for obtaining the insignificant coefficients for the OMXS30 index variable could be that Qu's sample firms better mirror the stock index.

The working hypothesis about the Volatility Index variable states that the Volatility Index should have a negative impact on the distance to default and positive on the probability of default, since an increasing equity price volatility is associated with anticipated economic instability. Researchers such as *Koopman et al (2009)* show the evidence of the Volatility Index's impact on the probability of default. However, our study concludes that neither the Volatility Index nor the Volatility $Index_{t-1}$ has any explanatory power. It is not a simple task to interpret such a result, since the calculation of the distance to default includes volatility as an important component. We believe that an increasing volatility (and thereby, reciprocally, a decreasing distance to default and increasing probability of default) should be reflected in the equity volatility index. An explanation could be that the equity volatility index we included doesn't mirror the equity volatility in our firm sample. This is referred to the problems we have earlier highlighted as survivorship bias or problems with randomly picked firms.

The performed panel data analysis has not indicated any significance for the Consumer Price Index or Consumer Price $Index_{t-1}$ variables. The working assumption regarding the CPI has been that the CPI can both boost the earnings of the company and raise their costs, making the CPI factor two-folded. A possible reason of insignificance of the CPI coefficient could be the relatively small changes in the CPI during the sample period, making us believe that the increase in prices is already incorporated in the firms' goods prices and costs. This explanation makes this factor unimportant from the perspective of defaults. Our result is not equivalent to the conclusion maid by *Li et al (2006)* who argue for the importance of inflation rate. The result of this study can possibly not coincide with the result obtained by Li *et al* because of the different sample periods and hereby different patterns exhibited by the inflation rate, and also different data matherial. A sample period in the study of Li *et al* extends between years 1980 and 2002. Within this period the inflation rate had been very volatile, especially between 1980 and 1995.[27] In contrast with Li's *et al* data matherial, the CPI pattern used in the current study is rather smooth, as already pointed above.

The relative variation in research results can probably depend on different starting assumptions concerning models' inputs and/or choice of different econometric models, which points up the complexity of the problem.

[27] www.riksbank.se

6 Conclusion

In this final chapter we give the comments on the empirical results of the thesis based on the analysis. We also give further research directions on the field of study.

The purpose of this study is to quantitatively verify the relationship between corporate default probability and macroeconomic factors, using a panel data analysis of 20 randomly selected firms from the Large Cap Index. Further, the purpose is to compare the result for the firms from the Large Cap with empirical findings generated by the similar model for 20 randomly selected firms from the Mid & Small Cap. Moreover, the study aims to examine the relationship between the probability of default at time *t-n* and the current default probability applying an autoregressive model on the data matherial of the Large Cap.

6.1 Regression Models

The empirical results of this thesis assignment are consistent with other studies.[28] The results are evidence for that the interest rate, interest $rate_{t-1}$, Industrial Production $Index_{t-1}$, and exchange rate SEK/EUR_{t-1} are significant and explain the variation in the probability to default for the firms in the working samples.

6.1.1 Large Cap

The Industrial Production $Index_{t-1}$ and the exchange rate SEK/EUR_{t-1} have been concluded being the most important factors that explain the variation in probability of default. Both of them are positively related to the distance to default, implying that growth of the Industrial Production Index and appreciation of the Swedish krona benefit the firms and hereby reduce the probability of default, demonstrating a lagged effect on

[28] See e.g. Wilson (1997a,b), Li et al (2006), Bonfim (2009) and Qu (2008).

it. Also, it has been concluded that the interest rate and interest $rate_{t-1}$ are negatively related to the distance to default and positively to the probability of default, which is referred to higher financial costs for the firms and higher discount rates for new projects.

We also have stated that exposure of the probability of default of the firms of interest to the model's macroeconomic variables is not constant within a sample period. That is because no coefficients are stable during the sample period, when performing a Chow test, and different factors demonstrate their significant properties within different estimation windows with different power.

6.1.2 Mid & Small Cap

We have also compared the results for the Large Cap firms with a panel data analysis performed on the matherial of 20 randomly selected firms from the Mid & Small Cap Indexes in order to verify and strengthen our findings. The reason behind this has been that the firms from the Large Cap Index are overweighed towards Industrials. A new sample containing the firms from the Mid & Small Cap Indexes has a larger spread between sectors and is not as overweighed towards industrials as the firms from the Large Cap Index. The model constructed for the Mid & Small Cap firms generates the same result as a similar model for the Large Cap firms.

6.1.3 Autoregressive Model

The autoregressive model AR(1) gives the evidence of that the distance to default is inclined to decrease every year, since the estimated coefficient of the autoregressive term is smaller than 1 (0,949). However, an exclusion of year 2008 because of the current financial crises gives a value of 0,998. This leads us to the conclusion that the best estimate that can be produced for the current distance to default/probability of default is the previous year distance to default/probability of default, since the distance to default/probability of default today is (almost) the same as last year.

6.2 Suggestions for Further Research

The macroeconomic impact on the default probability is an interesting research field with many more aspects to explore.

We would propose conducting a similar study on a longer sample period or expand the sample by including the firms from a wider geographical area. Another suggestion would be to analyze the firms that in the past had reached a very high probability of default and to study the differences between these firms' exposure to macroeconomic factors and more stable firms'. An additional recommendation would be to group the firms into growing versus mature firms and analyse the difference in their macroeconomic exposure (if there is a difference). We would also suggest enhancing/expanding the variability of the panel model by including idiosyncratic effects such as firm specific variables.

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8 Appendix

8.1 Appendix 1: Panel Data Analysis

Table 1
Summarizes the properties of the two types of models for panel data analysis

<table>
<tr><th colspan="2">types of panel estimator approachers</th><th>the intercept properties</th><th>regression equation</th><th>econometric requirements</th><th>estimation procedures</th></tr>
<tr><td rowspan="2">fixed effect models</td><td>unit-fixed models</td><td>cross-sectionally varying intercept u_i</td><td>$y_{it} = \alpha + \beta x_{it} + u_i + v_{it}$</td><td rowspan="2">a) strict exogeneity;
b)homoskedasticity
c)absence of autocorrelation in ideosyncratic errors;
d)independency and normality of ideosyncratic errors;
e)explanatory variables are not perfectly correlated</td><td rowspan="2">a) least squares dummy variables approach;
b)the demeaning procedure for endogeneity mitigating</td></tr>
<tr><td>time-fixed models</td><td>time-varying intercept λ_t</td><td>$y_{it} = \alpha + \beta x_{it} + \lambda_t + v_{it}$</td></tr>
<tr><td rowspan="2">random effect models</td><td>with unit-specific heterogeneity term</td><td>the intercept for each unit deviates from the common α by heteroheneity term ε_i</td><td>$y_{it} = \alpha + \beta x_{it} + \varepsilon_i + v_{it}$</td><td rowspan="2">a)strict exogeneity;
b)homoskedasticity
c)explanatory variables are not perfectly correlated;
d)no serial autocorrelation in errors;
e)constant over time explanatory variables are allowed</td><td rowspan="2">the quasi-demeaning procedure for elimination of serial autocorrelation in errors</td></tr>
<tr><td>with time-specific heterogeneity term</td><td>the intercept for each time period deviates from α by heteroheneity term ε_t</td><td>$y_{it} = \alpha + \beta x_{it} + \varepsilon_t + v_{it}$</td></tr>
</table>

8.2 Appendix 2: Large Cap firms

Table 1

Shows the distance to default for the firms included in the sample.

	ABB	Alfa Laval	AstraZeneca	Assa Abloy	Atlas Copco	Boliden	Electrolux	Ericsson	Hennes & Mauritz	Lundin Petroleum	Nokia	Sandvik	SCA	Scania	Skanska	SKF	SSAB	Swedish Match	TeliaSonera	Volvo	Mean
1998	2,55		2,88	2,43	2,70		2,19	1,81	2,53	1,99	2,00	2,78	2,59	2,59	3,09	2,30	2,28	3,70		2,30	*2,51*
1999	3,61		3,50	2,96	2,74		2,59	2,23	2,94	1,99	2,21	3,22	3,61	2,40	3,98	2,66	2,53	3,93		3,13	*2,95*
2000	2,97		2,82	2,15	2,37	1,70	2,34	1,66	1,83	1,99	1,48	2,73	3,03	4,24	3,81	2,48	2,62	3,70		3,38	*2,63*
2001	1,66		3,42	2,01	2,28	0,88	2,50	1,34	2,11	1,99	1,37	2,80	3,75	3,93	2,56	2,63	2,91	3,39	2,12	2,82	*2,45*
2002	0,78		2,37	2,16	2,25	1,79	2,11	1,03	2,44	1,51	1,64	3,11	3,62	2,98	2,45	2,74	3,01	2,77	1,69	2,65	*2,27*
2003	1,48	3,12	3,26	2,10	2,99	2,03	3,23	1,64	4,03	2,64	2,33	3,61	4,60	3,91	3,43	3,48	4,09	3,90	2,71	3,10	*3,08*
2004	2,63	3,80	4,39	4,06	4,39	2,70	4,47	2,28	4,91	2,37	2,77	5,52	6,37	4,84	4,35	4,49	4,87	4,88	4,17	4,28	*4,13*
2005	4,49	4,08	5,66	4,84	4,73	3,53	4,30	4,24	5,94	2,76	4,37	4,96	6,43	5,29	4,64	4,42	5,02	6,69	4,79	4,52	*4,79*
2006	3,17	2,67	4,66	3,20	2,75	1,71	2,79	3,63	4,66	2,31	4,20	3,17	4,49	3,49	3,72	2,99	2,50	4,47	3,89	3,95	*3,42*
2007	3,29	2,38	5,23	3,75	2,96	2,56	2,40	2,68	4,34	2,65	3,46	3,03	4,66	2,57	3,13	3,13	2,33	4,33	3,73	2,79	*3,27*
2008	1,59	1,78	2,51	1,87			1,80	1,79	2,37	1,32	1,88	1,88	2,15	1,66	1,86	1,92	1,41	2,55	2,35	1,77	*1,91*
																					3,04

Table 2

Shows which sector the firm is operating within.

ABB	Industrials
Alfa Laval	Industrials
Assa Abloy	Industrials
AstraZeneca	Health Care
Atlas Copco	Industrials
Boliden	Materials
Electrolux	Consumer Discretionary
Ericsson	Information Technology
Hennes & Mauritz	Consumer Discretionary
Lundin Petroleum	Energy
Nokia	Information Technology
Sandvik	Industrials
SCA	Materials
Scania	Industrials
Skanska	Industrials
SKF	Industrials
SSAB	Materials
Swedish Match	Consumer Staples
TeliaSonera	Telecommunication Services
Volvo	Industrials

Table 3

Shows the estimations of the rolling window coefficient stable test.

	1999-2004	1999-2005	1999-2006	1999-2007	1999-2008
Interest rate					
Coefficient	-0,993*	-0,330	-0,368	-0,003	-0,869***
Standard error	0,506	0,505	0,354	0,167	0,152
Industrial production(t-1)					
Coefficient	28,933***	20,266***	20,490***	23,377***	17,896***
Standard error	3,211	3,294	2,583	1,770	2,045
SEK/EUR(t-1)					
Coefficient	21,998***	15,093***	14,985***	17,641***	12,667***
Standard error	2,962	3,019	2,178	1,232	1,312
Interest rate(t-1)					
Coefficient	2,701***	2,701*	0,958**	1,204***	-1,256***
Standard error	0,599	0,599	0,395	0,361	0,105

	2000-2005	2000-2006	2000-2007	2000-2008
Interest rate				
Coefficient	-10,702***	-3,180**	-0,088	-0,931**
Standard error	1,769	1,373	0,377	0,425
Industrial production(t-1)				
Coefficient	42,755***	33,218***	23,486***	18,066***
Standard error	3,458	6,411	4,003	3,921
SEK/EUR(t-1)				
Coefficient	4,888	15,951***	17,586***	12,658***
Standard error	3,459	2,023	1,940	1,704
Interest rate(t-1)				
Coefficient	0,829	1,579***	1,146**	-1,249***
Standard error	0,509	0,503	0,474	0,297

	2001-2006	2001-2007	2001-2008
Interest rate			
Coefficient	-12,280***	-0,053	-0,374
Standard error	4,686	0,380	0,435
Industrial production(t-1)			
Coefficient	-30,513	19,842***	11,753***
Standard error	19,215	3,595	3,994
SEK/EUR(t-1)			
Coefficient	14,885***	15,765***	10,461***
Standard error	1,819	1,679	1,736
Interest rate(t-1)			
Coefficient	-3,209**	0,529	-1,698***
Standard error	1,393	0,435	0,263

	2002-2007	2002-2008
Interest rate		
Coefficient	1,691**	2,911***
Standard error	0,732	0,673
Industrial production(t-1)		
Coefficient	-0,501	-21,378***
Standard error	7,664	6,678
SEK/EUR(t-1)		
Coefficient	29,965***	39,130***
Standard error	4,251	4,983
Interest rate(t-1)		
Coefficient	-0,495	-2,418***
Standard error	0,553	0,272

	2003-2008
Interest rate	
Coefficient	-1,672***
Standard error	0,368
Industrial production(t-1)	
Coefficient	2,440***
Standard error	0,537
SEK/EUR(t-1)	
Coefficient	-3,073***
Standard error	0,683
Interest rate(t-1)	
Coefficient	0,543***
Standard error	0,120

8.3 Appendix 3: Mid & Small Cap firms

Table 1

Shows the estimation for the Mid & Small Cap firms.

	1998-2008
Interest rate	
Coefficient	-0,593***
t-statistic	-2,682
Standard error	0,064
Industrial production(t-1)	11,346***
Coefficient	4,515
t-statistic	2,513
Standard error	
SEK/EUR(t-1)	
Coefficient	9,642***
t-statistic	7,612
Standard error	1,265
Interest rate(t-1)	
Coefficient	-0,788***
t-statistic	-4,542
Standard error	0,173
DW	1,546
R-squared	0,678

Table 2

Shows the distance to default for the firms included in the sample.

	Bergs Timber	**Bilia**	**Brio**	**Cardo**	**Clas Ohlson AB**	**DORO**	**Enea**	**Hemtex**	**Haldex**	**Heba**	**Kabe**	**Midway**	**Munters**	**New Wave Group**	**Nobia**	**Nolato**	**Peab**	**Rottneros**	**Semcon**	**Skistar**	**Mean**
1998	2,32	2,18	1,39	1,14	1,37	1,99	2,72	2,02	2,34	1,49	2,59	3,51	2,25	2,63	2,11	1,91	2,70	2,26	2,66	2,74	*2,22*
1999	1,77	2,25	2,18	1,54	1,14	2,34	3,48	2,65	2,23	1,81	3,19	3,00	2,97	2,88	3,43	2,67	2,90	2,14	4,06	3,61	*2,61*
2000	1,72	2,05	1,58	1,71	0,98	2,61	2,10	1,53	2,18	1,18	3,13	3,18	2,71	2,56	2,27	2,01	2,89	2,44	2,35	2,12	*2,17*
2001	1,48	2,37	1,03	1,89	0,89	2,59	2,44	1,33	3,01	1,47	3,35	3,02	2,42	2,69	2,57	2,62	3,47	2,58	2,92	3,17	*2,37*
2002	1,79	2,63	0,96	1,89	0,94	2,48	2,60	1,29	2,35	1,41	3,18	3,06	2,30	2,65	3,27	1,83	3,29	2,76	2,81	3,00	*2,32*
2003	2,65	2,94	1,99	2,27	1,36	2,98	3,32	2,35	3,38	1,52	3,26	3,84	3,29	4,04	3,54	3,33	4,22	3,68	2,11	4,16	*3,01*
2004	2,79	5,75	2,06	2,61	1,63	3,64	4,78	3,12	4,21	2,43	5,82	4,86	4,28	4,05	4,84	3,34	5,20	4,62	4,34	3,72	*3,91*
2005	3,61	4,06	2,40	3,20	3,16	2,69	3,01	4,37	4,52	2,79	5,45	3,42	5,52	4,84	4,84	3,57	4,75	3,85	3,27	3,92	*3,86*
2006	3,16	3,73	1,45	2,58	2,10	2,96	2,80	3,19	3,35	2,56	3,83	3,46	3,09	3,01	2,95	3,61	3,25	3,40	2,40	4,03	*3,05*
2007	1,66	3,40	1,69	3,24	3,22	3,53	3,49	3,08	3,54	3,12	4,08	3,37	3,11	2,85	2,64	2,48	2,36	3,74	3,24	3,05	*3,04*
2008	1,71	1,81	1,23	1,70	2,14	1,90	2,17	2,13	1,50	1,54	2,52	1,85	1,86	2,26	2,07	1,45	1,57	2,30	2,57	1,73	*1,90*
																					2,77

Table 3

Shows which sector the firm is operating within.

Bergs Timber	Materials
Bilia	Consumer Discretionary
Brio	Consumer Discretionary
Cardo	Industrials
Clas Ohlson AB	Consumer Discretionary
DORO	Information Technology
Enea	Information Technology
Hemtex	Consumer Discretionary
Haldex	Industrials
Heba	Real Estate
Kabe	Consumer Discretionary
Midway	Industrials
Munters	Industrials
New Wave Group	Consumer Discretionary
Nobia	Consumer Discretionary
Nolato	Information Technology
Peab	Industrials
Rottneros	Materials
Semcon	Industrials
Skistar	Consumer Discretionary

8.4 Appendix 4: Diagnostic Testing

Table 1
Shows multicollinearity

	CPI	CPI(t-1)	GDP	GDP(t-1)	Intersect rate	Interest rate(t-1)	Industrial Production	Industrial Production(t-1)	OMXS30	OMXS30(t-1)	SEK/EUR	SEK/EUR(t-1)	Unemployment	Unemployment(t-1)	Volatility	Volatility(t-1)
CPI	1															
CPI(t-1)	0,41	1														
GDP	-0,78	-0,46	1													
GDP(t-1)	-0,28	-0,55	0,16	1												
Interset rate	0,57	-0,03	-0,52	0,39	1											
Interest rate(t-1)	0,52	0,63	-0,71	-0,29	0,11	1										
Industrial Production	-0,50	-0,36	0,88	0,14	-0,24	-0,74	1									
Industrial Production(t-1)	-0,28	-0,35	-0,14	0,71	0,39	-0,20	-0,23	1								
OMXS30	-0,70	-0,58	0,64	0,41	-0,11	-0,46	0,60	0,25	1							
OMXS30(t-1)	-0,04	-0,74	-0,13	0,73	0,38	-0,19	-0,25	0,68	0,13	1						
SEK/EUR	0,29	0,23	-0,45	-0,46	-0,13	0,43	-0,68	-0,10	-0,48	0,09	1					
SEK/EUR(t-1)	0,18	0,11	0,32	-0,32	0,04	-0,24	0,56	-0,61	-0,09	-0,43	-0,33	1				
Unemployment	0,42	0,69	-0,45	-0,82	-0,28	0,41	-0,41	-0,54	-0,67	-0,61	0,41	0,14	1			
Unemployment(t-1)	-0,32	0,26	0,39	-0,49	-0,63	-0,40	0,39	-0,32	-0,09	-0,58	-0,02	0,38	0,47	1		
Volatility	0,52	-0,24	-0,51	0,09	0,37	0,32	-0,48	0,23	-0,26	0,56	0,32	-0,28	-0,15	-0,58	1	
Volatlity(t-1)	0,03	-0,05	0,12	-0,16	0,22	-0,17	0,12	0,06	-0,04	-0,01	-0,07	0,14	-0,12	-0,16	0,25	1

Table 2
Shows Redundant Fixed Effects Test

Redundant Fixed Effects Tests			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	p-value
Cross-section F	5.500524	-23,201	0.0000
Cross-section Chi-square	111.802365	23	0.0000

Table 3

The first model contains one none-stationary series, whereas in the second model the non-stationarity is mitigated by applying the differencing.

Panel unit root test				
Exogenous variables: Individual effects				
Newey-West bandwidth selection using Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.93072	0.0017	24	201
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.81633	0.2072	24	201
ADF - Fisher Chi-square	50.2199	0.3855	24	201
PP - Fisher Chi-square	93.6415	0.0001	24	225

Panel unit root test				
Exogenous variables: Individual effects				
Newey-West bandwidth selection using Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.64132	0.0000	24	181
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.97094	0.1658	24	181
ADF - Fisher Chi-square	51.7089	0.3311	24	181
PP - Fisher Chi-square	38.3179	0.8400	24	205

Table 4
Shows the variance of the error terms

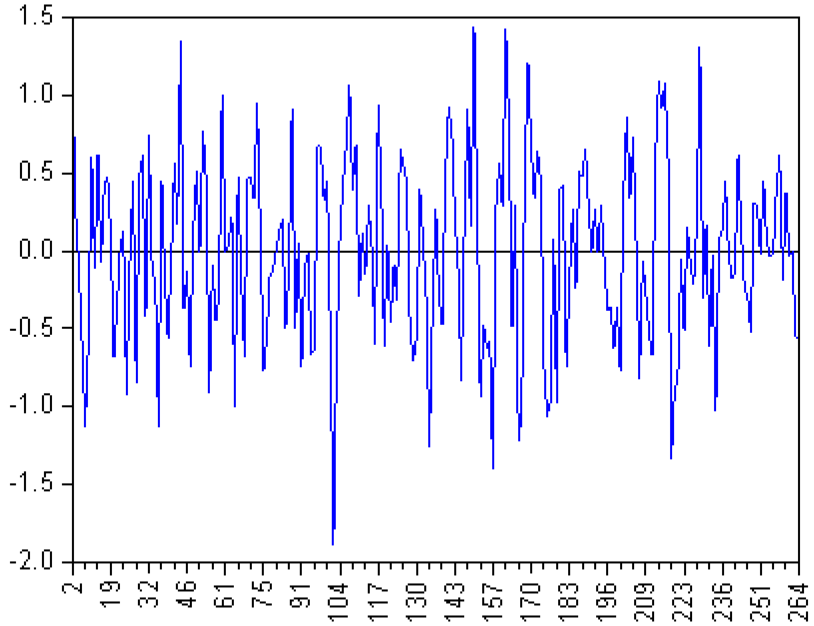
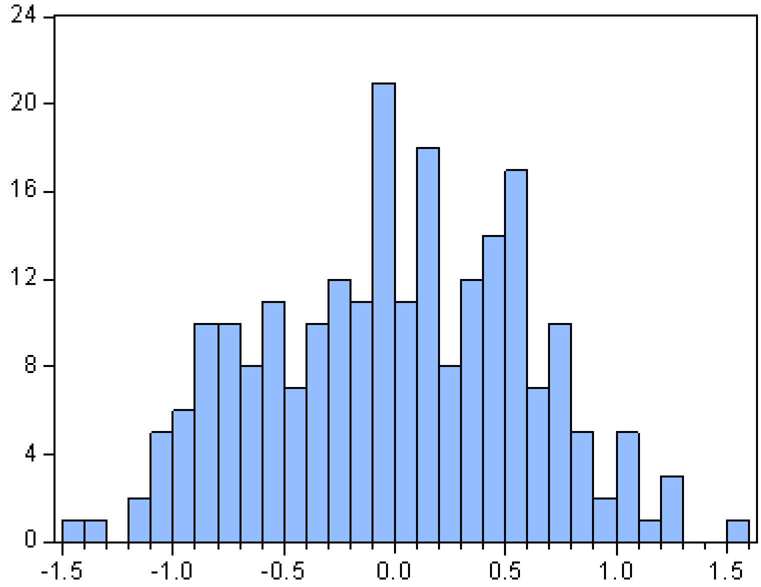


Table 5
Shows the normal distribution of the residuals



Standard Residuals			
Skewness	-0,053	Jarque-Bera	4,031
Kurtosis	2,358	Probability	0,133

Table 6

Shows the lag structure for the autoregressive term

Sample: 1998 2008						
Included observations: 249						
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	p-value
|***	|***	1	0,568	0,568	81,335	0,000
|**	*|	2	0,238	-0,126	95,626	0,000
*|	**|	3	-0,085	-0,248	97,46	0,000
*|	|*	4	-0,089	0,154	99,466	0,000
|	|	5	-0,026	0,046	99,636	0,000

Lag Exclusion Tests		
Included observations: 201		
Chi-squared test statistics for lag exclusion:		
	DD	Joint
Lag 1	110.9290	110.9290
	(0.000000)	(0.000000)
Lag 2	13.22804	13.22804
	(0.000276)	(0.000276)
df	1	1