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Leverage effects on the Swedish stock market

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Abstract

The leverage effect is one of two main hypotheses explaining the negative relationship between volatility of returns and return on equity. It states that a decrease in leverage, due for example to rising stock prices, increases the amount of equity which carries the firm volatility and thus decreases the volatility on rates of return. Using 51 companies that have been actively traded on the Stockholm Stock Exchange for the 15 year period 1991-2005, this study examines the signs of a leverage effect on the Swedish market. Using returns, realized volatilities and debt levels the presence of the leverage effect, in competition with other models such as the volatility feedback effect, is examined. The study concludes that the effect on the Swedish market most likely is a combination of the leverage effect and some other effect, with the leverage effect being more predominant for small companies and less liquid assets. There are however some inconsistencies in the results, especially the lack of monthly observations of debt, which makes the conclusion open to speculation.

Introduction

The rate of return of a stock or other financial asset is of fundamental interest to investors, however to fully manage their portfolio they also need a measure of how much their investment may vary on a daily, monthly or yearly basis and how much different assets within their investment may co-vary. The measure of variation in an asset is the assets volatility, and it is central in theories as diverse as the Capital Asset Pricing Model (CAPM) (Mossin, 1966) (Sharpe, 1964), option theory (Black & Scholes, 1973) (Merton, 1973), structural credit models (Merton, 1974) and other risk management tools such as VaR and ES (Crouhy, Galai, & Mark, 2001).

In many of these theories the volatility of an asset is considered being constant over the investment horizon, however market knowledge and several studies have shown that the volatility varies is time with a number of different factors, such as the asset price (Glosten, Jagannathan, & Runkle, 1993), interest rate (Spiro, 1990) and macroeconomic variables (Officer, 1973).

Market knowledge has long been that the volatility of an asset is negatively correlated with the rate of return of the asset, this common knowledge was confirmed in early studies of the volatility of stocks (Christie, 1982) and a hypothesis was presented that explains the negative correlation between stock returns and stock volatility by the change of leverage in the underlying firm. This explanation was consequently named the leverage effect and subsequently all kinds of negative correlations between asset returns and asset volatility where contributed to leverage effect, although no leverage existed in the asset's underlings. In accordance with Duffee (1995) this study intends to define leverage effect in its original meaning, thus only relating to an effect that truly relates to the change of the leverage in the underlying firm.

There is however no consensus on the presence of a leverage effect as the negative correlation between stock prices and stock volatility can be explained by two main effects. The leverage effect, which states that a decrease in the stock price reduces the total market value of equity and thus the amount of equity that is to bear the total volatility of the underlying firm's value, this resulting in an increase of the volatility of equity. The other major explanation is the volatility feedback effect (Pindyck, 1984); as volatility is a measure of risk, an increase in volatility signals a higher risk and also higher expected future risk. To bear this risk, investors will require higher returns thus be willing to pay less for the corresponding equity.

Many studies have been undertaken trying to determine the contribution of these different effects and their relative explanatory power but the results have been quite varied. Early studies by Christie (1982) incorporating both a leverage model based on the Modigliani & Miller corporate valuation framework (Modigliani & Miller, 1958) and a model with risky debt gave clear indications of a negative correlation between rate of return and volatility, and also that the correlation between volatility and stock returns decreases monotonously with increasing leverage, a relation which supports the leverage effect theory. Later studies by Figlewski and Wang (2000) show that all thought there are signs of a leverage effect when running basic regressions, more thorough analysis show inconsistencies such as asymmetric results depending on the sign of returns. Finally studies of high frequency data by Avramov, Chordia and Goyal (2006) finds no significant correlation between leverage and volatility in daily trading when other factors such as trading volume have been accounted for.

This study intends to build on previous work to examine the presence of a leverage effect on the Swedish market by studying the correlations between stock returns and volatility, debt levels and volatility, and leverage levels and volatility. The study further intends to examine if there is any difference in the perceived leverage effect between different industries, companies of different sizes or assets with different liquidity. This study and models used within are largely based on Figlewski and Wang (2000) and Christie (1982), with extensions made mostly to accommodate the different set of data available for the Swedish market. The study assumes basic university level knowledge in the field of finance, some basic university level mathematical understanding, and knowledge in the fields of statistics and econometrics.

The following theory section formalizes the leverage effect and develops a simple theoretical model based on the assumption of risk free debt; this model is the base for most of the analysis made later on. However, this simplified model is not always enough to explain the results from the analysis and by relaxing the assumption of risk free debt a more complex and realistic model is derived. The theory section is concluded with a summary of the more advanced statistical methods used in the analysis.

Following the theory section is the dataset section where the selection process of the data sample is explained. This is followed by an explanation of data preparation required to arrive at the dataset actually used for the analysis section. The section is then concluded with a presentation of the characteristics of the dataset, broken down over the different subsamples used in the analysis and with all the major variables and their statistics presented.

The analysis section uses the models developed in the theory section to set up a number of regression models on which the dataset is run using different sub samples and sample frequencies. Several different models are run against the dataset analyzing different aspects of the leverage effect, such as the relationship between change in volatility and rate of return, change in volatility and change in debt and the relationship between volatility and leverage.

In the result section the results from the analysis are dissected and their explanatory power for and against the leverage effect is discussed. It is considered whether there is proof of a leverage effect on the Swedish market, whether the leverage effect is the only effect relating the change in volatility to the rate of return and whether there are differences in the extend of the leverage effect between different industries, company sizes or asset liquidities.

Finally, in the summery section, the conclusions of the study are summarized and suggestions for further studies are made.

Theory

A Modigliani-Miller approach to the Leverage effect

This derivation of the risk-free debt model of the leverage effect is in large based on Figlewski and Wang (2000). To be able to derive a relationship between the volatility of returns on equity and the financial leverage of a firm a few basic assumptions have to be made about how the capital structure of firms affects the volatility of returns. Let us therefore assume a Modigliani-Miller world (Modigliani & Miller, 1958). In this framework, where we assume no taxes, no cost of bankruptcy, no asymmetric information, and an efficient market, it is known that the value of the firm is independent of how it is financed. Thus, the value of the firm is independent of the leverage. Let us further assume that the value, V, of the firm follows some kind of process, for example a geometric Brownian motion, is which the volatility of the returns on value is constant.

$$r_V = \frac{\partial V}{V} \approx \ln(V_t) - \ln(V_{t-1}) \tag{1}$$

$$\sigma_V = \sqrt{Var[r_V]} = constant \tag{2}$$

Let us in this simplified model further assume that all corporate debt is risk-free, and thus the market value of debt is the same as the book value of debt. This is clearly a harsh assumption; however this restriction is later relaxed. With this assumption we have that the value of the company is simply the sum of the book value of debt, D, and the market value of equity, E.

$$V = E + D \tag{3}$$

Let us finally assume that all increases in the value of the firm translate into increases in the market value of equity. This is a reasonable assumption since the level of debt is often held fairly constant, and any movements in the market value of the firm will directly be reflected in changes in the value of the firm on equity markets.

$$\Delta V = \Delta E \tag{4}$$

In addition to this we define the leverage of a firm as the debt-to-equity ratio, although this is not the standard way of defining leverage, the two definitions are monotonous functions of each other, and using debt-to-equity ratio results in more concise expressions. The derivation of the relationship between return on equity, r_S, and return on firm value, r_V, then becomes.

$$r_S = \frac{\partial S}{S} = \frac{\partial E}{E} = \frac{\partial V}{V}\frac{V}{E} = \frac{\partial V}{V}\left(\frac{E+D}{E}\right) = (1+L)r_V, \qquad L = \frac{D}{E} \tag{5}$$

Where the second step in the derivation above uses that the change of price of stock, $\frac{\partial S}{S}$, is the same as the change in market value of equity, $\frac{\partial E}{E}$. Combining (5) with the assumption of constant volatility of firm value, the relation for volatility of equity, σ_S, is easily reached.

$$\sigma_S^2 = Var[r_S] = Var[(1+L)r_V] = (1+L)^2\sigma_V^2 \tag{6}$$

$$\sigma_S = (1+L)\sigma_V \tag{7}$$

As the leverage depends on two variables, the book value of debt, and the market value of equity, there are two different ways to test this relationship; by measuring to what extent a change in market value of equity corresponds to a change in volatility, and by measuring to what extent a change in book value of debt corresponds to a change in volatility. Suitable measurements for this are the elasticity of volatility with respect to equity, θ_S, and elasticity of volatility with respect to debt, θ_D, which are derived below.

$$\theta_S = \frac{\partial \sigma_S}{\sigma_S}\Big/\frac{\partial S}{S} = \frac{\partial \sigma_S}{\partial E}\frac{E}{\sigma_S} = \sigma_V\frac{\partial L}{\partial E}\frac{E}{(1+L)\sigma_V} = -\frac{D}{E^2}\frac{E}{1+L} = -\frac{L}{1+L} \tag{8}$$

$$\theta_D = \frac{\partial \sigma_S}{\sigma_S}\Big/\frac{\partial D}{D} = \frac{\partial \sigma_S}{\partial D}\frac{D}{\sigma_S} = \sigma_V\frac{\partial L}{\partial D}\frac{D}{(1+L)\sigma_V} = \frac{D}{E(1+L)} = \frac{L}{1+L} \tag{9}$$

As can be seen by the above equations the following inequalities hold, $-1 \leq \theta_S \leq 0$ and $0 \leq \theta_D \leq 1$, which will be used as an initial test of the presence of a leverage effect. In addition to this the elasticities are assumed to be constant over time, which allows us to derive the following simple regressive models:

$$\Delta \ln \sigma_S = \beta_0 + \theta_S r \tag{10}$$

$$\Delta \ln \sigma_S = \beta_0 + \theta_D \Delta \ln D \tag{11}$$

Which follows from the approximation of the proportional change:

$$\frac{\partial \sigma_S}{\sigma_S} \approx \partial \ln \sigma_S = \ln \sigma_{S,t+1} - \ln \sigma_{S,t} = \Delta \ln \sigma_S \tag{12}$$

Leverage Effect with Risky debt

The model of the leverage effect using risk-free debt explained above gives us a hint in what direction the volatility should move in response to the rate of return or a change in level of debt. However it gives little information to distinguish it from the volatility feedback model (French, Schwert, & Stambaugh, 1987) or other models trying to explain the negative correlation between stock return and volatility. By relaxing the restrictions imposed in the model above a more nuanced model can be arrived at making it possible to examine effects that are distinctive to the leverage effect.

There are several different suggestions of how to model the debt of a company; this derivation draws on the model used in Christie (1982) which was proposed in Black and Cox (1976). The model assumes that the market is efficient, that there be no taxes, bankruptcy costs, transaction costs or agent costs, and that value of the firm follows a geometric brownian motion (13). It is however important to note that the absence of bankruptcy costs is not that same as the absence of bankruptcies, the model assumes that the debt holders have a senior claim on the company and if the company's value moves below the face value of the debt, debt holders will force it into bankruptcy thus salvaging their claims and leaving the equity holders with nothing. The model further assumes that debt is a simple consol bond which pays a coupon, c, and that no dividend payments are made.

Let the value process of the firm, the value of equity and the value of debt be defined as:

$$\partial V = (\mu_V V - c)\partial t + \sigma_V V \partial W \tag{13}$$

$$V(t) = D(V(t), t) + E(V(t), t) \tag{14}$$

Thus the value of the firm grows with the average return, μ_V, less the cost of debt c and with a constant volatility on returns of σ_V. For this model the value function of debt, D, is derived in Black and Cox (1976, p. 364) as:

$$D(V) = \frac{c}{r} - \left(\left(\frac{\alpha}{\alpha+1}\right)^{\alpha} - \left(\frac{\alpha}{\alpha+1}\right)^{\alpha+1}\right)\left(\frac{c}{r}\right)^{\alpha+1} V^{-\alpha}, \quad \alpha = \frac{2r}{\sigma_V^2} \tag{15}$$

Where r is the risk less interest rate. To now derive the volatility of equity as a function of volatility of the firm a relationship between the two volatilities derived in Merton (1974, p. 5) is used.

$$\sigma_E = \epsilon_V \sigma_V = \frac{V}{E}\frac{\partial E}{\partial V}\sigma_V \tag{16}$$

Where ε_V is the elasticity of the volatility of return on equity with respect to the volatility of return on the firm. By using that $V = D + E$, the derivative part of (16) can be calculated as:

$$\frac{\partial E}{\partial V} = \frac{\partial (V - D)}{\partial V} = 1 - \alpha\left(\left(\frac{\alpha}{\alpha+1}\right)^{\alpha} - \left(\frac{\alpha}{\alpha+1}\right)^{\alpha+1}\right)\left(\frac{c}{r}\right)^{\alpha+1} V^{-\alpha-1} = 1 - \alpha\frac{\frac{c}{r} - D}{V} \tag{17}$$

And then by assuming that the cost of debt can be expressed as $c = r_D D$, where r_D is the interest rate on company debt, the elasticity can be expressed as:

$$\begin{aligned} \epsilon_V = \frac{V}{E}\frac{\partial E}{\partial V} = \frac{V - \alpha\left(\frac{r_D D}{r} - D\right)}{E} &= \frac{V - D}{E} + \frac{(1+\alpha)D - \alpha\frac{r_D D}{r}}{E} \\ = 1 + \left(1 + \frac{2r}{\sigma_V^2} - \frac{2r}{\sigma_V^2}\frac{r_D}{r}\right)\frac{D}{E} &= 1 + \left(1 - 2\frac{r_D - r}{\sigma_V^2}\right)L \end{aligned} \tag{18}$$

Finally by combining (16) and (18) the volatility on equity can be expressed as:

$$\sigma_E = \sigma_V + \sigma_V \underbrace{\left(1 - 2\frac{r_D - r}{\sigma_V^2}\right)}_{k} L \tag{19}$$

Worth noting is that the difference, $r_d - r$ being the risk premium on debt, tends towards 0 when the leverage tends to 0. This is natural since as the company reduces its relative use of debt in comparison to equity, the risk associated with the debt decreases and thus also the risk premium, $r_d - r$. This means that when the leverage is 0 the expression denoted k in the equation has its maxima. Further, when the amount of debt increases the risk premium required will increase, and the expression denoted k will decrease. Thus, there should be a negative relationship between the leverage of a company and the value of k. For a full discussion on the behavior of k, see Christie (1982).

The value of k can be estimated using the following simple regressive model.

$$\sigma_t = \beta_0 + \beta_1 L_t \tag{20}$$

Where, assuming a bias free estimator, it holds that $E[\beta_0] = \sigma_V$ and $E[\beta_1] = k\sigma_V$, and thus by taking the quotient between the two correlation coefficients we get an estimate of k:

$$E\left[\frac{\beta_1}{\beta_0}\right] \approx \frac{\sigma_V\left(1 - 2\frac{r_D - r}{\sigma_V^2}\right)}{\sigma_v} = 1 - 2\frac{r_D - r}{\sigma_V^2} \tag{21}$$

Using the expression for the volatility of equity in equation (19), a new equation for the elasticity of volatility with respect to equity can be derived. This expression is fairly similar to the one derived in the risk-free model, but allows for a larger set of possible values for the elasticity.

$$\theta_E = \frac{\partial \sigma_E}{\partial E}\frac{E}{\sigma_E} = \sigma_V\left(1 - 2\frac{r_D - r}{\sigma_V^2}\right)\left(-\frac{L}{E}\right)\frac{E}{\sigma_E} = -\frac{L'}{1 + L'} \quad , L' = \left(1 - 2\frac{r_d - r}{\sigma_V^2}\right)L \tag{22}$$

When comparing this expression with the one in (8), we notice that the only difference is in the usage of L' instead of L. This change does not affect the lower limit of -1 for the elasticity as the minimal value is still reached for $L' = 0$. However, the maximal value for the elasticity is no longer 0. Assume that a company is highly leveraged; this heavy reliance on debt may bring up the risk premium demanded on the company's debt and thus make $L' < 0$ in the expression above. Further assuming that $L' > -1$, as the model becomes instable as L' approaches -1, we get an elasticity that is greater than 0 (when L' approaches -1, the elasticity goes towards infinity, a very unrealistic result).

Statistical theory

All of the analysis in this study is based on multiple linear regression, and the basics of this is assumed to be known by the reader. However, some extending techniques regarding regression are also used to determine if one model is significantly better than another, or more specifically, if a set of regression coefficients are all simultaneously statistically equal to 0. This is tested using the procedure put forward in Woolridge (2003, pp. 142-148).

Assume we have the following regression model:

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k + \lambda_1 x_{k+1} + \cdots + \lambda_q x_{k+q} + \epsilon \tag{23}$$

Where λ_i are the q coefficients we want to test for significant difference from 0. Thus we want to test the null hypothesis:

$$\begin{gathered} H_0: \lambda_1 = \lambda_2 = \cdots = \lambda_q = 0 \\ H_1: \lambda_1 \neq 0 \;\; or \;\; \lambda_2 \neq 0 \;\; or \;\; \cdots \;\; or \; \lambda_q \neq 0 \end{gathered} \tag{24}$$

We then calculate the regression of the unrestricted model in (23) and specifically the sum of squared residuals, SSR_u, and then do the same for the restricted model in (25) and its sum of squared residuals, SSR_r.

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k + \epsilon \tag{25}$$

With the two values for SSR the f-value can be calculated and using F statistics it is possible to determine whether or not to reject the null hypothesis.

$$f = \frac{(SSR_r - SSR_u)/q}{SSR_u/(n-k-q-1)} \sim F(q, n-k-q-1) \tag{26}$$

Where n is the size of the dataset being regressed over.

The second extending technique used in this study is when running separate regressions over independent companies and then weighting together the coefficients and standard deviations to get a representative value for the group as a whole. More specifically we have a normal linear regression which is run over several different datasets, giving us a set of different estimated for the regression coefficients. Let the model be

$$y = \alpha + \beta x_1 + \gamma x_2 \dots \tag{27}$$

And the multiple datasets have give a set of estimates for β, $[\hat{\beta}_1 \quad \dots \quad \hat{\beta}_k]$, and a set of estimates for the standard deviation of beta $[\hat{\sigma}_1 \quad \dots \quad \hat{\sigma}_k]$. As in all linear regressions the distribution of both the estimates of beta and the estimates of the standard deviation are known (Blom & Holmquist, 1998, pp. 231-232).

$$\hat{\beta}_i \sim N(\beta, \sigma^2) \tag{28}$$

$$d_i \frac{\hat{\sigma}_i^2}{\sigma^2} \sim \chi^2_{d_i} \tag{29}$$

Where d_i is the number of degrees of freedom for regression i. It is easy to see that an unbiased estimate of β is now just the average of the estimates.

$$\hat{\beta} = \frac{1}{k} \sum_{i=1}^{k} \hat{\beta}_i \sim N\left(\beta, \frac{\sigma^2}{k}\right) \tag{30}$$

To arrive at the estimate for the standard deviation we first use that the sum of Chi-square distributions are Chi-square distributed, and then that the quotient of a standard normal distribution and the square root of a Chi-square distribution over degrees of freedom is t distributed.

$$\sum_{i=1}^{k} d_i \frac{\hat{\sigma}_i^2}{\sigma^2} = \frac{1}{\sigma^2} \sum_{i=1}^{k} d_i \hat{\sigma}_i^2 \sim \chi^2_{\sum_{\mathrm{i=1}}^{\mathrm{k}} \mathrm{d_i}} \tag{31}$$

$$\begin{cases} \dfrac{\hat{\beta}-\beta}{\sigma/\sqrt{k}} \sim N(0,1) \\ \dfrac{N(0,1)}{\sqrt{\chi_f^2/f}} \sim t_f \end{cases} \Rightarrow \frac{\hat{\beta}-\beta}{\sigma/\sqrt{k}} \Bigg/ \sqrt{\frac{\sum_{i=1}^k d_i \hat{\sigma}_i^2}{\sigma^2} \Bigg/ \sum_{i=1}^k d_i} = \frac{\hat{\beta}-\beta}{\underbrace{\frac{1}{\sqrt{k}} \sqrt{\frac{\sum_{i=1}^k d_i \hat{\sigma}_i^2}{\sum_{i=1}^k d_i}}}_{\hat{\sigma}}} \sim t_{\sum_{i=1}^k d_i} \tag{32}$$

The identification of the standard deviation estimation as the numerator in (32) follows from comparing it with the corresponding expression for a normal linear regression (Blom & Holmquist, 1998, p. 156). Thus, the estimated standard deviation is calculated as:

$$\hat{\sigma} = \frac{1}{\sqrt{k}} \sqrt{\frac{\sum_{i=1}^k d_i \hat{\sigma}_i^2}{\sum_{i=1}^k d_i}} \tag{33}$$

And the number of degrees of freedom is $d = \sum_{i=1}^k d_i$.

Dataset

Selection

The aim of this study is to investigate the presence of a leverage effect on the Swedish market. Thus the set of companies available for studies are those that are traded actively on the Stockholm Stock Exchange as of April 2007. From this sample of 272 companies a subset of companies was created for which all necessary data for studying the leverage effect exists.

There are two types of data needed to test for the leverage effect. The first is equity pricing time series, such as stock price and market value of equity, from which the return on equity and the volatility of return on equity can be calculated. This data is readily available on a daily basis for all companies from their entry into the market. The second type of data is balance sheet information, such as a company's book value of debt which is used in combination with the market value of equity to calculate the company's leverage. This information is unfortunately only available on an annual basis for companies registered on the Stockholm Stock Exchange. Thus, to achieve statistically significant results on the regressions involving changes in levels of debt, several years worth of data is needed. To accommodate for this, a dataset was chosen covering the 15 years from 1991 to 2005. During these 15 years only 52 companies have been traded continuously on the Stockholm Stock Exchange and out of these, complete balance sheet data only exists for 51 (Onetwocom AB lacks data on total debt for the year 1996). All though a longer sampling period would have been preferred in order to get more significant results in the volatility to debt regression, increasing the sample period beyond 15 years results in a rapid decrease of available companies, thus a tradeoff had to be made.

Using 51 companies over 15 years gives a total of 765 annual observations to test the relationship between changes in volatility and changes in debt. In addition to this, daily return to equity observations can be used to calculate monthly volatility of returns and thus give 9180 monthly observations to test the relationship between change in volatility and return on equity.

To examine if the presence and size of a potential leverage effect varies over different industries, company sizes or asset liquidities, the sample of companies was sub-divided based on 3 different variables. To divide the companies by industry the Industry Classification Benchmark (ICB, 2004) was used. This structure divides companies into 10 different industries whereof 7 are present in the dataset used for this study. To distinguish between different company sizes the market capitalization of the companies was used. For the Nordic Exchange (of which the Stockholm Stock Exchange is a part) there already exists a division into Large, Mid and Small Cap which is used in this study. Large Cap companies are by this definition companies with a market capitalization of above 1 billion euro, Mid Cap companies are those with a market capitalization between 150 million euro and 1 billion euro, and finally Small Cap companies are those with a market capitalization below 150 million euro (OMX). The final variable used to sub-divide the data sample according to market liquidity was the inclusion of a company in the OMX Stockholm 30 (OMXS30) index. This index contains the 30 most actively traded stocks on the Stockholm Stock Exchange out of which 12 are also in our dataset. This therefore gives a partitioning into 12 highly traded, highly liquid assets, and 39 assets with less active trading.

Preparation

The data used in this study was acquired from the Datastream Advanced 4.0 service and comes from two different sources. The daily time series data on adjusted stock prices and market value of equity come from the Datastream Time Series database whereas annual balance sheet data such as total debt come from the Worldscope Data Items database. The acquired data was then processed to give the quantities needed for this study.

To calculate the return on equity the average of the bid and ask prices for the adjusted price of stocks in the Datastream Time Series was used. The adjusted price is the price of a stock at the closing of the market with adjustments for capital actions such as stock splits and dividend payments. By using the adjusted price instead of the actual price no compensation is needed for above mentioned capital actions when calculating return on equity. Return on equity was calculated using the log-difference of the previous period's stock price and the current period's stock price:

$$r_t = \ln S_t - \ln S_{t-1} \quad (34)$$

This value corresponds to the continuously compounded interest rate for the period.

As for the volatilities on returns, these were estimated from the daily returns on equity using an unbiased estimator. The volatility was then normalized to volatility on yearly returns by multiplying by the square root of 252, the expected number of trading days during a year (Hull, 2005, pp. 270-271).

$$\sigma = \sqrt{252} \cdot \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(r_i - \bar{r})^2} \quad (35)$$

Characteristics

The dataset contains a total of 51 companies which have been continuously traded on the Swedish marked between 1991 and 2005; the complete list of companies is available in Appendix A. The average annually continuously compounded return on equity for all the firms during the time period was 11.01% with an average volatility of 41.44%. For a complete statistical breakdown of rate of return, volatility of return, book value of debt, market value of equity and leverage, see Table 1.

	Average	Minima	1st Quartile	Median	3rd Quartile	Maxima
μ	11.01%	-3.10%	6.80%	10.61%	15.13%	30.28%
σ	41.44%	25.52%	32.28%	36.76%	47.49%	86.77%
Debt (SEK)	37 425 026	0	218 088	677 865	5 737 500	822 192 100
Equity (SEK)	34 924 215	143 409	1 183 155	8 461 078	24 628 300	433 092 387
Leverage	0.606	0.000	0.072	0.235	0.514	7.449

Table 1 – General sample composition over 51 companies

As can be seen in the statistical breakdown above the distribution of debt, equity and leverage is very askew with average values far above even the values of the 3rd quartile. As far as market value of equity goes, this result is owed to 7 major companies on the Swedish market each having a market value of equity in excess of 100 million SEK. As for the skewed distribution of the debt and leverage the story is somewhat different. By studying the average debt and leverage values for each industry, see Table 2, the financial sector is noted to have exceptionally high values for both these variables. This is due to the somewhat different usage of debt within the financial sector, and more specifically, within banks. Banks operate by having huge liabilities, all deposits made into bank accounts, and usually only holding a small amount of liquid assets at hand to cover for these liabilities, i.e. a small amount of equity. Thus a substantially higher level of debt and leverage is consistent with expectations. When looking at the debt and leverages of the individual companies two outliers are clearly recognized; Skandinaviska Enskilda Banken and Svenska Handelsbanken have leverages of 7.4 and 6.4 respectively, almost 3 times as much as the third highest leverage. When exclude both of these companies the average debt instead becomes about 5.5 million SEK and the average leverage about 0.35, both values significantly closer to their respective median values, and below the 3rd quartile.

As previously mentioned the dataset has also been divided in a number of different sub-sets to accommodate tests of differences in the leverage effect over industries, market capitalization level and market liquidity. In the breakdown over industries a total of 7 different industries where present among the companies in the dataset, with industrials being the most heavily represented with 22 companies, for a complete breakdown see Table 2.

	Companies	Average Equity (SEK)	Average Debt (SEK)	Average Leverage	μ	σ
Basic Materials	5	14 036 004	4 187 367	0.48	7.66%	39.33%
Industrials	22	24 594 539	6 066 227	0.33	11.76%	41.68%
Consumer Goods	7	8 402 332	6 939 603	0.68	10.11%	42.89%
Health Care	1	3 236 681	360 499	0.11	-3.10%	76.74%
Consumer Services	3	75 715 330	555 622	0.35	15.36%	38.48%
Financials	10	44 348 385	167 824 990	1.51	9.55%	39.66%
Technology	3	145 730 745	8 476 003	0.10	18.47%	59.24%

Table 2 – Dataset as divided over industries

The other sub-sampling criterions used were market capitalization and presence on the Stockholm OMX 30 index. In the market capitalization segmentation, 27 companies were classified as having a large market capitalization, 10 having a medium and 14 having a small. Notably, there was no correlation between leverage and market capitalization, with high leverage values for companies with high and with low market capitalization but with a low values for companies with a medium market capitalization, see Table 3.

	Companies	Average Equity (SEK)	Average Debt (SEK)	Average Leverage	µ	σ
Large	27	64 721 129	70 411 931	0.77	11.97%	35.94%
Mid	10	2 329 300	357 739	0.15	8.73%	49.61%
Small	14	740 819	284 057	0.62	10.80%	50.66%

Table 3 – Dataset as divided over market capitalization

As for market liquidity, 12 companies were included in the OMX 30 index, whilst the other 39 were not traded actively enough to make the index. To make sure that the companies on the OMX 30 list were actually traded more actively and thus being more liquid, the average daily turnover volume was calculated for the two subsets. For the companies on the OMX 30 the average number of shares traded daily was more than 60 times bigger than that of companies not on the index. Thus, using the OMX-30 as an indicator for asset liquidity seems like a reasonable choice. Also, a noticeable difference between OMX-30 companies and non-OMX 30 companies is that the former have a significantly higher average leverage, see Table 4.

	Companies	Average Equity (SEK)	Average Debt (SEK)	Average Leverage	µ	σ
OMX 30	12	125 585 507	153 277 262	0.68	14.18%	35.22%
Not OMX 30	39	7 028 433	1 778 184	0.23	10.04%	45.44%

Table 4 – Dataset as divided over presence on OMX Stockholm 30 index.

Analysis

Several studies have previously showed that a negative correlation between rate of return and volatility exist on the American stock market, however, this author is not aware of any such studies made on the Swedish market. Thus the first step in the analysis is to determine that this negative correlation exists also on the Swedish market. Further this negative correlation should, according to the simplified model of leverage outlined in the theory section, have an elasticity in the range -1 to 0 (see Equation (10)).

The regression model (36) was therefore run on the complete pooled dataset and also on different pooled partitions of the dataset to examine if the magnitude of the elasticity varies between different industries, different market capitalization levels or between companies that are on the OMX Stockholm 30 list and those that are not.

$$\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \epsilon_{c,t} \tag{36}$$

According to the theoretical model and the average leverage of the dataset an elasticity of volatility with respect to equity of about -0.38 is expected (Equation (8) with the average leverage from Table 1). Running the regression on monthly data an elasticity of about -0.42 was estimated with a t-value of 0.084 which does not make the result significantly different from the expected theoretical value. The result is however significantly, on the 5% level, smaller than 0 and thus in the range projected by the theoretical model.

Monthly data	N	$\hat{\alpha}$ [1]	$\hat{\theta}_S$	$P(H_0)$ [2]
All industries	9129	-0.0030±0.0098	-0.4216±0.0837	0.00 %
All industries but financial	7339	-0.0029±0.0112	-0.4243±0.0945	0.00 %
Basic Materials	895	-0.0071±0.0310	-0.4980±0.2984	0.05 %
Industrials	3938	-0.0032±0.0148	-0.3946±0.1365	0.00 %
Consumer Goods	1253	-0.0007±0.0311	-0.5502±0.2997	0.02 %
Health Care	179	-0.0100±0.0643	-0.2838±0.3275	4.45 %
Consumer Services	537	-0.0008±0.0428	-0.3671±0.3782	2.86 %
Financials	1790	-0.0035±0.0201	-0.4097±0.1782	0.00 %
Technology	537	0.0032±0.0385	-0.4502±0.2047	0.00 %

[1] All confidence intervals are presented at the 5% level unless otherwise stated.

[2] Hypothesis: $H_0: \theta_S = 0$, $H_1: \theta_S < 0$

Large Cap	4833	-0.0020±0.0122	-0.4706±0.1165	0.00 %
Mid Cap	1790	-0.0027±0.0223	-0.4541±0.1752	0.00 %
Small Cap	2506	-0.0051±0.0221	-0.3365±0.1662	0.00 %
OMX	2148	-0.0007±0.0168	-0.4872±0.1579	0.00 %
Non-OMX	6981	-0.0036±0.0118	-0.4055±0.0977	0.00 %
Quarterly data	**N**	$\hat{\alpha}$	$\hat{\theta}_S$	**P(H_0)**
All industries	3009	-0.0095±0.0129	-0.2558±0.0588	0.00 %
All industries but financial	2419	-0.0097±0.0148	-0.2337±0.0675	0.00 %
Basic Materials	295	-0.0206±0.0428	-0.2655±0.2340	1.31 %
Industrials	1298	-0.0094±0.0194	-0.2716±0.0939	0.00 %
Consumer Goods	413	-0.0083±0.0432	-0.2428±0.2485	2.77 %
Health Care	59	-0.0196±0.0931	-0.3014±0.2723	1.53 %
Consumer Services	177	-0.0095±0.0524	-0.0450±0.2467	35.97 %
Financials	590	-0.0089±0.0255	-0.3462±0.1162	0.00 %
Technology	177	0.0048±0.0483	-0.1762±0.1306	0.42 %
Large Cap	1593	-0.0083±0.0158	-0.2949±0.0811	0.00 %
Mid Cap	590	-0.0095±0.0269	-0.2757±0.1162	0.00 %
Small Cap	826	-0.0107±0.0305	-0.1991±0.1202	0.06 %
OMX	708	-0.0038±0.0218	-0.2964±0.1081	0.00 %
Non-OMX	2301	-0.0110±0.0155	-0.2463±0.0690	0.00 %
Yearly data	**N**	$\hat{\alpha}$	$\hat{\theta}_S$	**P(H_0)**
All industries	714	-0.0398±0.0223	-0.0332±0.0457	7.71 %
All industries but financial	574	-0.0391±0.0248	-0.0145±0.0501	28.46 %

Table 5 – Regression results of model (36) over different data subsets

As noted in the section covering the data material, the leverage of financial firms has a somewhat different nature than that of other firms. Further, the breakdown by industry, in Table 2 shows that the average leverage within the financial industry is significantly higher than among non-financial industries. It is therefore reasonable to assume that the financial industry would have a different empirical elasticity than the market as a whole, especially since the theoretical value calculated from Table 2 is about -0.60. To test this hypothesis a model was introduced with the financial industry represented with a dummy variable. Using the technique described in the theory section, the restricted and unrestricted models were compared giving an f-value of 0.0169 and no significance at all in the difference in empirical leverage between financial and non-financial firms.

The regression in (36) was also calculated over the different industries, market capitalizations and market liquidities by pooling all observations from, for example, one industry and estimating the coefficients, these results are all summarized in Table 5. When using monthly data, all subsets of the dataset give statistically significant results at the 5% level that $\hat{\theta}_S < 0$, the exact value of the elasticity however varies widely between -0.55 and -0.28. These variations however are not significant enough to draw the conclusion that the elasticity is actually different in different industries, between different market capitalizations or between different marked liquidities. When regressing a model allowing different industries to have different elasticities a comparison with a uniform elasticity using the restricted/unrestricted approach gave an f-value of 0.35 and no significantly higher explanatory power in the unrestricted model. A similar analysis for the different market capitalizations gave an f-value of 1.00 and for different marked liquidities 0.55, thus neither unrestricted model was statistically significantly better. For the complete results see Table 6, Table 7 and Table 8.

Model: $\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \sum_{\mathrm{i} \in \mathrm{industry}} \beta_\mathrm{i} \mathrm{r}_{\mathrm{c,t,i}} + \epsilon_{c,t}$

Hypothesis: $H_0 : \forall_{i \in industry} \beta_i = 0$

$H_1 : \exists_{i \in industry} \beta_i \neq 0$

Monthly data	SSR	df	F-value	$P(H_0)$
Restricted model	1969.54	8908		
Unrestricted model	1969.08	8902	0.3491	91.08 %
Quarterly data	**SSR**	**df**	**F-value**	**$P(H_0)$**
Restricted model	381.34	2987		
Unrestricted model	380.55	2981	1.0297	40.39%
Yearly data	**SSR**	**df**	**F-value**	**$P(H_0)$**
Restricted model	62.98	712		
Unrestricted model	62.43	706	1.0274	40.61 %

Table 6 – Comparison of model (36) with compensation for different industries

Model: $\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \sum_{\mathrm{m} \in \mathrm{caps}} \beta_\mathrm{m} \mathrm{r}_{\mathrm{c,t,m}} + \epsilon_{c,t}$

Hypothesis: $H_0 : \forall_{m \in caps} \beta_m = 0$

$H_1 : \exists_{m \in caps} \beta_m \neq 0$

Monthly data	SSR	df	F-value	$P(H_0)$
Restricted model	1969.54	8908		
Unrestricted model	1969.10	8906	0.9957	36.95 %
Quarterly data	**SSR**	**df**	**F-value**	**$P(H_0)$**
Restricted model	381.34	2987		
Unrestricted model	381.07	2985	1.0407	35.33%
Yearly data	**SSR**	**df**	**F-value**	**$P(H_0)$**
Restricted model	62.98	712		
Unrestricted model	62.75	710	1.2862	27.70 %

Table 7 – Comparison of model (36) with compensation for different market capitalizations

Model: $\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \sum_{\mathrm{o} \in \mathrm{OMX}} \beta_\mathrm{o} \mathrm{r}_{\mathrm{c,t,o}} + \epsilon_{c.t}$

Hypothesis: $H_0 : \forall_{o \in OMX} \beta_o = 0$

$H_1 : \exists_{o \in OMX} \beta_o \neq 0$

Monthly data	SSR	df	F-value	$P(H_0)$

Restricted model	1969.54	8908		
Unrestricted model	1969.42	8907	0.5463	45.99 %
Quarterly data	**SSR**	**df**	**F-value**	**P(H_0)**
Restricted model	381.34	2987		
Unrestricted model	381.29	2986	0.3549	55.14%
Yearly data	**SSR**	**df**	**F-value**	**P(H_0)**
Restricted model	62.98	712		
Unrestricted model	62.89	711	0.9775	32.31 %

Table 8 – Comparison of model (36) with compensation for different liquidity

When running the regression over individual companies only 26 out of the 51 companies had an elasticity that was statistically significantly below 0. And the elasticity varied widely from as low as -1.70 to as high as 0.66, both values being outside the range of theoretically possible values according to our model (8). However the positive elasticity estimates are possible to explain using the extended model in (34). Further, an unrestricted model was regressed, where each company's volatility was allowed to be set independently, and then compared with a restricted model of all companies having the same elasticity. Te results indicate that the unrestricted model is significantly better than the restricted model, which is in accordance with theory, as the expected elasticity is a function of the leverage which in its turn is depends on the individual companies.

When changing the frequency of the data to first quarterly and then finally yearly observations, the elasticity of the complete dataset decreased to -0.26 for quarterly and to -0.03 for yearly observations, with the yearly value not even being statistically significantly different from 0. The same trend holds for all subsets of the dataset, see Table 5, and it thus seems like the leverage effect is more pronounced in higher frequency data. This however might be a result of how the variables in the regression are measured. When running the regression on for example yearly data, the change in volatility for year 2 is calculated by taking the change in volatility between year 1 and year 2. The corresponding rate of return regressed against this is the rate of return for the whole of year 1. This means that if the market changes significantly in the second year, a higher rate of return might drive down the volatility (all in accordance with the leverage effect) and thus exogenously affect the estimated elasticity. This effect is more pronounced the more the rate of return may change over a period, and thus it is more pronounced when lower frequency data is used.

The fact that there exists a negative correlation between rate of return and volatility has now been established and that the elasticity is in the range predicted by the leverage effect. To bring clarity to whether it is the leverage effect that causes these results, or if the results are due to some other effect, other aspects of the data set are now examined. The first such extension of the model is to study the asymmetry of the change in volatility. According to the model of the leverage effect, the volatility should change by the same percentage whether the rate of return is positive or if it is negative. To study this behavior a dummy variable representing positive rates of returns was introduced in the model.

$$\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \theta_{S+} r_{+,c,t} + \epsilon_{c,t} \tag{37}$$

The results from this regression on monthly data are very interesting, with values of $\hat{\theta}_{S+}$ being significantly different from zero, and this for all subsets of the dataset. Also worth noting is that the elasticity for negative rates of return are fairly consistently greater than 0 while the elasticity for positive rates of returns tend to be smaller than -1. Both of these values are outside the theoretical range of our basic model, however, the positive elasticity can be explained by a high risk premium in the risky debt model. It is however likely that both the positive elasticity and the large negative elasticity to some extent is due to other effects than the leverage effect, such as for example the volatility feedback effect.

Further, running the regression (37) for quarterly and yearly data yielded a similar result as in (36) with the coefficients moving closer to 0 for lower frequency data, for a complete breakdown of the regression results, see Table 9.

Monthly data	N	$\hat{\alpha}$	$\hat{\theta}_S$	$\hat{\theta}_{S+}$	$P(H_0)$[3]
All industries	9129	0.0632±0.0132	0.4470±0.1431	-1.6725±0.2248	0.00 %
All industries but financial	7339	0.0692±0.0149	0.5080±0.1602	-1.8079±0.2526	0.00 %
Basic Materials	895	0.1057±0.0433	1.1034±0.5288	-3.0342±0.8376	0.00 %
Industrials	3938	0.0595±0.0199	0.4409±0.2244	-1.7021±0.3649	0.00 %
Consumer Goods	1253	0.0945±0.0428	0.9712±0.5626	-2.6678±0.8401	0.00 %
Health Care	179	0.0936±0.0898	0.4757±0.5689	-1.4742±0.9138	0.17 %
Consumer Services	537	0.1324±0.0591	1.4233±0.6756	-3.3159±1.0525	0.00 %
Financials	1790	0.0373±0.0275	0.1565±0.3171	-1.0585±0.4915	0.00 %

[3] Hypothesis: $H_0: \theta_{S+} = 0$
$H_1: \theta_{S+} \neq 0$

Technology	537	0.0687±0.0530	0.0754±0.3589	-1.0031±0.5654	0.05 %
Large Cap	4833	0.0475±0.0169	0.2604±0.2100	-1.3600±0.3261	0.00 %
Mid Cap	1790	0.0679±0.0313	0.3617±0.3096	-1.5679±0.4929	0.00 %
Small Cap	2506	0.0822±0.0279	0.6949±0.2639	-2.0797±0.4186	0.00 %
OMX	2148	0.0396±0.0235	0.1102±0.2909	-1.0886±0.4463	0.00 %
Non-OMX	6981	0.0691±0.0156	0.5173±0.1643	-1.8017±0.2598	0.00 %
Quarterly data	**N**	$\hat{\alpha}$	$\hat{\theta}_S$	$\hat{\theta}_{S+}$	**P(H_0)**
All industries	3009	0.0352±0.0177	0.0417±0.0999	-0.5887±0.1605	0.00 %
All industries but financial	2419	0.0394±0.0203	0.0916±0.1140	-0.6467±0.1836	0.00 %
Yearly data	**N**	$\hat{\alpha}$	$\hat{\theta}_S$	$\hat{\theta}_{S+}$	**P(H_0)**
All industries	714	0.0131±0.0310	0.1337±0.0826	-0.3081±0.1279	0.00 %
All industries but financial	574	0.0082±0.0347	0.1317±0.0907	-0.2713±0.1409	0.02 %

Table 9 – Regression results of model (37) over different data subsets

The model (37) was also extended to test for differences in the value of θ_S and θ_{S+} for different industries, market capitalizations and asset liquidities, see Table 10, Table 11 and Table 12. In these regressions no significant difference in the value of θ_S, the elasticity for negative correlations, could be found between the different subsamples. However a significant difference in the elasticity of positive returns, θ_{S+}, existed between different industries.

Model: $\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \theta_{S+} r_{+,c,t} + \sum_{i \in \mathrm{industry}} \beta_i r_{+,c,t,i} + \epsilon_{c,t}$

Hypothesis: $H_0 : \forall_{i \in industry} \beta_i = 0$
$H_1 : \exists_{i \in industry} \beta_i \neq 0$

Monthly data	SSR	df	F-value	P(H_0)
Restricted model	1923.61	8907		
Unrestricted model	1920.05	8901	2.7477	1.14 %

Table 10 – Comparison of model (37) with compensation for different industries

Model: $\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \theta_{S+} r_{+,c,t} + \sum_{m \in \mathrm{caps}} \beta_m r_{+,c,t,m} + \epsilon_{c,t}$

Hypothesis: $H_0 : \forall_{m \in caps} \beta_m = 0$
$H_1 : \exists_{m \in caps} \beta_m \neq 0$

Monthly data	SSR	df	F-value	P(H_0)
Restricted model	1923.61	8907		
Unrestricted model	1923.48	8905	0.2939	74.54 %

Table 11 – Comparison of model (37) with compensation for different market capitalization

Model: $\Delta \ln \sigma_{c,t} = \alpha + \theta_S r_{c,t} + \theta_{S+} r_{+,c,t} + \sum_{o \in \mathrm{OMX}} \beta_o r_{+,c,t,o} + \epsilon_{c,t}$

Hypothesis: $H_0 : \forall_{o \in OMX} \beta_o = 0$
$H_1 : \exists_{o \in OMX} \beta_o \neq 0$

Monthly data	SSR	df	F-value	P(H_0)
Restricted model	1923.61	8907		
Unrestricted model	1923.45	8906	0.7155	39.76 %

Table 12 – Comparison of model (37) with compensation for different liquidity

According to the theory developed governing the leverage effect, the overall percentage change in volatility from one period to another is proportional to the change in rate of return over the same period. By using quarterly measurements of the volatility and subdividing the quarterly rate of returns into the sum of monthly rates of returns it is possible to measure if each of the monthly returns have the same impact on the change in volatility, as is predicted in the theory. The model in (38) was regressed using pooled data for each of the available data subsets with the volatility difference measured between quarterly volatility observations and regressed against monthly rate of return observations.

$$\Delta \ln \sigma_{c,3t} = \alpha + \theta_1 r_{c,3t} + \theta_2 r_{c,3t-1} + \theta_3 r_{c,3t-2} + \epsilon_{c,3t} \qquad (38)$$

The regression over the complete dataset gave a contribution from the different time lagged rates of returns of between -0.32 and -0.58, and when comparing this model to the restricted model where all the time lagged variable have the same value, the restricted model can be rejected at the 5% level. Thus it seems like the different time lags do not contribute uniformly to the change in volatility. However, breaking down the analysis into the different data subsets we cannot draw the same conclusion in general. In the breakdown over industry, none of the industries have coefficients that are significantly different enough to discard the hypothesis of a uniform coefficient.

In the breakdown over marked capitalization and market liquidity an interesting pattern can be observed. In both the Large Cap and the OMX companies the hypothesis of a uniform coefficient can be discarded at the 5% level (actually at the 2.5% level in Large Cap and 0.27% level in OMX), but in the Mid Cap, Small Cap and Non-OMX companies this same conclusion cannot be reached. Interestingly the uniformity of the coefficient seems to increase when moving from Large Cap through Mid Cap to Small Cap companies, and the same holds when moving from OMX to Non-OMX companies. A possible interpretation of this is that the smaller a company is and the less liquid its assets are the less influenced by other effects such as volatility feedback it is, thus the effect we observe for these companies are more strongly a pure leverage effect. For the complete result of the regression, see Table 13.

Quarterly - Monthly	N	$\hat{\alpha}$	$\hat{\theta}_1$	$\hat{\theta}_2$	$\hat{\theta}_3$	$P(H_0)$[4]
All industries	3009	-0.0053±0.0151	-0.3224±0.1226	-0.5779±0.1279	-0.4444±0.1321	2.67%
All industries but financial	2419	-0.0048±0.0173	-0.3098±0.1365	-0.5413±0.1466	-0.4009±0.1498	9.21%
Basic Materials	295	-0.0061±0.0492	-0.5494±0.5060	-0.8608±0.4506	-0.2926±0.4838	21.27%
Industrials	1298	-0.0062±0.0232	-0.3888±0.1912	-0.6243±0.2132	-0.3957±0.2186	20.65%
Consumer Goods	413	0.0018±0.0457	-0.6157±0.4572	-0.6985±0.4173	-0.4007±0.4735	61.26%
Health Care	59	-0.0328±0.1195	-0.4052±0.4977	-0.1556±0.6929	-0.5425±0.6782	71.90%
Consumer Services	177	0.0035±0.0599	0.3653±0.5064	-0.4285±0.6000	-0.4770±0.4859	5.68%
Financials	590	-0.0089±0.0306	-0.3914±0.2806	-0.6938±0.2580	-0.6208±0.2781	32.02%
Technology	177	0.0027±0.0664	-0.0771±0.3400	-0.2419±0.3618	-0.4775±0.3668	27.26%
Large Cap	1593	-0.0036±0.0193	-0.4671±0.1873	-0.8009±0.1753	-0.5068±0.1810	2.41%
Mid Cap	590	-0.0115±0.0327	-0.2558±0.2383	-0.5293±0.2636	-0.4742±0.2678	29.73%
Small Cap	826	-0.0030±0.0336	-0.2326±0.2286	-0.3149±0.2584	-0.3433±0.2708	81.77%
OMX	708	0.0099±0.0267	-0.3289±0.2609	-0.9879±0.2336	-0.6680±0.2455	0.27%
Non-OMX	2301	-0.0088±0.0180	-0.3157±0.1391	-0.4692±0.1503	-0.3928±0.1547	37.08%

Table 13 – Regression results of model (38) over different data subsets

The one factor that the leverage effect depends on, that none of the other explanations of the negative correlation do, is the level of debt in the company. The next regression was therefore intended to determine the empirical elasticity of volatility with respect to debt.

$$\Delta \ln \sigma_{c,t} = \alpha + \theta_D \Delta \ln \mathrm{D}_{c,t} + \epsilon_{c.t} \tag{39}$$

Running regression (39) over the complete pooled dataset at yearly intervals resulted in a very small estimate for the elasticity, 0.015, which is not statistically significantly different from 0. However, comparing this to the corresponding regression for the elasticity with respect to rate of return, equation (36), neither this elasticity was significantly different from 0 when regressing on yearly data.

Running the regression on higher frequency data resulted in very shifting elasticities, with few elasticities being significantly larger than 0 (the one exception being OMX companies on monthly data, however this is more likely to be a probabilistic fluke than a significant result). That the elasticities for higher frequency data do not conform to the theory for the leverage effect is however not as troubling as it might seem. The problem with higher frequency data for debt levels is that these values have been linearly interpolated from the annual data, which are

[4] Hypothesis: $H_0: \theta_1 = \theta_2 = \theta_3$
$H_1: \theta_1 \neq \theta_2 \;\; or \;\; \theta_1 \neq \theta_3 \;\; or \;\; \theta_2 \neq \theta_3$

the only true values available. Thus the change in debt for high frequency data does not correspond to the true changes of debt for the company at hand.

Monthly data	N	$\hat{\alpha}$	$\hat{\theta}_D$	$P(H_0)$[5]
All industries	9129	-0.0069±0.0100	0.0090±0.0711	40.21%
All industries but financial	7339	-0.0071±0.0114	0.0035±0.1372	48.00%
Basic Materials	895	-0.0106±0.0314	0.1683±0.4057	20.79%
Industrials	3938	-0.0073±0.0151	0.0091±0.1920	46.30%
Consumer Goods	1253	-0.0055±0.0311	-0.1960±0.4191	82.05%
Health Care	179	-0.0104±0.0694	0.1124±0.4548	31.32%
Consumer Services	537	-0.0017±0.0454	0.3047±0.8150	23.15%
Financials	1790	-0.0063±0.0204	0.0112±0.0764	38.66%
Technology	537	-0.0040±0.0402	-0.0653±0.3180	65.66%
Large Cap	4833	-0.0068±0.0123	0.0248±0.1040	32.03%
Mid Cap	1790	-0.0052±0.0228	0.0163±0.1071	38.28%
Small Cap	2506	-0.0083±0.0229	-0.0498±0.2084	68.04%
OMX	2148	-0.0065±0.0170	0.2095±0.4469	17.90%
Non-OMX	6981	-0.0072±0.0120	0.0053±0.0751	44.46%
Quarterly data	**N**	$\hat{\alpha}$	$\hat{\theta}_D$	$P(H_0)$
All industries	3009	-0.0160±0.0133	-0.0285±0.0424	90.67%
All industries but financial	2419	-0.0162±0.0152	0.0056±0.0743	44.13%
Basic Materials	295	-0.0262±0.0437	0.0552±0.2213	31.19%
Industrials	1298	-0.0178±0.0198	-0.0116±0.0979	59.15%
Consumer Goods	413	-0.0142±0.0430	0.0010±0.2151	49.65%
Health Care	59	-0.0141±0.1070	-0.0186±0.2904	55.08%
Consumer Services	177	-0.0003±0.0548	0.2446±0.4379	13.58%
Financials	590	-0.0169±0.0268	-0.0464±0.0464	97.49%
Technology	177	-0.0004±0.0527	0.0060±0.2223	47.87%
Large Cap	1593	-0.0167±0.0161	-0.0487±0.0592	94.65%
Mid Cap	590	-0.0138±0.0280	-0.0118±0.0613	64.76%
Small Cap	826	-0.0159±0.0320	-0.0212±0.1234	63.21%
OMX	708	-0.0143±0.0220	0.2177±0.2183	2.53%
Non-OMX	2301	-0.0170±0.0161	-0.0349±0.0451	93.50%
Yearly data	**N**	$\hat{\alpha}$	$\hat{\theta}_D$	$P(H_0)$
All industries	714	-0.0392±0.0226	0.0148±0.0253	12.59%
All industries but financial	574	-0.0373±0.0250	0.0039±0.0387	42.17%

Table 14 – Regression results of model (39) over different data subsets

The final analysis is based on the risky debt leverage effect model. More specifically, equations (20) and (21) are used to test if the proportionality coefficient between volatility and leverage decreases with increasing leverage.

$$\sigma_t = \beta_{c,0} + \beta_{c,1} L_t + \epsilon_t \tag{40}$$

[5] Hypothesis: $H_0\colon \theta_D = 0$
$H_1\colon \theta_D > 0$

As the coefficients, β, greatly depend on the company in question and our aim is to examine how these differences depend on the company leverage, the regression in (40) was calculated on each individual company's time-series data to obtain a cross-section of coefficients β. To compare how these coefficients vary with leverage, the companies were divided into 4 groups depending on in what quartile their average leverage fell. For each of these groups the average of the coefficients within the group was calculated to get a value representing the coefficient for companies within the specific range of leverages. The complete result of the regression can be found in Table 15.

For all of the three sample frequencies, monthly, quarterly and yearly, the quotient, β_1/β_0, decreased with increasing leverage, all in agreement with the theory. Unfortunately however the author knows of no statistical method to calculate confidence intervals for the quotient β_1/β_0, and no method for model comparison to determine whether the quotients are significantly different between the different leverage quartiles. To get around this an approximate confidence interval was calculated which overstates the true confidence interval (see footnote 6), and assuming the confidence intervals for the different quartiles do not overlap, it can safely be assume that the β_1/β_0 quotients are statistically significantly different. For both the monthly and for the quarterly observations, the confidence intervals do not overlap, and thus the quotients are truly different. For the yearly observations however the confidence intervals do overlap. This however does not mean that the quotients for the yearly observations cannot be statistically significantly different at the 5% level just that our coarse approximations of the confidence intervals can neither confirm nor deny this.

Monthly data		$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_1/\hat{\beta}_0$ [6]
Q1	$0.01 \leq \bar{L} < 0.38$	0.3320±0.0028	0.1712±0.0255	0.5156±0.0817
Q2	$0.38 \leq \bar{L} < 1.06$	0.3052±0.0031	0.0451±0.0040	0.1478±0.0146
Q3	$1.06 \leq \bar{L} < 2.50$	0.3262±0.0032	0.0263±0.0010	0.0808±0.0038
Q4	$2.50 \leq \bar{L} < 10.41$	0.3275±0.0028	0.0059±0.0003	0.0180±0.0011

[6] As the author knows of no statistical approach to calculate the confidence interval of a quotient of two normally distributed random variables, the interval was instead calculated by first determining the largest and smallest value the quotient could have given the confidence intervals for β_0 and β_1. The confidence interval for the quotient was then selected to include both of these extreme values. It should be noted that this confidence interval is not at the 5% level, however, as it includes all values possible at the 5% levels for β_0 and β_1, the interval is bigger than required at the 5% level.

Quarterly data		$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_1/\hat{\beta}_0$
Q1	$0.01 \le \bar{L} < 0.38$	0.3417±0.0070	0.2163±0.0667	0.6331±0.2126
Q2	$0.38 \le \bar{L} < 1.06$	0.3132±0.0076	0.0520±0.0101	0.1660±0.0372
Q3	$1.06 \le \bar{L} < 2.50$	0.3357±0.0076	0.0334±0.0024	0.0994±0.0097
Q4	$2.50 \le \bar{L} < 10.41$	0.3389±0.0066	0.0070±0.0007	0.0206±0.0026
Yearly data		$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_1/\hat{\beta}_0$
Q1	$0.01 \le \bar{L} < 0.38$	0.3527±0.0228	0.1970±0.1914	0.5586±0.6189
Q2	$0.38 \le \bar{L} < 1.06$	0.3221±0.0234	0.0522±0.0311	0.1620±0.1168
Q3	$1.06 \le \bar{L} < 2.50$	0.3432±0.0205	0.0431±0.0080	0.1256±0.0329
Q4	$2.50 \le \bar{L} < 10.41$	0.3258±0.0205	0.0129±0.0026	0.0396±0.0113

Table 15 – Regression results of model (40) over the different leverage quartiles

Discussion

The goal of this study was to examine the presence of a leverage effect on the Swedish market; to what extent this effect explains the negative correlation between volatility and rate of return and if there is any difference in how the effect materializes over different industries, company sizes or asset liquidities.

The first section of the analysis aimed to verify that the negative correlation between rate of return and change in volatility was present on the Swedish market as assumed by marked knowledge. In addition to this, the analysis of monthly data gave estimates of the elasticity of volatility with respect to equity which coincided with the values projected by the theoretical model of the leverage effect previously derived. Further, no statistically significant differences were observed between different industries, company sizes or asset liquidities. This however is somewhat surprising, since the financial industry has a significantly higher average leverage than other industries, and thus should have a smaller (more negative) elasticity estimate. A possible explanation is the different function of leverage within the financial industry, and thus our model might not be applicable to this industry. Another interesting result with the elasticity estimates is that they tend towards 0 when the regression data used moves from monthly through quarterly to yearly observations. This kind of decline in the elasticity is not in agreement with the theory; however it might be explained in the way the dependent and independent variables in the regression are averaged over larger and larger time intervals.

According to the models of the leverage effect, the percentage change in volatility due to a specific rate of return should be the same no matter if the return is positive or negative. However, in the volatility feedback model this is not the case. Assuming a volatility feedback effect, there should be an asymmetric relation between change in volatility and rate of return (French, Schwert, & Stambaugh, 1987). This is also the result found in the second regression model used. Thus there are clear signs that the negative correlation between volatility and returns is due to the volatility feedback effect. However, this regression is unable to conclusively distinguish between the two effects. And the only thing that can be said with certainty is that there are clear suspicions of a volatility feedback effect due to the asymmetric nature of the elasticity. However, the measured elasticities may be a combination of an asymmetric volatility feedback effect and a symmetric leverage effect.

In order to try to separate the two effects, the effect on volatility due to time lagged rates of returns was examined. In the leverage effect consecutive rates of returns should have the same individual contribution to the change in the volatility. However, for the volatility feedback effect a change in volatility drives the rate of return at a specific time (the moment when the asset changes price to reflect the new riskiness) and thus the consecutive rates of returns should make different contributions to the overall change in volatility. When running the regression on time lagged rates of returns the different time lags do contribute differently towards the change in volatility. However, all the different time lagged returns have an elasticity that is in accordance with the leverage effect. It is therefore possible that the differences in the time lagged elasticities are due to the volatility feedback effect, which does not contributes uniformly to the time lagged elasticities, and that the average of the time lagged elasticities is a result of the leverage effect, which has a uniform contribution. This explanation is further supported by the regressions run on the data subsets, the relative size of the different time lagged elasticities are not constant across industries, i.e. the biggest elasticity occurs for different time lags for different industries. This can be interpreted as the variation of at which time lag the largest elasticity occurs is a random process, dependent on when the distinctive change in return, predicted by the volatility feedback effect, takes place more often for a specific industries. Another interesting result is that the different time lagged elasticities are more and more uniform the smaller the company is and the less liquid the asset is. Thus for large companies with liquid assets the volatility feedback effect seems prominent, but for smaller companies with less liquid assets the leverage effect is more dominant.

Since it has now been concluded that the effects measured so far are most likely a superposition of the leverage effect and the volatility feedback effect. It is reasonable to move on and examine effects that can only be contributed to the leverage effect. Since the volatility feedback effect is completely independent on the level of debt underlying the asset, the elasticity of volatility with respect to debt is examined. Unfortunately data on company debt levels are only available through the annual balance sheet, and thus reliable regressions can only be made using yearly observations. These regressions show no significant proof of an elasticity constant that is in agreement with the elasticity predicted in the leverage effect model. This result can however be explained in the same manner as the decline, with decreasing sample frequency, of the elasticity of volatility with respect to equity (see the analysis section). Therefore the only possible conclusion is that the results obtained from this regression neither supports nor contradicts the presence of a leverage effect. And more data on company debt levels, preferably on a monthly basis, would be needed to be able to come to a clear conclusion.

As the elasticity of volatility with respect to debt neither confirmed nor rejected the hypothesis of a leverage effect, another model was needed that examined traits that distinguished the leverage effect from the volatility feedback effect. In the risky-debt model of the leverage effect, it is predicted that the volatility should be proportional to the leverage, with the proportionality constant being a function of the risk premium on the company debt. Further, a higher leveraged company should have a higher risk-premium, thus companies with different leverage should have somewhat different constants of proportionality. This is a relationship that is not consistent with the volatility feedback effect, and thus is a measurement of the pure leverage effect. Running the regression on the dataset partitioned into four different groups based on leverage, show that the proportionality constant varies with leverage in a statistically significant way and in the way predicted by the model. Thus, this test is conclusive evidence of the presence of the leverage effect as opposed to the volatility feedback effect on the Swedish market.

Summary

Having tested five different regressions, all examining different aspects of the leverage effects presence on the Swedish market, the conclusion of this study most be that there is a clear leverage effect in the relationship between change in volatility and the rate of return. There are however some inconsistencies in the results which to some extent can be explained by the leverage effect not being the only effect working on the relationship between volatility and rate of return. Most likely the effect seen in the market is a superposition of the leverage effect and the volatility feedback effect.

Other inconsistencies occur when testing the models on yearly observations, in theory this should not be a problem, however the approximate methods used to measure the change in volatility and the corresponding change in debt or equity might be the origin of these inconsistencies. Therefore a more thorough study would be desired in which monthly data for debt could be used to calculate the elasticity of volatility with respect to debt and thus get a clearer measure on the contribution of the leverage effect. This however seems unlikely as companies rarely reveal their debt in other circumstances than in the annual balance sheet.

When examining the contribution of the leverage effect across different industries no significant differences were noted. It is however somewhat surprising that the financial industry, which is highly levered, did not diverge from the rest of the industries as was expected. Instead it seems like companies in the financial industry behave like ordinary companies and thus behave like they have a lower leverage then they actually have. This is however feasible considering the different usage of leverage in the financial industries.

When examining the relative contributions of the leverage effect and the volatility feedback effect, there are differences depending on the company size and the asset liquidity. For more liquid assets and larger companies the volatility feedback effect is more pronounced, and for small companies the leverage effect seems to dominate.

There are a few improvements to this study that would be interesting to delve into in future studies. The first would be to obtain higher frequency, preferably monthly, observations of the company's debt levels to verify that the estimated elasticities of volatility with respect to debt agree with the model predictions. Another aspect that would require future study is to examine the exact contributions of the leverage effect and volatility feedback effect. This could be done by developing a joint model of the leverage effect and the volatility effect and designing a test that captures and quantifies the differences between the two.

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Appendix A Companies

Company	Asset	ICBI	Cap	OMX 30
ACTIVE BIOTECH AB	ACTIVE BIOTECH	Healthcare	Mid	No
ANGPANNEFORENINGEN AB	ANGPANNEFORENINGEN 'B'	Industrials	Mid	No
ATLAS COPCO AB	ATLAS COPCO 'A'	Industrials	Large	Yes
B&B TOOLS AB	B&B TOOLS 'B'	Industrials	Mid	No
BEIJER ALMA AB	BEIJER ALMA 'B'	Industrials	Mid	No
G & L BEIJER AB	G & L BEIJER	Industrials	Small	No
BILIA AB	BILIA 'A'	Consumer Services	Mid	No
BONGS LJUNGDAHL AB	BONGS LJUNGDAHL 'B'	Basic Materials	Small	No
BERGS TIMBER AB	BERGS TIMBER 'B'	Basic Materials	Small	No
BRIO AB	BRIO 'B'	Consumer Goods	Small	No
CONCORDIA MARITIME AB	CONCORDIA MARITIME 'B'	Industrials	Mid	No
ELANDERS AB	ELANDERS 'B'	Consumer Services	Small	No
ELEKTRONIKGRUPPEN BK AB	ELEKTRONIKGRUPPEN BK 'B'	Industrials	Small	No
ELECTROLUX AB	ELECTROLUX 'B'	Consumer Goods	Large	Yes
ENEA AB	ENEA	Technology	Small	No
ERICSSON TELEPHONE AB	ERICSSON 'B'	Technology	Large	Yes
FENIX OUTDOOR AB	FENIX OUTDOOR	Consumer Goods	Small	No
GEVEKO AB	GEVEKO 'B'	Industrials	Small	No
HEXAGON AB	HEXAGON 'B'	Industrials	Large	No
HALDEX AB	HALDEX	Consumer Goods	Mid	No
H&M HENNES & MAURITZ AB	HENNES & MAURITZ 'B'	Consumer Services	Large	Yes
HOLMEN AB	HOLMEN 'B'	Basic Materials	Large	No
HUFVUDSTADEN AB	HUFVUDSTADEN 'A'	Financials	Large	No
IBS AB	IBS 'B'	Technology	Mid	No
INDUSTRIVARDEN AB	INDUSTRIVARDEN 'A'	Financials	Large	No
INVESTOR AB	INVESTOR 'B'	Financials	Large	Yes
JM AB	JM	Financials	Large	No
LATOUR INVESTMENT AB	LATOUR INVESTMENT 'B'	Industrials	Large	No
LUNDBERGFORETAGEN AB	LUNDBERGFORETAGEN 'B'	Basic Materials	Large	No
MIDWAY HOLDINGS AB	MIDWAY HOLDINGS 'B'	Industrials	Mid	No
NCC AB	NCC 'B'	Industrials	Large	No
OEM INTERNATIONAL AB	OEM INTERNATIONAL 'B'	Industrials	Small	No
OMX AB	OMX	Financials	Large	No
ORESUND INVESTMENT AB	ORESUND INVESTMENT	Financials	Large	No
PEAB AB	PEAB 'B'	Industrials	Large	No
RATOS AB	RATOS 'B'	Financials	Large	No
SANDVIK AB	SANDVIK	Industrials	Large	Yes
SCA AB	SCA 'B'	Consumer Goods	Large	Yes
SE BANKEN	SEB 'A'	Financials	Large	Yes
SECO TOOLS AB	SECO TOOLS 'B'	Industrials	Large	No
SVENSKA HANDBKN. AB	SVENSKA HANDELSBANKEN 'A'	Financials	Large	Yes
SKANSKA AB	SKANSKA 'B'	Industrials	Large	Yes

Company	Asset	ICBI	Cap	OMX 30
SKF AB	SKF 'B'	Industrials	Large	Yes
SSAB AB	SSAB 'A'	Basic Materials	Large	No
SKANDITEK INDRI.FRV.AB	SKANDITEK INDUSTRI FORVALTNINGS	Financials	Mid	No
TRELLEBORG AB	TRELLEBORG 'B'	Industrials	Large	No
VBG AB	VBG	Consumer Goods	Small	No
VOLVO AB	VOLVO 'B'	Industrials	Large	Yes
BORAS WAFVERI AB	BORAS WAFVERI 'B'	Consumer Goods	Small	No
WESTERGYLLEN AB	WESTERGYLLEN 'B'	Industrials	Small	No
XANO INDUSTRI AB	XANO INDUSTRI 'B'	Industrials	Small	No